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# Performance of three trap types for monitoring plantain weevil (*Cosmopolitis sordidus,* Germar) in plantain cropping systems in Ghana

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***Abstract :*** *Studies were carried out to compare the performance of a commercially available synthetic male produced aggregation pheromone of the plantain weevil (Cosmopolites sordidus, Germar) and the traditional methods of monitoring, using corm and pseudostem traps in a 2 year old cocoa-plantain intercrop management system. Trap effectiveness was conducted in the field in three seasons (major rainy season, minor rainy season and dry season) from June 2012 to February 2013. The results indicate that all the treatments attracted more insects compared with the control (only pitfall trap). Pheromone traps attracted significantly more adult weevils (68.36%) compared with corm traps (18.13%), and pseudostem traps (13.51%). More females than males were captured in all three trials in the ratio of 2:1, with pheromone traps attracting the highest number of females followed by corm traps and pseudostem traps. Findings in this study suggest that pheromone of the plantain weevil could offer an effective means of monitoring and managing the population of the plantain weevil in Ghana.*
***Keywords:*** *Cosmopolites sordidus, Semiochemicals, aggregation pheromone, pseudostem and corm*

## I. INTRODUCTION

The plantain weevil, *Cosmopolites sordidus,* Germar (Coleoptera: Curculionidae) a native of Malaysia and Indonesia is one of the most important pests of bananas and plantains in Ghana [1, 2] and throughout the tropical regions where the crop is grown [3]. Yield loss due to plantain weevils alone during the first year of cropping has been reported in Ghana to be about 34.8% [2]. The adult weevils are free living and most often associated with banana mats and cut residues. They are attracted to their hosts by volatiles, especially following damage to the plant corm. Males produce an aggregation pheromone that is attractive to both sexes. Eggs are laid in the corm or lower pseudostem. The immature stages are all passed within the host plant, mostly in the corm [3].

Adult plantain weevils are attracted by the volatiles released by the plantain plants [4]. Infestation of the weevil normally starts in 5-month-old plants. Early symptoms of the infestation are the presence of small pinhead-sized holes on the stem, fibrous extrusions from bases of leaf petioles, and exudation of a gummy substance from the holes on the pseudostem. During the advance stages of infestation, the stem, when split open, exhibits extensive tunneling both in the leaf sheath and in the true stem [3].

Measures to curb plantain weevil damage vary widely depending upon the type of plantain production systems practiced [5]. Large plantations resort to regular application of chemical insecticides such as pirimiphos-ethyl, chlorpyrifos to control the weevil. Resource-limited small-holder farmers cultivating plantains and bananas as a subsistence crop are unable to undertake chemical pesticide interventions due to cost and availability of pesticides. In this situation, cultural control strategies such as clean planting material, crop sanitation (especially destruction of residues), agronomic methods to improve plant vigour and tolerance to weevil attack and, possibly trapping become more important due to their ease of application and their compatibility with other methods of control. Natural enemies including arthropods, entomopathogenic nematodes and entomopathogens have great potential to reduce the population of the weevils in severely infested gardens but these have not been exploited fully [3]. Field sanitation is imperative in the control of this pest. Suckers should be pruned periodically and infested pseudostems must be removed from the field and destroyed. Banana stumps kept in the field after harvest must be removed and destroyed as they serve as weevil refuges and breeding [6]. Investigations made at the National Research Centre for Banana (NRCB) in India have indicated that traps could be efficiently used to monitor and reduce the adult weevil population [7].

The use of semiochemicals to trap the weevil has also been in use since the early twentieth century and retained in modern recommendations for monitoring and control [8]. Historically, semiochemical trapping of the plantain weevil was mainly based on chemicals emitted by the host plant (kairomones) [9, 10]. These traps are still used today and are developed from residual pseudostems and rhizomes of the plantain plant [3].

The male aggregation pheromone of C. sordidus has since been isolated, synthesized and even field-tested [11], [12]. This synthetic pheromone, named sordidin or Cosmolure+ (depending on manufacturers), have been found to be successful in mass trappings;capturing18 times more weevils than the conventional pseudostem traps in Uganda [11]; although [12] highlighted a range of 2½ to 8-fold increases under different conditions Several factors such as the pest biology, pheromone efficacy, trap parameters, cropping system and environmental factors were found to variously influence the effectiveness of the pheromone-baited traps. In Ghana, split pseudostem traps are used exclusively and the effectiveness of pheromone traps is unknown. Traps manufactured from different plant clones show great variation in weevil capture, although reports are inconsistent [3]. Pseudostem [7, 13] and rhizomes [14] have been claimed to be the most effective trapping material. Fresh [15] or decayed [16] material may attract the most weevils. However, further evaluation of pheromones in small-holder production systems and under different ecological conditions is needed [17].

The objective of this study was to investigate the performance of a commercially available male aggregation pheromone and traditional traps in plantain production systems in Ghana. The ultimate goal of the work is to develop a management system for plantain production in the forest ecological zone in Ghana.

## II. MATERIALS AND METHODS

### *1.1. Study location and site description*

The study was carried out at the Forest and Horticultural Crops Research Center (FOHCREC), Kade of the University of Ghana.The Centre is located (06º 09' 26N; 000º 55' 00W) in the forest transition ecological zone which is characterized by humid climate associated with a bimodal rainfall pattern with peaks in June and October with a short break in August and a dry season from December to March. This provides the appropriate environmental conditions for many plantain cultivars to do well in this region (wet seasons and a dry spell with average elevation of 150 m). The mean annual temperature range at this location is 24-38°C. Relative humidity is around 70-80% in most part of the year.

### *1.2. Experimental field*

The 10 ha field used for the study was established in May 2011 on a cocoa plot under rehabilitation. The field comprised of cocoa as the main crop and plantains grown in it to serve as temporary shade for the young cocoa seedlings. The plantains were planted at a spacing of 3 x 3 m. The most common cultivars were *Apantu pa* (False horn plantain) and *Apem* (French plantain). Manual weeding using cutlass was done along the rows and when necessary hand irrigation using watering can was carried out during the dry season. The cocoa seedlings were mulched at the base with rice husk to conserve soil moisture.

### *1.3. Treatments and Experimental Design*

In this cocoa-plantain intercrop field, we evaluated the performance of plantain corm, pseudostem and pheromone traps. The experiments were conducted during the 2012-2013 major (June to July), minor (August to October), and dry (December to February) seasons. In each season, the following treatments were evaluated: 1) corm, 2) pheromone (Cosmolure®), 3) pseudostem and 4) pitfall (control). Pheromone and pitfall traps were made from 8-liter transparent plastic buckets (24 cm height, 22 cm rim diameter) purchased from a local market in Accra. The design followed that of [18]. Two cut windows of 10 × 10 cm were made at opposite sides of the bucket at a height of 10 cm from the bottom, to allow adult *C. sordidus* to enter the traps. The plastic buckets were then filled with liquid detergent solution (for both control and pheromone traps) and buried such that the cut sides were leveled with the soil surface to ensure easy access by the weevil into the trap. In each pheromone trap, a single pheromone was suspended by a metal wire string in the center to reach the cut windows from the top end of the trap. The pheromones obtained from ChemTica International, San Jose, Costa Rica were shipped in closed polythene bags delivered through courier services and it was stored in a freezer until use. Pheromones were replaced monthly and the liquid detergent changed at every sampling day. Pitfall traps (control) were also placed 30 cm away from the central mat of the plot and buried 10 cm so that the cut windows flush against the soil. Traps were separated by 21 m in order to minimize treatment interference. Pseudostem plant materials were selected from freshly harvested plantain plants of not more than one week. Only one trap was prepared from each plant and pseudostems with internal necrosis/damage/tunnels were discarded. Pseudostem traps were 30 cm in length (obtained from 30-60 cm above the collar), bisected longitudinally and each half placed ventrally and directed next to the mat of the plant [19]. Corm disk traps (selected from the widest part of the corm) were prepared from the same plants used for the pseudostem traps. Corms with internal damage/necrosis/tunnels were discarded. Each corm had an average circumference of at least 60 cm and cut to a thickness of 5 cm. The pseudostem and corm traps were replaced every two weeks. The field was laid out in a randomized complete block design with four replicates. Each plot measured 144 $m^2$: 5 rows of 5 plantain mats (25 plants) planted at 3

× 3 m spacing. Treatments were arranged in a randomized complete block design. Plots within a block were separated by 9 m and distance between blocks was 18 m.

### *1.4. Sampling and data collection*

During each sampling the number of adult weevils found in each trap was collected, and recorded. Also, the maximum and minimum temperatures, relative humidity and dew point in every individual treatment were recorded using a thermohygrometer. At the end of every week the data on weather conditions was averaged as the weekly total. The sampled *C. sordidus* (target) and other insects (non-target) were put in vials containing 70% alcohol for preservation until sex determination. Treatments were sampled every third and seventh day of the week [20] for twelve weeks for all the trials (major rainy season, minor rainy season and dry season). Trap inspection commenced at 0600 GMT. Weevils captured were counted, sexed [21, 22] and recorded.

## III. Statistical Analysis

Data for each season was analyzed and presented separately. Trap capture data were not normally distributed and thus were transformed using the square root transformation method ($y=\sqrt{x}+0.5$). The data were first analyzed using standard least square (JMPIN version 10.0, SAS Institute 2010) to determine the effect of treatment, weeks and week*treatment interaction. Because the week*treatment interaction was not significant the data was pooled and analyzed using one-way ANOVA. Seasonal mean trap captures were analysed with ANOVA followed by Tukey-Kramer honestly significant difference (HSD) test to determine significant effects of treatments and blocks.

## IV. Results

### *1.5. Trap performance in the major rainy season*

The standard least square ANOVA showed that there was no significant differences among the sampling weeks ($F= 0.57$; d.f= 11, 144; $P= 0.8517$) and week*treatment interaction ($F= 0.45$; d.f= 33, 144; $P= 0.9956$), however a significant difference existed among the treatments for total number of weevils attracted ($F= 39.13$; d.f= 3, 185; $P<0.0001$). The pheromone-baited traps attracted significantly more weevils than the corm traps, pseudostem traps and pitfall traps; however the other traps were not significantly different from each other.

### *1.6. Trap performance in the minor rainy season*

The standard least square ANOVA showed no significant difference among the weeks ($F= 0.72$, d.f= 11, 144; $P= 0.7198$) and the week*treatment interaction ($F= 0.73$; d.f= 33, 144; $P= 0.8505$). Because there was no significant interaction between sampling date and treatments, the data were pooled and analyzed using one way ANOVA. The result showed a significant difference among the treatments for total number of weevils attracted ($F= 20.58$; d.f= 3, 185; $P<0.0001$). The pheromone-baited traps attracted significantly more weevils than the corm traps, pseudostem traps and pitfall traps

### *1.7. Trap performance in the dry season*

During the dry season the standard least square ANOVA showed that there were no significant differences among the catches in the various weeks ($F= 0.94$; d.f= 11, 144; $P= 0.5068$) and the week*treatment interaction ($F=0.99$; d.f= 33, 144; $P= 0.4939$), however the result showed a significant difference among the treatments for the total number of weevils attracted ($F= 53.58$; d.f= 3, 185; $P<0.0001$). The pheromone-baited traps attracted significantly more weevils than the corm traps, pseudostem traps and pitfall traps.

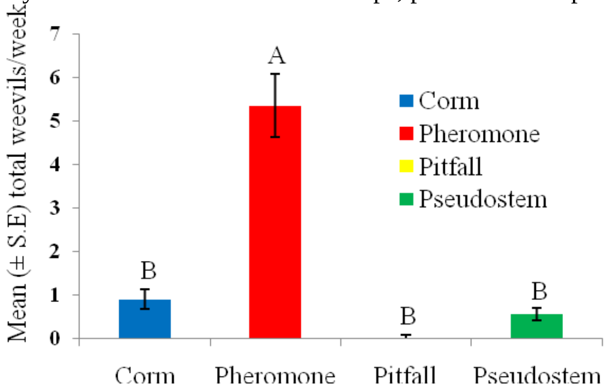


Figure 1: The mean (± S.E) total weevils/week attracted by different traps from June-Aug 2012 (major rainy season). Levels not connected by same letter are significantly different at 5% level.

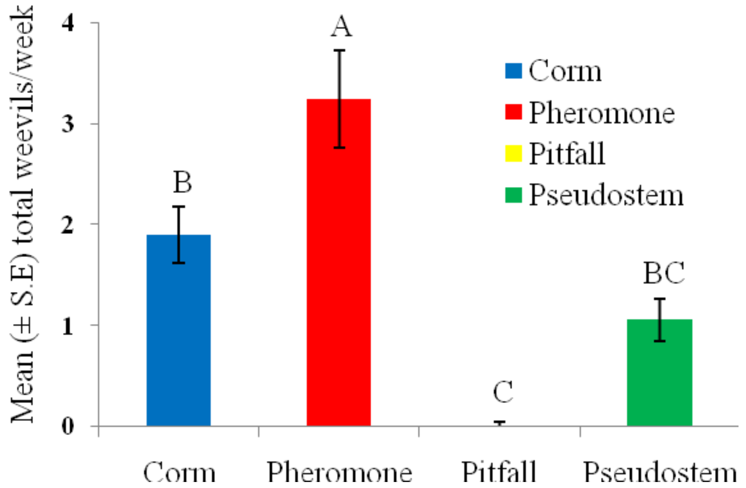


Figure 2: The mean (± S.E) total weevils/week attracted by different traps from Sept-Nov 2012 (Minor rainy season). Levels not connected by same letter are significantly different at 5% level.

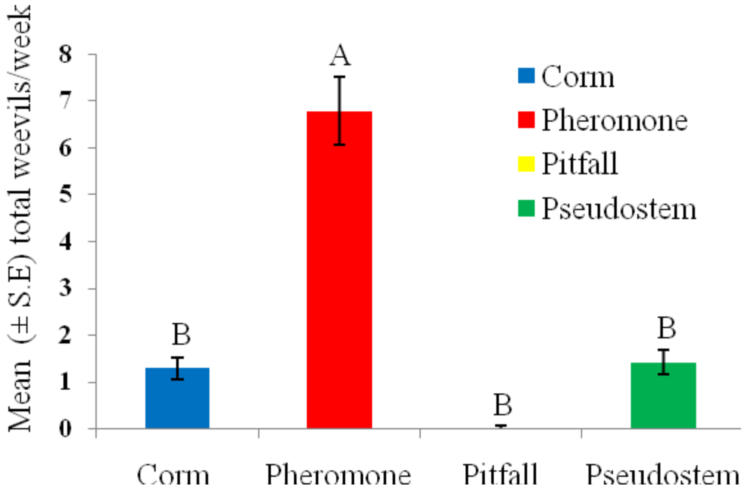


Figure 3: The mean (± S.E) total weevils/week attracted by different traps from Dec-Feb 2013 trial (dry season). Levels not connected by same letter are significantly different at 5% level.

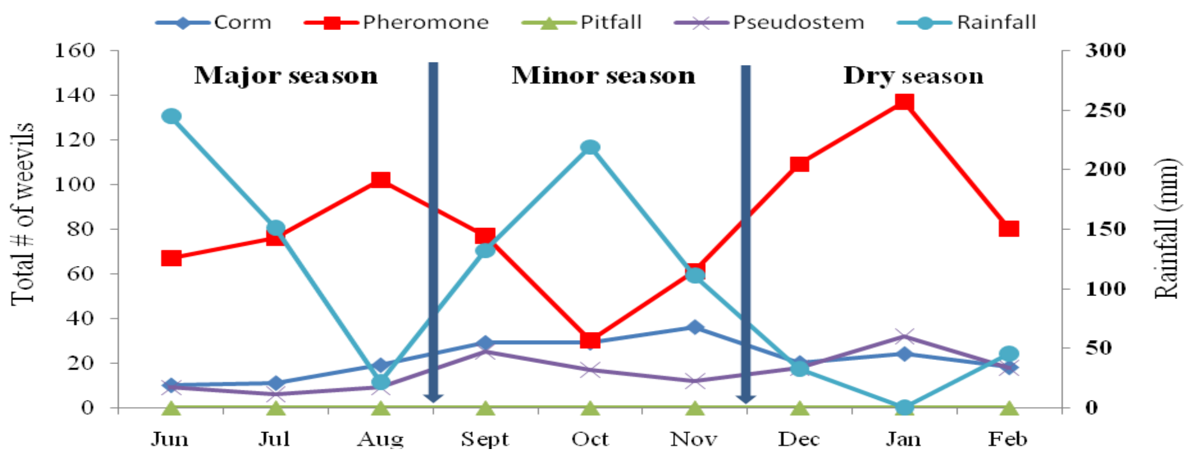


Figure 4: plot of treatment catches in the major rainy season (June-August, 2012), minor rainy season (September-November 2012) and dry season (December 2012-February 2013) in relation to rainfall patterns.

### *1.8. Sex ratio determination of C. Sordidus from the different traps*

The major rainy season showed a significant difference among the treatments in the total number of female (F= 34.94; d.f= 3, 185; P<0.0001) and male (F= 12.25; d.f= 3, 185; P<0.0001) weevils attracted. Pheromone-baited traps attracted significantly more females than corm traps (P<0.0001), pitfall traps (P<0.0001) and pseudostem traps (P<0.0001). Pheromone-baited traps attracted a mean female weevil of 4.02 ± 0.61, corm traps attracted a mean of 0.52 ± 0.13 and pseudostem traps attracted a mean of 0.31 ± 0.09 (Table: 1).

The minor rainy season showed a significant difference among the treatments in respect of total number of female (F= 20.07; d.f= 3, 185; P<.0001) and male (F= 11.20; d.f= 3, 185; P<.0001) weevils attracted. Pheromone traps attracted significantly more females than corm (P<.0001), pitfall (P<.0001) and pseudostem (P<.0001). Pheromone traps significantly were more effective attracting a mean total of 2.29 ± 0.36 compared to 1.10 ± 0.19, 0.56 ± 0.14 and 0.00 ± 0.03 by corm, pseudostem and pitfall respectively (Table: 1).

The dry season showed a significant difference among the treatments in the total number of female (F= 54.32; d.f= 3, 185; P<.0001) and male (F= 21.38; d.f= 3, 185; P<.0001) weevils attracted. Pheromone traps attracted significantly more females than corm (P<.0001), pitfall (P<.0001), and pseudostem (P<.0001). Pheromone traps were significantly more effective, attracting a mean total weevil of 4.83 ± 0.54 female compared to 0.73 ± 0.15, 0.81 ± 0.18 and 0.00 ± 0.06 by corm, pseudostem and pitfall respectively (Table: 1).

Table 1: Mean (± S.E) female and male weevils/week attracted by different traps from June 2012 to February 2013. Levels not connected by same letter in the same column are significantly different at 5% level.

| | Major rainy season | | Minor rainy season | | Dry season | |
|---|---|---|---|---|---|---|
| | *C. sordidus* mean ± s.e | | *C. sordidus* mean ± s.e | | *C. sordidus* mean ± s.e | |
| Treatments | Males | Females | Males | Females | Males | Females |
| Pheromone | 1.33 ± 0.29 **a** | 4.02 ± 0.61 **a** | 0.95 ± 0.17 **a** | 2.29 ± 0.36 **a** | 1.95 ± 0.29 **a** | 4.83 ± 0.54 **a** |
| Corm | 0.37 ± 0.12 **b** | 0.52 ± 0.13 **b** | 0.79 ± 0.13 **a** | 1.10 ± 0.19 **b** | 0.56 ± 0.14 **b** | 0.73 ± 0.15 **b** |
| Pseudostem | 0.25 ± 0.07 **b** | 0.31 ± 0.09 **b** | 0.50 ± 0.11 **a** | 0.56 ± 0.14 **bc** | 0.60 ± 0.14 **b** | 0.81 ± 0.18 **b** |
| Pitfall (Control) | 0.00 ± 0.03 **b** | 0.00 ± 0.06 **b** | 0.00 ± 0.02 **b** | 0.00 ± 0.03 **c** | 0.00 ± 0.02 **b** | 0.00 ± 0.05 **b** |

## V. Discussion

The results from the trial indicated that pheromone-baited traps were most effective in trapping the *C. sordidus* (Fig. 1, 2, 3) in all the seasons. This confirms work done by [23] in Costa Rica, [24] in Uganda and [25] in South Africa, in which the aggregation pheromone was more effective than pseudostem traps. In this study pheromone-baited traps were also more effective in the dry season (December 2012-February 2013) than in the major rainy (June-August 2012) and the minor rainy seasons (September- November 2012) (Fig. 4). This might be due to the strong winds associated with rains, sloppy nature of the study area and weather conditions in the different seasons. Toppled or snapped plants emitted volatiles (kairomones) into the field which might have interfered with the pheromone-baited trap volatiles thereby limiting their attractiveness. The sloppy nature of the study field introduced run-off during heavy rainfall and this destroyed trap entry windows that makes it difficult for the plantain weevils to enter the pheromone-baited traps and pitfall traps (control). In the tropics, conditions are drier in the dry season and this supports the volatility and diffusion of the pheromone thereby increasing trapping efficiency in the field.

Pseudostem traps were also more effective in the dry season (December 2012-February 2013) than in the wet season (June-November 2012) (Fig. 4). This was because pseudostem traps were observed to ferment towards the second week of trapping due to the dry weather and this fermentation increased the spectrum of odorants that were significantly different from those released by healthy plants [26]. This could also be due to the fact that the plantain weevil was susceptible to desiccation and would prefer hiding under newly cut or fermented plant materials with wet surfaces than hiding under dry pseudostem materials. During field sampling in the dry season we had to place our fingers deep into the rotten pseudostem to catch weevils that had managed to bore deep into the pseudostem trap. Generally, pseudostem traps were found to be less effective (Fig. 1, 2, 3) and this confirms the reports by [27], who earlier had observed that pseudostem traps are ineffective and cannot be recommended for effective monitoring of the plantain weevil. This observation was however in conflict with observations by [8] that pseudostem trapping reduced the population of plantain weevils. Probably, these conflicting reports could be attributed to variation in the *Musa* cultivars used as pseudostem traps, diversity in weather conditions and management practices of the study location.

Corm performance was the same between the dry season and the minor rainy season (Fig. 4), but the major rainy season was significantly different from the dry season and this could be due to trap interference from volatiles emitted by toppled plants in the field. Generally corm and pseudostem traps were not significantly different from one another but corm traps attracted more weevils than pseudostem traps (Fig 1, 2, 3). This confirms work done by [28] that showed similar effectiveness between corm and pseudostem traps.

This study has shown that pheromone trapping was more advantageous than corm and pseudostem trapping which were more labourious and normally lasted for between 7-14 days [29], and required regular sampling to remove and destroy adult weevils [3]. Pheromone trapping has the advantage of lasting for one month and killing adult weevils attracted to the traps. The efficiency of pheromone trapping is based on the assumptions that; in one month the traps would remove a high population of adult weevils within 21 metres relative to the traps. Generally adult weevils are sedentary and migration from one part of the field to another is very limited. In addition their low reproductive potential limits population build-up. Thus, the results from this study suggest that pheromones of the plantain weevil could offer an effective means of monitoring and managing the population of the plantain weevil in Ghana because it was 4 and 5 times more effective in attracting the weevils than corm and pseudostem traps, respectively. The observation in this study that fermented pseudostems were very attractive to the *C. sordidus* is an indication that harvested plantain residues could serve as breeding grounds for fecund adult weevils. Consequently, these should be removed from the field and destroyed after harvest as a management strategy.

More females than males were captured in all three trials in a ratio of 2:1. This might be because female *C. sordidus* are known to be more active and move greater distances than the male in search of oviposition sites and mates [3]. A greater proportion of female *C. sordidus* were captured in the dry season than in the major and minor rainy seasons (Table: 1). The number of female *C. sordidus* peaked in January and August which occurred in the dry season and short dry spell after the major rainy season respectively. Thus, these two months are the driest in the trial period (fig 4.). A laboratory study earlier conducted at the research center (FOHCREC) showed that the female *C. sordidus* laid more eggs in the dry season than the wet seasons and a greater percentage of these eggs hatched in the dry season [30]. This suggests that the female weevils are more active in the dry season in search of breeding grounds. This probably explains the reason why they are more captured by traps during this time. Pheromone-baited traps were most effective than corm and pseudostem and captured a greater proportion of female *C. sordidus* in the trials. This confirmed the work of [25], who reported more females in pheromone-baited traps than plant material traps (corm and pseudostem) in South Africa. In a recapture trial, [31] found that more female than male *C. sordidus* responded to pheromone-baited traps at different distances. Based on the findings in this study, *C. sordidus* management could be improved with the use of pheromone-baited traps in the dry season when female weevils are more active and trap efficiency is increased.

## VI. Conclusion

This study has shown that pheromone-baited traps are more effective for monitoring and managing *C. sordidus* in plantain fields and has the advantage of detecting *C. sordidus* in both newly established and old plantations.

Future studies should be carried out to determine the species composition and relative abundance of predators associated with the *C. sordidus* in plantain fields in Ghana. During the trial a different species (*Polytus mellerbergi*) that attack pseudostem of plantain and banana was found, it is recommended that a thorough survey be conducted in plantain fields in all districts in the Eastern region to checked distribution and population density and economic importance of this weevil. The effectiveness of pheromone traps is dependent on parameters such as trap size, trap location, trap design, trap distance and release rate. More work need to be done on these parameters to maximize pheromone performance. Work should also be conducted to set an economic threshold level for the *C. sordidus* in Ghana; this would enable farmers to take action at the appropriate time with the appropriate measures.

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