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Comparative studies on chemical, hot and cold water treatments of banana suckers to control the banana weevil, *Cosmopolites sordidus* and the effect of paring suckers on banana nematodes in Uganda

W. Tinzaara, I. Kashaija, W. Tushemereirwe & C. Nankinga
Kawanda Agricultural Research Institute, Box 7065, Kampala, Uganda

Abstract

Chemical, hot and cold-water treatments were evaluated for effectiveness in cleaning banana suckers of weevils. Preliminarily, the effectiveness of paring suckers on removal of weevils and nematodes from banana suckers was validated. Results indicated a 36.6%, 67.9% and 96.3% reduction of larvae in corms treated with cold water, hot water and Chlorpyrifos (Dursban) respectively. Use of Dursban at a rate of 1.5 cc in a litre of water and soaking for one hour was recommended as the best of the three methods for cleaning banana suckers. A test carried out to establish the declining rate of efficiency over successive use of the same solution indicated that the solution does not loose potency, hence can be re-used until the volume cannot submerge suckers any more. With regard to paring alone, there was a 95% reduction of weevil eggs in pared suckers. The number of larvae recorded from unpared suckers was significantly higher than that recovered from pared suckers. No nematodes were recovered from pared suckers while both *R. similis* and *H. multicinctus* nematodes were recovered in high numbers from unpared suckers.

Key words: Banana weevil, chemical treatment, *Cosmopolites sordidus*, clean planting material, Paring

Introduction

The banana weevil *Cosmopolites sordidus* Germar is considered among the most serious pests of bananas (Stover & Simmonds, 1987) and is one of the major constraints to banana production especially in small scale farming systems (Bujulu *et al.*, 1983; Sikora *et al.*, 1989). The weevil (in association with low soil fertility and diseases) can cause decline in banana productivity (Gold *et al.*, 1999). Additionally, the pest causes tremendous yield losses and shortens plantation life span if not controlled (Gold *et al.*, 1993; Rukazambuga *et al.*, 1998).

The weevil follows a k-selected life cycle (Pianka, 1970) with a long life span of up to two years (Simmonds, 1966; Whalley, 1957) and low fecundity (Dellatre, 1980; Koppenhoeffer, 1993). The adult which measures 11-13 mm long with functional wings, has rarely been observed to fly (Whalley, 1957), but can walk short distances over soil surface and vegetation (Delattre, 1980). As a result, it disperses slowly, and population build up in new areas is gradual. Movement of adult weevils is limited although some individuals may move more than 30 m in five days (Gold and Bagabe, 1997). In contrast, Delattre (1980) recorded a maximum movement distance of 60 m in five months. Therefore, movement of suckers carrying eggs, larvae and sometimes adults into new fields offers the major entry points of infestation of new stands. Low initial infestation levels may slow population build up and hence provide extended protection to newly planted fields.

The female lays its eggs singly at the bases of the banana pseudostems at maximum oviposition depth of eggs being 5 cm below the soil surface (Abera *et al.*, 2000). Egg production is low with oviposition estimated per female to range 1 to 3 eggs per week (Arleu and Neto, 1984; Koppenhoeffer, 1993) and 10 to 270 eggs in the lifetime of the insect (Cuille, 1950). 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 (Gold, 1998). Damage can be high in plantations with poor residue management, longer cropping cycle and slower plant growth (Stanton, 1994).

Currently, cultural control including trapping using split pseudostems and use of clean planting materials forms the first line of defense and are the only available option to the majority of small holder farmers, though trapping effectiveness has always been disputed (Gold *et al.*, 1993). There are studies that demonstrate that this method is tedious (Gold *et al.*, 1993) with variable efficiency ranging from 20-25% of weevils recaptured depending on weevil density and soil moisture conditions (Gold *et al.*, 1998; Rukazambuga, 1996). Use of clean planting material may provide resource poor farmers with the cheapest and most efficient alternative of protecting their crops against banana weevils.

There are efforts to advance use of tissue culture plants as a source of clean planting material but the production capacity, costs and means of dissemination are limiting

factors (Gold, 1998). It is also well known that tissue culture plantlets are initially very sensitive and do not have a lot of reserve food and therefore are affected more than conventional suckers by weevils and nematodes if attacked before establishment (Robinson, 1998). Paring (i.e removal of the peel off suckers' corm) eliminates a large proportion of weevil eggs and nematodes but do not remove weevil larvae inside corms (Gold, *et al.*, 1998). Hot water treatment of pared suckers at 52-55°C for 20 minutes is another method of providing clean planting material to farmers (Stover and Simmonds, 1987; Gettman *et al.*, 1992; Prasad & Seshu Reddy, 1994; Gold *et al.*, 1998). Hot water treatment for weevil control in suckers is also limited as it reportedly kills 32% of weevil larvae inside corms (Gold, *et al.*, 1998). In some countries, this method is not recommended due to the cost and equipment needed for the treatment (Jones and Milne, 1982).

Chemical treatment of pared suckers though expensive and hazardous may provide a plausible alternative. It is thought that a chemical may be more effective as it may not only kill the deeply buried larvae in the corm but also may kill the eggs or reduce their viability. The aim of this study was to compare cold and hot water treatment with chemical treatment of banana planting material for the control of the banana weevil, and to validate the effect of paring on weevil and nematode removal from banana suckers.

Materials and methods

The experiment was conducted at Kawanda Agricultural research Institute (KARI)(00.25N, 32 32E, 1195m) in a protected roofed-in area. The site has two rainy seasons (March-May and September-November) with average precipitation of 1180mm per year. Average daily temperatures are 16°C minimum and 29°C maximum. Four to six months old suckers of Nakitengu (AAA-EA), an East African highland cooking banana cultivar were used, and were obtained from weevil infested banana plantations at Kawanda. The pseudostems of suckers were cut 15 cm above the collar before use.

Insect material

Weevils freshly collected from fields at Kawanda Agricultural Research Institute (KARI) using pseudostem traps (Mitchell, 1978) were used. Weevil sexes were determined according to Longoria (1968). Female weevils for use in the experiments were kept for three days in all cases on a non-laying substrate (old corm pieces). Each individual was used only once to avoid contamination.

Effect of paring on weevil eggs and nematode removal

Twenty unpared suckers were each placed in a bucket. Ten field-collected weevils (females) were introduced into each bucket and left for five days to oviposit. The buckets were tightly covered with perforated lids to prevent weevils from escaping. After five days, adult weevils were removed out of the buckets. Ten suckers were pared and the other 10 left unpared as control, after which they were replanted in buckets. After four weeks, the replanted suckers were uprooted and the weevil larvae (hatched from remaining eggs) searched out and counted.

To determine the effect of paring on nematode removal, 30 corms were collected from a nematode infested plantation at KARI. Care was taken to uproot them with their roots undetached. Ten corms were pared, another 10 had their roots removed but not pared while the other 10 suckers were left with the long roots. The corms were then planted in 30 litre buckets (a corm per bucket) half filled with sterilized soil (loam soil + cow manure +sand). Plants were placed in a protected roofed-in area and watered whenever necessary for three months to allow nematodes in the roots or corm to reproduce for at least two generations. After the three months, the plants were uprooted and assessed for nematode presence and damage. Data was recorded on live and dead roots, root necrosis, and number of different nematode species. By counting the live and dead roots (due to nematodes), the percentage of dead roots was calculated. Percentage root necrosis was calculated from five functional primary roots selected randomly and sliced longitudinally to expose the necrotic areas in the cortex (Speijer and De Waele, 1997). Nematodes were extracted from sub samples of 5 g macerated in a blender and incubated overnight (Hooper, 1990). They were identified, counted and recorded as number per 100g roots.

Weevil larvae reduction assessment

To determine the effect of chemical, hot or cold-water treatment of suckers on larvae reduction, unpared suckers were placed in buckets (one sucker per bucket) and inoculated with weevils. Ten field-collected weevils (females) were introduced into each bucket. The buckets were tightly covered with perforated lids to prevent weevils from escaping. After five days, adult weevils were removed from buckets and suckers were planted in buckets, and kept for 18 days for the eggs to hatch and develop to third instar larvae within corms. The suckers were then pared and subjected to cold water, hot water and chemical treatments. For cold-water treatment, pared suckers were immersed in cold water in a 30 litre basin for 48 hours at room temperature (25°C). Pared suckers were immersed in hot water maintained at 52-55°C for 20 minutes in a specially designed metal tank (Colbran, 1967) for hot water treatment. Water temperature was monitored with a thermometer at 5-minute intervals, while regulation of the gas flow controlled the rate of heating. The chemical treatment was tested by immersing suckers for 2 hours, in a solution made of 1.25 cc Dursban per litre of water, in a 30 litre plastic basin. This was a rate used by some banana farmers in Uganda (Pers. Comm.). Control suckers were pared but not treated. Each treatment was replicated 10 times.

The treated suckers were then replanted in buckets half filled with soil. They were watered, whenever necessary using a watering can, to maintain soil moisture. After two weeks of incubation (in a shade house), the suckers were uprooted and their corms dissected to expose larvae. Live larvae were counted and recorded. The percentage reduction in larvae due to treatments was obtained by comparing the mean larvae found in treated with control corms.

Application dosage and exposure time

To determine the effect of the dose and time of soaking in a chemical solution on larval reduction, pared suckers were each first placed in a bucket and weevils (10 females per corm) were introduced in the buckets to oviposit. Five days were allowed for oviposition, after which the suckers were planted in weevil free buckets filled with loam soil for the eggs to hatch and develop to third instar larvae within corms. After 18 days, the suckers were pared and soaked for 0.1, 0.3, 0.5, 1, 2, 3, 4, 6, 12 and 24 hours in a solution of Dursban at a rate of 1.25, 1.50, 5.00, and 6.00 cc per litre of water. Control suckers were not treated. Ten suckers were used for each treatment.

After applying treatments, the suckers were replanted in soil in buckets and kept in a protected roofed-in area for two weeks. The experiment was monitored daily to ensure that the soil is kept moist enough. Watering was done when necessary. After the two weeks, the corms were dissected to determine the effect of the treatments on the larvae survival in corms.

Re-using Dursban solution

Unpared suckers were placed in 10 litre buckets (one sucker per bucket) and 10 female were introduced to oviposit. Weevils were removed from buckets after 5 days and suckers replanted in buckets half full of loam soil. After 18 days (when larvae have developed to third instar) suckers were uprooted, pared and were soaked successively for one hour in the same solution of dursban (1.50cc Dursban to 1litre of water). In this trial, 15cc Dursban to 10litres of water, mixed in a 20-litre basin was used. There were five soaking lots each consisting of 10 corms. Larval survival was assessed by carefully dissecting corms two weeks after treatment application.

Data analysis

Data of the number of weevil larvae recovered from suckers exposed to different treatments, and on nematode and their damage on roots of pared and unpared banana suckers was subjected to analysis of variance (ANOVA). 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 mean number of larvae recovered from unpared control suckers was significantly higher as compared to the mean larvae recovered from pared suckers ($P<0.05$). Paring reduced weevil eggs from suckers by 95%. Similar results were reported by Gold *et al.*, (1998). The results suggest that paring alone does not completely eliminate eggs from suckers (5% of eggs remain), and therefore there is need for developing a method to obtain clean planting material. It is however necessary to encourage resource poor farmers in Uganda who cannot afford additional means of treating suckers to use pared suckers and reject suckers with damage symptoms.

The limitation here may be that farmers may find it impossible to reject infested suckers especially where planting material is scarce.

Paring was found to remove a large proportion of nematodes from infested suckers (Table 1). Effective elimination of nematodes was reported possible after hot water treatment of pared suckers for 20 minutes in hot water at 54° C (Speijer *et al.*, 1995). Farmers' use of hot water treatment has been however limited by the cost and equipment needed for the treatment (Jones and Milne, 1982). The data of this study suggests that where a farmer cannot afford hot treatment, paring could be used to obtain a clean banana planting material.

Results of the different treatments on larvae survival in corms are presented in table 2. Dursban treatment resulted in the lowest mean larval survival in suckers. Treatment of artificially weevil larvae infested suckers with Dursban and hot water treatments significantly reduced ($p<0.05$) weevil larvae compared to the control. According to the results, hot water treatment caused 67.9 % larval reduction in corms. The results suggest that the efficiency of this method is limited as it caused little mortality to larvae inside tunnels although it was reported to cause 100% weevil eggs mortality (Gold *et al.*, 1998). The number of larvae recovered in cold water treated suckers was not significantly different ($p>0.05$) from that recovered from the control suckers. Soaking of suckers in cold water for 48 hours appeared to have little effect on weevil larvae

Table 1: Mean number of nematodes (number/100g of roots) and their damage on roots of pared and unpared banana suckers

Treatment	Number of nematodes/100g roots		% root bases with lesions	%dead roots	%root necrosis
	Rodophilus similis	*Helicotylenchus multicinctus*			
Long roots	55.6±55.6	1220.0±866	1.2±0.7	19.2±6.6	2.2±1.4
Roots cut short	222.0±222.0	0.0±0.0	1.4±0.8	15.1±5.6	0.0±0.0
Pared suckers	0.0±0.0	0.0±0.0	0.0±0.0	2.7±1.2	0.0±0.0

Means of nematode counts and damage indices are of 10 replicates

Table 2: Number of weevil larvae recovered from suckers with different treatments

Treatment	Soaking time (hours)	Larvae recovered from suckers (n=10, ± S.E)	% larvae reduction
Control	-	13.4 ± 2.9	-
Cold water	48	8.5 ± 0.9	36.60
Dursban	2	0.5 ± 0.3	96.30
Hot water	0.3	4.3 ± 1.4	67.90

reduction in corms although some farmers in Uganda had reported effective (pers. comm.).

Results of the effect of using different Dursban doses and exposure times on larvae survival in corms are presented in table 3. Increasing the doses and soaking times of suckers in the solution increased larval reduction in corms although there was no significant difference ($p>0.05$) between the mean larvae recovered from corms of the soaking times and doses tested. There was no significant difference ($p>0.05$) in the mean number of larvae recovered from corms soaked successively in the same Dursban solution (Table 4). However, the mean numbers of larvae recovered from suckers of the different soaking lots were significantly different ($P<0.05$) from the control.

Soaking of pared suckers in a solution of Dursban solution has been considered as a possible alternative for cleaning infested planting material of both weevil eggs and larvae. There are reports that paring and then hot water treatment does not remove weevil larvae inside tunnels (Gold, 1998; Gold *et al.*, 1998). Therefore, soaking pared suckers in a Dursban solution (at a rate of 1.5 cc per litre of water) and soaking for 1 hour could be an appropriate method for cleaning suckers of weevils. The recommended rate is small and the chance of having the chemical accumulating in the plant and having future problems on yield is less likely. This rate is however higher than what is recommended by manufacturers for soil invertebrates and therefore weevil resistance is less likely to develop. The advantage here is that a given solution can be used to treat as many suckers as possible as the solution can be re-used until it cannot submerge suckers any more.

Table 3: Percentage* weevil larvae reduction in corms treated with dursban at different dosage levels and soaking times

Dose	Soaking time (hours)									
(cc/l of water)	0.1	0.3	0.5	1.0	2.0	3.0	4.0	6.0	12	24
1.25	80.8	82.5	81.2	90.5	91.7	94.4	95.2	91.6	91.9	99.5
1.50	84.5	87.2	91.2	93.7	94.1	95.2	95.5	95.7	96.5	99.8
1.75	85.4	88.0	92.7	-	-	-	-	-	98.3	98.4
2.00	89.8	94.2	-	-	-	-	-	-	99.3	99.5
5.00	93.3	97.8	9.2	93.5	96.0	96.4	99.1	-	-	-
6.00	92.5	95.1	93.3	98.2	97.7	95.2	98.6	-	-	-
8.00	93.3	96.9	96.4	98.2	-	-	-	-	-	-
10.00	94.6	98.8	98.4	97.5	-	-	-	-	-	-

*=Percentage larvae reduction from treated corms was calculated relative to larvae recovered from control corms

Table 4: Weevil larval reduction in corms treated with re-used solutions of Dursban

Soakin ground	Mean number of larvae recovered (n=10, ±SE)	% larva reduction
First	1.38 ± 0.3	93.3
Second	1.20 ± 0.3	94.1
Third	2.15 ± 0.5	89.5
Forth	1.70 ± 0.5	91.7
Fifth	1.17 ±0.2	94.3

* Percentage larvae reduction from treated corms was calculated relative to larvae recovered from control corms

The use of a clean planting material can retard initial weevil and nematode population development. Farmers can benefit if other sanitary measures in the plantation are properly done. This method however should not be seen as the only solution. It has to be integrated with other management practices for reducing weevil and nematode infestation.

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