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Investigation on the Use of Trapping in the Management of the Banana Weevil, *Cosmopolites Sordidus* (Germar) (Coleoptera: Curculionidae) in Mauritius

A Gokool*
Entomology Division
Agricultural Research and Extension Unit
Reduit
Email: ashvin_269@hotmail.com

D Abeeluck
Entomology Division
Agricultural Research and Extension Unit
Reduit
Email: entoareu@gmail.com

V Dooblad
Entomology Division
Agricultural Research and Extension Unit
Reduit
Email: entoareu@gmail.com

S Facknath
Faculty of Agriculture
University of Mairitius
Reduit
Email: sunif@uom.ac.mu

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Abstract

The banana weevil, *Cosmopolites sordidus* (Germar) is an important pest of banana in Mauritius. At present, control of *C. sordidus* is achieved by soil treatment with insecticides by growers. No research has been conducted to understand the pest abundance and develop alternative methods to better manage *C. sordidus* with minimum use of insecticides. In this 11-month study, the potential of two trap types (pseudostem and pheromone traps) to lure weevils in banana fields was determined at three different ecological sites (Clemencia, Nouvelle France and Rivière du Poste). The effect of treatment of pseudostem trap with insecticides (Imidachloprid, Cyfluthrin and Lambda-cyhalothrin) was evaluated under field condition. The damage level in fields at Clemencia and Rivière du Poste was also determined. The pseudostem and pheromone traps were effective in luring banana weevils. The average number of weevil caught per week in pseudostem and pheromone traps were 2.03 and 5.92 respectively. Relatively more adults were caught at Nouvelle France. This indicates that weevils were in higher numbers in the super humid site (Nouvelle France) compared to humid (Rivière du Poste) and dry (Clemencia) sites. Pseudostem treated with Imidachloprid was more effective than the other two insecticides. Damage by *C. sordidus* ranged from 15.5 % to 31 % at Clemencia and Rivière du Poste. Pseudostem and pheromone traps can be used for monitoring and mass trapping of *C. sordidus*. A better weevil management can be easily achieved by the use of either pseudostem or pheromone traps and proper timing of soil drenching. This will, no doubt greatly reduce insecticide application in banana field.

Keywords: Banana, Cosmopolites sordidus, pseudostem and pheromone traps, insecticides, mass trapping

**For correspondences and reprints*

1. **INTRODUCTION**

Banana (Musaceae: *Musa* sp.) is an important fruit crop grown on about 520 ha in Mauritius with an annual production of about 12,000 T (Anon, 2007). Its production system ranges from backyards to low input stands on small scales to intensively managed plantations. Six varieties (Dwarf Cavendish, Williams, Ollier, Gingeli types, Mamoul and Mamzelle) are grown throughout the year mainly in the South and East.

The banana weevil, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) is an important pest of banana (Moutia, 1930; Graaf, 2006; Dahlquist, 2008). Its larvae tunnel into corms of plants and feed on them. Such damage over several crop cycles can prolong maturation rates and reduce banana yield up to 60% (Abera et al., 2000). Severely attacked plants can topple over by bunch weight or slightest wind. Furthermore, corm damage encourages bacterial infection that becomes severe when plants are weakened during drought or other adverse climatic conditions. The perennial cropping of banana and coupled with planting of infested material, readily supports the pest survival strategies, resulting in pest build-up and crop losses (Karamura and Gold, 2000). Damage in ratoon crops is usually greater than that in new ones (Abera et al., 1999).

Control of *C. sordidus* is effected by soil drenching with persistent chemical products (e.g., chloropyrifos-ethyl) at critical periods when plants are heavily damaged. Besides, the biological characteristics of *C. sordidus* render chemical control difficult and even ineffective. *C. sordidus* has shown high probability of resistance problem to many chemical insecticides (Gold, C. S., 1998; Gold et al., 1999; Musabyimana et al., 2001). Such insecticides can also decimate non-target soil organisms and can be harmful to the environment and human health. No research has been conducted on the biology of *C. sordidus* and even no attempt has been made to search for alternatives of control. Semiochemical trapping and the use of the aggregation pheromone in traps have proved effective for monitoring and control of *C. sordidus* (Tinzaara et al., 2002; Budenberg et al., 1991; Graaf et al., 2005).

The government, in its proposed non-sugar strategic plan (2003-2007), promotes the concept of sustainable agriculture and integrated pest management (IPM) to reduce pesticide use in food crop production. This study is aimed at the development of an appropriate trapping system that could be eventually used in a banana weevil management programme. It consisted of the evaluation of the efficacy of two types of traps for trapping weevils in banana plantain.

2. MATERIALS AND METHODS

2.1 Study sites

Banana fields were first inspected to confirm presence of *C. sordidus* by damage symptoms and 13 fields (var. Cavendish subgroup) were selected from the South (3 at Nouvelle France and 4 at Rivière du Poste) and East (6 at Clemencia). The plantations were fourth ratoon crops and rainfed. Experimental fields (0.52 acre each) were five km from one another and each had about 450 plants. All fields were managed by growers and no insecticides were used during the study.

2.2 Evaluation of the efficacy of pheromone and pseudostem traps

2.2.1 Source of traps

Two types of traps were used: (1) pheromone baited traps, and (2) locally prepared pseudostem traps.

The pheromone baited trap was purchased from Pherobank (Plant Research International, Wageningen, The Netherlands). It consisted of a pitfall trap with two yellow buckets of 20 cm in height and 15 cm rim diameter and a commercially available aggregation pheromone, Cosmolure that contained sordidin. The second trap was prepared with freshly cut pseudostems. A cut pseudostem (about 40-45 cm in length) was split lengthwise down the middle into two halves. The two halves were placed (with the cut surface ventrally) on opposite sides of the mat and regarded as one trap.

2.2.2 Placement of traps in banana field

The two traps were placed in two fields at a site. Two pheromone traps (recommended rate–2/acre) were placed in the first field. The buckets of these pheromone traps were buried 15 cm in the soil with their opening at ground level and the dispenser was slightly unscrewed for a gradual release of the pheromone. Every month, traps were moved 20 m along the same line and direction to cover the whole field. The pheromone dispenser was changed every three months. Seven pseudostem traps (recommended rate–25/acre) were placed in the second field in a randomised block design and were replaced by new ones every week. Traps were checked every seven days for 11 months during winter and summer. Trapped weevils were collected and killed in laboratory. The experiment was replicated twice at selected sites in the East (Clemencia) and South (Nouvelle France and Rivière du Poste).

2.3 Evaluation of the efficacy of insecticide treated pseudostem traps

The cut surfaces of 12 pseudostem traps were treated with three insecticides: Confidor 200 SL (imidachloprid) at 2 ml/L, Baythroid 50 EC (cyfluthrin) at 0.5 ml/L and Karaté 5 CS (lambda-cyhalothrin) at 0.5 ml/L with a hand sprayer. The treated traps (4/each insecticide treatment) were placed in a field in a randomised block design. The traps were serviced and weevils counted as method described above. The trials were replicated in fields at Nouvelle France (n=1), Rivière du Poste (n=2) and Clemencia (n=2) from July 2006 to September 2006.

2.4 Damage Assessment
Corm damage was assessed in fields at Clemencia and Rivière du Poste as per Vilardebo's method (Kéhé et al, 2002). The Coefficient of Infestation (CI) was determined by paring the corms of ten recently harvested plants at ground level and scoring the proportion of the rhizome circumference with weevil galleries. The percentage damage was scored at 10 % intervals, using a transparent circular grid divided in 36 ^{0} sections. Damage of 1-3 % was considered as minor, 4-9 % as moderate and more than 10 % as heavy (Gold et al., 1997).

Monthly data on rainfall, temperature and relative humidity at the three locations were obtained from the Meteological Services, Vacoas.

2.5 Data Analysis
The trap catches were Log (X+1) transformed to stabilise variances. A general linear model was first used to determine effects on locations, months, trap types and interactions between months/trap type, location/trap type and months/trap type/locations. One-way Analysis of variance (ANOVA) was used to quantify differences between treatment and locations at 5 % level of significance. The Fisher's Least Significant Difference was used to compare means of treatments. The two sample t- Test analysis was used to compare between trap types in general as well as on monthly basis. The Statistical Analysis System (SAS) Enterprise Guide 3.0 software and Microsoft Excel programs were used for analysis.

3. RESULTS

3.1 Evaluation of the efficacy of pheromone and pseudostem traps
During the 11-month study, 2855 weevils were collected in both traps in the field and highest catches were recorded in the pheromone traps. Pheromone traps attracted banana weevils only whereas pseudostem traps attracted other insects as well.

One thousand one hundred and seventy nine weevils were caught in eight pheromone traps set in fields at Clemencia, Nouvelle France and Rivière du Poste during the whole study. The average number of weevils caught per trap/week at Clemencia, Nouvelle France and Rivière du Poste was 4.53 (± 0.48), 8.31 (± 1.54) and 4.95 (± 0.55) respectively. There was no significant difference in numbers caught at the three different locations ($F_{2, 220}$ = 1.93, P = 0.148).

One thousand six hundred and seventy six weevils were collected from 3510 pseudostem traps from the four fields at the three sites. The total number of weevils caught at Clemencia (in 2 fields), Nouvelle France (in 1 field) and Rivière du Poste (in 1 field) was 773, 395 and 508 respectively. The average number of weevils per trap/week at Clemencia, Nouvelle France and Rivière du Poste was 1.69 (± 0.09), 2.45 (± 0.25) and 1.93 (± 0.15) respectively. However, catches among sites differed significantly ($F_{2, 878}$ = 3.09, P = 0.046) and highest being at Nouvelle France.

There was significant interaction between trap type and month ($F_{10, 1064} = 4.12$, $P < 0.0001$), suggesting that difference in catches between the traps varied on monthly basis. In general, the pheromone trap captured significantly higher number of weevils than pseudostem trap at all sites. But the level of significance in differences in their number in the two traps varied in relation to month at the three locations. Generally, differences between traps increased during those periods when catches were highest.

At Clemencia, weevil catches (4.53 $\pm$ 0.48/trap) in pheromone traps were significantly higher than those (1.70 $\pm$ 0.09/trap) in pseudostem traps ($t_{562} = 6.75$, $P < 0.0001$). Catches in pheromone traps were highest in August 2006 (8.05 ± 1.56), July 2006 (6 ± 1.73), September 2006 (5.33 ± 1.09) and December 2006 (5.13 ± 0.89) but low (1.1 ± 0.67) in February 2006. No weevil was caught in March 2007. The average number of weevils per pseudostem trap ranged from 0.86 (± 0.15) to 2.19 (± 0.32).

At Nouvelle France, the average number of weevils per pheromone and pseudostem trap was 8.31 (± 1.54) and 2.45 (± 0.25) respectively and highest being in the former ($t_{198} = 4.35$, $P < 0.0001$). The average number of weevils per pheromone trap was highest in August (15.67 ± 1.47), and November 2006 (9.63 ± 0.87) and in May (6.14 ± 2.08) and June 2007 (15 ± 2.00) and was lowest in December 2006 (3.75 ± 0.85) and March 2007 (1.00 ± 0.64). The average number of weevils caught per pseudostem trap was comparatively lower and ranged from 1.23 (± 0.21) to 3.96 (± 0.95).

At Rivière du Poste, the average number of weevils per pheromone and pseudostem trap/week was 4.95 (± 0.55) and 1.93 (± 0.15) respectively. Catches in pheromone traps were significantly higher ($t_{334} = 7.12$, $P < 0.0001$). Catches in pheromone trap were highest in August 2006 (9.13 ± 3.13) and December 2006 (8.11 ± 1.59). The average numbers of weevils per pseudostem trap ranged from 1.03 (± 0.24) to 3.64 (± 0.65).

Pheromone trap catches were generally negatively correlated with temperature, rainfall and relative humidity at the three sites. However, it was positively correlated with relative humidity at Nouvelle France only. Catches in pseudostem traps were weakly positively correlated with the three agrometeorological parameters (Table1).

Site: Nouvelle France			
Trap type	Temperature	Rainfall	Relative humidity
Pheromone	r= -0.26	r= -0.01	r= 0.52
Pseudostem	r= 0.28	r= 0.34	r= 0.08
Site: Rivière du Poste			
Pheromone	r= -0.75	r= -0.52	-
Pseudostem	r= 0.44	r= 0.4	-
Site: Clemencia			
Pheromone	r= -0.62	r= -0.54	r= -0.72
Pseudostem	r= 0.44	r= 0.25	r= 0.38

Table 1: Correlation between trap catches and agrometerological parameters

3.2 Evaluation of the efficacy of pseudostem traps treated with insecticides

At Clemencia and Rivière du Poste, pseudostem traps treated with Confidor caught significantly highest number of weevils ($F_{2,191} = 42.35$, $P < 0.0001$; $F_{2,59} = 6.91$, $P = 0.0020$) among treatments. An average of 2.0 (± 0.29) and 1.05 (± 0.31) weevils was caught per trap in Confidor treated traps at Clemencia and Rivière du Poste respectively (Figure 1). At Nouvelle France, there was no significant difference among treatments ($F_{2,59} = 1.83$, $P = 0.17$). Baythroid was ineffective at the three locations.

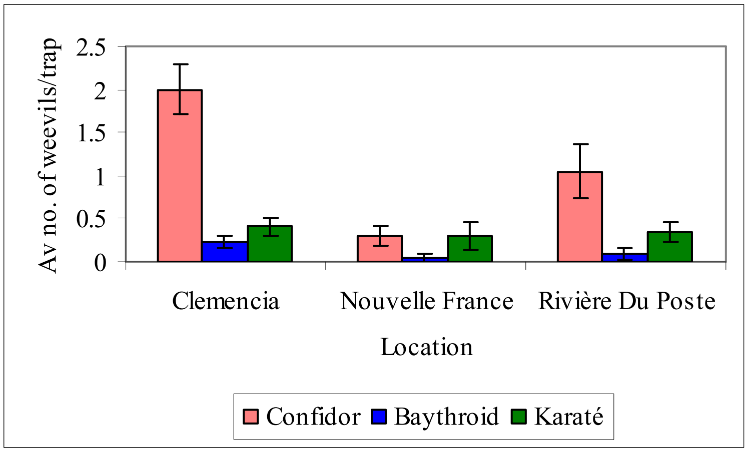

Figure 1: The average number of weevils caught weekly in pseudostem traps treated with insecticides at different locations. (Values represent ± SE)

3.3 Damage Assessment

The mean percentage damage at Clemencia was 15.5 % in July 2006 and increased to 37.75 % in June 2007. At Rivière du Poste, the mean percentage damage was 31 % in July 2006 and decreased to 25 % in June 2007.

4. DISCUSSION

In this study, pseudostem and pheromone traps were found attractive to *C. sordidus* in banana fields. The pheromone trap was more effective and similar results were obtained by Graaf at al. (2005) in South Africa. In Costa Rica, traps baited with the aggregation pheromone (cosmolure +) were found to be 5-10 times more effective than the conventional pseudostem traps (Tinzaara et al., 1998). In Uganda, up to 18 times as many weevils per day as pseudostem traps in field heavily infested with *C. sordidus* was caught in pheromone-baited traps (Tinzaara et al., 2002).

There had been variations in trap catches among sites. This is shown by the higher catches of weevils at Nouvelle France and lower at Rivière du Poste and Clemencia. This could be probably due to variation in levels of weevil infestation in banana fields as a result of different climatic conditions at study sites.

The topography (400-600 m above sea level) and the weather condition (high rainfall and humidity) at Nouvelle France could have favoured population build up of *C. sordidus*. Clemencia has dry climatic conditions and hence, may have not been suitable for the development of *C. sordidus*. Differences in environmental conditions (particularly temperature) affect the developmental periods of *C. sordidus* (Gold, 1998). A relationship between climatic factors (rainfall, relative humidity and temperature) and pseudostem trap catches of *C. sordidus* was reported by Tinzaara et al. (2005). In this study, a consistent relationship between pheromone trap catches and relative humidity was not observed. Catches from pseudostem traps were also not related to relative humidity.

Although weevils are reported to be active in moist conditions (Gold et al., 2001), the systematic negative correlation of rainfall with catches from pheromone traps at the three locations could be probably due to pheromone dissemination being hampered during rainy seasons (Tinzaara et al., 2005). On the other hand, temperature is reported to increase the dissemination rate of the pheromone and insect activity (Tinzaara et al., 2002) and therefore a positive relationship with weevil catches was expected. However, in this study, catches from pheromone traps were negatively correlated with temperature at the three locations.

In contrast, catches from pseudostem traps were positively correlated with temperature at the three locations. This could be possibly due to greater emanation of volatiles from split pseudostems, or weevils seeking refuge under pseudostem traps where conditions are moist to escape high temperatures. But, these cut pseudostem traps become less effective when they desiccate during prolonged dry conditions. Low catches in pseudostem traps could be explained by the fact that freshly cut pseudostem being most attractive within the first 24 hours of trap placement (Price, 1991). Similarly, Karamura and Gold (2000) reported that leaving pseudostem traps for seven days before examination being a great compromise that leads to lower trap catches. Ogenga-Latigo and Bakyalire (1993) mentioned that increases in percentage trap occupancy and number of weevils caught can be obtained by wetting the mat before setting traps during dry season.

The inconsistency of trap catches with agrometerological parameters points out that a number of other factors may influence the effectiveness of both traps in the study. These include trap location and placement, residue management, cropping systems, immigration from neighbouring farms and distance of weevils to traps.

The use of pseudostem traps is more appropriate for local farmers but is labour intensive. Pseudostem traps captures are more or less constant during both seasons (summer and winter) compared to pheromone traps. Therefore, it can be used throughout the year as per availability of harvested plants. A major drawback is that pseudostems are not readily easily available for use in small farms (0.25-0.5 ha).

Pheromone traps were more effective than pseudostem traps but also more expensive. The trapping system with the pheromone costs around $ 26 per unit. It has to be imported and stored and these add to the cost of banana production. On the other hand, pheromone trapping as a control method does not require labour and trap servicing is done on a monthly basis.

Caught weevils can be killed by treating pseudostem traps with insecticides. Mortality in caught weevils in traps treated with imidachloprid (systemic in action) was comparatively highest. Weevils normally feed on pseudostems (Budenberg and Ndiege, 1991) and their feeding on treated traps could have caused this high rate of mortality. Lower mortality was observed in weevils caught in traps treated with lambda-cyhalothrin and cyfluthrinm. Also, lambda-cyhalothrin and cyfluthrin may have repelling effects on weevils. This is in contrast with results obtained by Graaf et al. (2005) in South Africa who reported that cyfluthrin caused a high rate of mortality. Another explanation to low weevil catches in treated pseudostem traps can be that the weevils after contact with insecticides die away from traps.

Treated pseudostem traps do not require regular monitoring to remove caught weevils. If females do oviposit in treated traps, it is most probable that eggs will not develop.

5. CONCLUSIONS AND RECOMMENDATIONS

The study showed that a trapping sytem can be developed for the management of *C. sordidus* in banana fields in Mauritius. The pseudostem and pheromone traps were effective in luring weevils. Damage by weevils is within the corm of the plant and is difficult to detect infestation at early stage. These trapping methods can be used to monitor weevil population and as a method for its control.

The traps will further assist in reducing weevil numbers in fields. The slow rate of reproduction coupled with a long adult life suggests that trapping can be used to reduce pest population below economic threshold. It is important to point out that Imidachloprid provides good control but are very expensive.

Mass trapping can thus be used to reduce weevil population and hence, reducing damage by *C. sordidus* on banana plants to obtain better yield and good quality bananas. By combining both pheromone and pseudostem traps, it is possible that good control could be achieved using mass trapping. Alternatively, the traps could be used for the selective application of insecticide (Imidachloprid).

A broad integrated pest management strategy is necessary where trapping is an important component along with other control methods. Therefore, further investigation is needed on the combined effect of pseudostem and pheromone traps against *C. sordidus* and the economics and sustainability of trapping system

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