Field studies on the susceptibility of six plantain cultivars to infestation by the banana weevil, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae) in Ghana

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ABSTRACT

Field studies were used to identify plantain cultivars that were less susceptible to infestation by the banana weevil *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae). Six plantain cultivars, *Osoboaso*, *Borodewuio*, *Apantu-pa*, *Asamienu*, *Agbagba* and *Obino L'Ewai*, were evaluated between October 1997 and September 1998. The results indicated that all the cultivars were susceptible to weevil damage in weevil oviposition, egg hatchability, and larval growth and development. Weevil population was not significantly different among the cultivars, but differences in the corm damage were significant. *Agbagba* and *Borodewuio* were significantly more susceptible to borer attack than *Obino L'Ewai* and *Osoboaso*, *Asamienu* and *Apantu-pa* were intermediate in their susceptibility to borer attack. Cultivating *Obino L'Ewai*, *Osoboaso*, *Asamienu* and *Apantu-pa*, using good management practices, may increase plantain yields and enhance the sustainability of plantain production in Ghana.

Original scientific paper. Received 17 Jul 06; revised 19 Oct 06.

RÉSUMÉ

NKAKWA, A. A., AFREH-NUAMAH, K., OBENG-OFORI, D. & AHIEKPOR, E. K. S.: *Etudes sur le terrain de la prédisposition de six variétés de plantain à l'infestation par le charançon de banane,* Cosmopolites sordidus *(Germar) (Coléoptères: Curculionidés) au Ghana.* Des études sur le terrain étaient faites pour identifier les variétés de plantain qui étaient moins prédisposées à l'infestation par le charançon de banane *Cosmopolites sordidus* Germar. Six variétés de plantain c.-à-d., *Osoboaso, Borodewuio, Apantu-pa, Asamienu, Agbagba* et *Obino L'Ewai* étaient évaluées entre Octobre 1997 et Septembre 1998. Les résultats indiquaient que toutes les variétés étaient prédisposées aux ravages de charançon sous l'angle de la ponte du charançon, la capacité d'éclore l'œuf, la croissance et le développement larvaire. La population de charançon n'était pas considérablement différente parmi les variétés mais les différences entre les dégâts de bulbe étaient considérables. *Agbagba* et *Borodewuio* étaient considérablement plus prédisposées à l'attaque d'insecte térébrant qu'*Obino L'Ewai* et *Osoboaso*. *Asamienu* et *Apantu-pa* étaient intermédiaires en leur prédisposition à l'attaque d'insecte térébrant. La culture d'*Obino L'Ewai, Osoboaso, Asamienu* et *Apantu-pa* en adoptant les pratiques de bonne exploitation, peut augmenter les rendements de plantain et améliorer la durabilité de la production de plantain au Ghana.

Introduction

Plantain is an important staple food in rural and urban populations of Ghana. It actually contributes about 13 per cent of the GDP of the country. It is frequently intercropped with other crops to serve as sort of insurance to an all-year round food availability (Swennen, 1990; Afreh-Nuamah & Hemeng, 1991; Akomeah, Ohemeng-Appiah & Adomako, 1995). Plantain also helps in protecting and augmenting soil fertility within its agro-ecosystem (Jagtap, 1991; Gold *et al.*, 1991). Despite the popularity of plantain as a staple food, some insect pests and nematodes continue to affect plantain production in Ghana. Among the worse pests is the banana weevil, *Cosmopolites sordidus*, causing a loss of 33 per cent during the first-year cropping and 50 per cent in subsequent years (Afreh-Nuamah & Hemeng, 1991; Udzu, 1997). The poorly resourced Ghanaian farmer can seldom afford to apply costly insecticides (Koppenhoffer, 1991; Collins, Treverrow & Lambkin, 1991).

Few farmers use the cultural practices owing to the absence of functional extension services (Schill, Afreh-Nuamah & Gold, 1996).

This research was, therefore, undertaken to identify tolerant *Musa* cultivars to banana weevils (Hord & Flippin, 1956; Simmonds, 1996; Pavis & Minost, 1993; Abera *et al*., 1996; Pavis & Lemaire, 1996). To achieve this objective, field experiments were used to study the banana weevil (*Cosmopolites sordidus*) oviposition and development, as well as the extent of corm damage due to weevil attack on six local plantain cultivars, *Apantu-pa, Asamienu, Borodewuio, Osoboaso, Agbagba* and *Obino L'Ewai*.

Materials and methods

Experimental site

The site for the study was the University of Ghana Agricultural Research Centre (ARC), Kade, located about 120 km northwest of Accra. The climate is characterized by two wet and dry seasons (Afreh-Nuamah, 1994). The vegetation of the ARC is a moist semi-deciduous tropical forest (Taylor & Sasser, 1982).

Plantain cultivars

The six plantain (AAB) cultivars used in this study were collected from the ARC, Kade *Musa* Collection. The four Ghanaian cultivars had been classified using their local names, the *Osoboaso, Borodewuio, Apantu-pa,* and *Asamienu* varieties (Karikari, 1971). The other two, *Agbagba* and *Obino L'Ewai,* were Nigerian varieties (Ortiz *et al.*, 1995).

Land preparation and planting

Weeds were cleared and allowed to decay on the field to increase the organic matter content of the soil (Swennen, 1990; Hemeng, Bandul & Twumasi, 1996). The planting holes were 30 cm deep and 20 cm wide, and the planting distances were 3 m × 2 m (Ahiekpor, 1996) with 8 m distance separating the various blocks. Three-month-old suckers raised in the nursery through split-corm rapid multiplication technique (Adelaja, 1996) were cleaned by paring (Hemeng *et al.,* 1996) and transplanted onto the field in October 1997. Mulching was applied using the cleared weeds and tree foliage (Swennen, 1990). Plant mats were watered two times every week during the major dry season and weeding was applied once every month. The incidence of the black sigatoka disease caused by *Mycosphaerella fijiensis* was monitored. Leaves with more than a third of their surface area having necrotic lesions were removed. The incidence of nematodes was also monitored through monthly random sampling of the stools of plants and subsequent screening in the laboratory.

Weevil trapping and rearing

Cosmopolites sordidus was trapped from fields in neighbouring villages (Akanteng and Nkwantanang) of the Agricultural Research Centre, Kade, using split plantain pseudostem traps (Hord & Flippin, 1956; Simmonds, 1966). The traps measured 20 cm × 50 cm (INIBAP, 1988). They were placed with their cut sections down on the bare soil at the mat of the plants. The traps were inspected every 3 days for weevils (INIBAP, 1988). Trapped weevils were taken to the laboratory and reared on fresh *Musa* corm placed in plastic buckets at 26 ± 2 °C and 90 ± 5 per cent relative humidity (Budenberg & Ndiege, 1991).

Weevil oviposition in the laboratory

Corm materials derived from plantain cultivars 10 months after transplanting were used for the study. They were washed with tap water and each corm, with a portion of its pseudostem (10 cm above the collar) intact, was placed in a 60-l plastic bucket measuring 50 cm × 30 cm in the laboratory.

Each bucket was half filled with humus soil such that the crown of each plant specimen was just above the soil surface.

Twenty weevils (15 females and five males) were introduced onto the plant material in each of the buckets. Six corms per cultivar were placed singly in six buckets and replicated six times. The insects were confined to the buckets by 0.8-mm² nylon mesh fastened around the mouth of each bucket with the aid of elastic cord. The buckets were then covered with plastic lids to prevent rainwater from entering them and kept under shade. Light watering was applied once every 2 days using tap water from a 10-cm³ beaker to improve humidity. The diameter of each corm was measured and recorded at the pseudostem/corm interface.

Seven days after the weevils were introduced, the plant materials were removed and the pseudostem and corm surfaces were gently scraped with a blunt kitchen knife to show the embedded eggs. Each egg was extracted with the aid of a pointed needle pierced into the corm's tissue beneath it and the tip of the needle raised to push it out. The extracted eggs were counted and recorded.

Weevil oviposition on six cultivars in the field

Thirty adult weevils (1male:1female) were released at the base of 6-month-old plantain plants (Seshu-Ready *et al*., 1992) for each of the six cultivars and replicates. After 7 days the plantain corms were uprooted and washed. Oviposition was assessed by careful inspection of roots for eggs, followed by gently scrapping with a blunt knife, the corm and pseudostem surface up to 5 cm above the collar, using to show the embedded eggs. The eggs were extracted, and number recorded. Each plantain corm served as a replicate.

Larval population

Larval population was assessed 21 days after introducing the 30 weevils (15 males × 15 females). The corms were uprooted, washed and carefully dissected with a kitchen knife; and the larvae within them extracted, counted and recorded.

Pupal and adult weevil population

Forty-five days after introducing weevils, the plants were harvested and the corm carefully dissected for pupae and newly emerged adults. These were extracted, counted and recorded. Single traps, 10 cm thick and 15 cm long, cut lengthwise from spent plantain pseudostems, were also placed at the base of each stool. Newly emerged adults and the numbers collected from the traps were recorded (Ogenga-Latigo & Bakyalire, 1991).

Assessment of corm damage

A 6 × 6 Latin square design with six replications of Latin squares was used. Two additional blocks served as controls, bringing the total number of blocks to eight. Randomization in all the eight blocks was such that each cultivar in a block was planted adjacent to the others as much as possible. Six blocks (treatment blocks) were artificially inoculated with adult weevils while the remaining two (control blocks) were without weevils. There were 36 plants per cultivar, giving a total of 288 plants in the field. Adult weevils (15 males and 15 females) were released at the base of 6-month-old plantains for the treatment plots (Seshu-Reddy *et al*., 1992). The weevils were introduced in the evening hours after 5.30 p.m. because the insects are nocturnal (Abera *et al*., 1996). Corm damage was assessed when the plants were 12 months old, using the peripheral percentage coefficient of infestation (PCI) and template conversion of external tunneling points. Damage on the outer surface was assessed 5-10 cm from the pseudostem/rhizome interface, using a suitable semi-circular wooden template divided into 10 equal segments of 1-cm interval.

The portion within each segment with weevil galleries was expressed as a percentage of the total area occupied by that segment and the value was recorded on a segmental basis. Each segment was assigned a value of 10 per cent. Hence, a maximum value of 100 per cent was recorded if the portion within all the segments was completely covered by weevil galleries. The percentage damage in each segment was added up to give the total peripheral damage of the corm (Gold *et al*., 1994). The cross-sectional damage was assessed by making two transverse cross-sectional cuts on the corms of harvested plants at 0 and 5 cm below the pseudostem/rhizome interface. These cuts exposed two areas in the corm (an inner and outer), which were easily distinguished by colour. The percentage corm damage was assessed (as described above) and the average taken for each level.

Statistical analysis

Analysis of variance, using GENSTAT (Anon., 1993), was applied on the collected data. Data involving counts such as numbers of eggs, larvae, pupae, and adult weevils were transformed using the square root transformation. Those involving calculated percentages were transformed using arcsine transformation before analysis. The Least Significant Difference (LSD) was used to separate the means of treatments.

Results

Weevil oviposition in the laboratory

Table 1 shows that on average weevil oviposition was highest in *Asamienu* (80 eggs) and lowest in *Agbagba* (61 eggs). Next to *Asamienu* was *Apantu-pa* with an average of 73.2 eggs, followed by *Osoboaso* with 72.5 eggs. *Obino L'Ewai* and *Borodewuio* had an average of 72.0 and 69.5 eggs laid on their pseudostems and corms, respectively. However, these differences were not significant. About 95 per cent of the extracted eggs were from the corm region in all the cultivars.

Weevil oviposition preference in the field

On average, *Asamienu*, a 'high mat' cultivar, had the highest egg population of 9.3, while the lowest (6.3) was recorded by *Osoboaso* (Table 2). Most eggs were again extracted from the collar and corm regions in all the plantains.

Larval population

Table 2 shows the population of larvae. *Agbagba* harboured the highest mean number of larvae (1.25), while *Osoboaso* and *Obino L'Ewai* each had the lowest (0.25). The difference was also not significant.

TABLE 1

Oviposition of Adult Cosmopolites sordidus *on Six Plantain Cultivars*

Cultivar	*Mean no. of eggs*
Osoboaso	72.5
Asamienu	80.0
Borodewuio	69.5
Obino L'Ewai	72.0
Apantu-pa	73.2
Agbagba	61.0
LSD (P<0.05)	15.0

TABLE 2

Weevil Oviposition, Larval, Pupal and Adult Populations in Six Cultivars

Cultivar	*Mean no. of eggs*	*Mean no. of larvae*	*Mean no. of pupae*	*Mean no. of adults*
Osoboaso	6.30	0.25	0.75	0.50
Asamienu	9.30	0.75	1.00	0.25
Borodewuio	8.70	0.75	1.00	0.75
Obino L'Ewai	8.30	0.25	0.50	0.25
Apantu-pa	7.00	1.00	1.50	1.00
Agbagba	7.70	1.25	2.00	0.75
LSD (P<0.05)	3.25	1.20	1.50	0.75

Pupal and adult weevil population

The highest pupal population was recorded by *Agbagba* (2.0) and the lowest by *Obino L'Ewai* (0.5) (Table 2). The highest average number of adult weevils was collected from *Apantu-pa* (1.0), followed by *Borodewuio* and *Agbagba* with 0.75 adults each. *Obino L'Ewai* and *Asamienu* each had 0.25 adults, the lowest average recorded.

Corm damage due to weevil borers

Table 3 shows that *Agbagba* suffered the greatest damage due to the feeding activities. This cultivar had peripheral corm damage (PD) of 12.3 per cent and cross-sectional damage (CS) of 21.0 per cent. The cultivar that had the least corm damage was *Obino L'Ewai*. A peripheral damage of 4.0 per cent and a cross-sectional damage of 8.3 per cent were recorded. In both parameters, significant differences were observed among the six plantain cultivars. In all the cultivars, CS was higher than PD.

Tunneling point counts in *Borodewuio* and *Agbagba* were highest for peripheral tunneling points (PTP) and cross-sectional tunneling points (CTP) (Table 3). There were 6.3 PTP and 3.1 CTP for *Agbagba*, and 6.0 PTP and 5.1 CTP for *Borodewuio*. The lowest PTP was observed in *Osoboaso* and *Obino L'Ewai*, each of which had 3.9. The CTP of 2.9 and 2.8, respectively, were recorded for *Obino L'Ewai* and *Apantu-pa*. Significant differences, thus, occurred in the PCI.

Discussion

Weevil oviposition in the laboratory was high for all the plantains evaluated in this study. However, the field oviposition was lower in all the cultivars because in the field, the corms (the preferred region for weevil oviposition) were not readily accessible to the female weevils as they were buried beneath the soil surface. However, *Asamienu*, a 'high mat' cultivar with exposed corm, recorded higher egg numbers. In this study, low larval, pupal and adult weevil populations were observed in all the cultivars with no significant differences among them. These low populations could be associated with low egg production.

Weevil borer population was not significantly different among the cultivars, but the differences in corm damage were significant. *Agbagba* and *Borodewuio* had significantly higher corm damage than *Obino L'Ewai* and *Osoboaso* cultivars. It was usually observed that the level of internal corm damage was higher than the peripheral corm damage. This suggests that plant growth would be retarded should the larval activities extend to the meristem, which was likely to occur with time. The impact of weevil attack on plantains is generally felt after the first-year cropping because of a gradual build up of the weevil population in the field (Afreh-Nuamah, 1994). This suggests that weevil damage is a cumulative process, the effect of which is hardly noticed within the first year of cropping, especially under good farm

TABLE 3

Percentage Coefficient of Infestation (PCI) for Weevil Borer Corm Damage on Six Plantain Cultivars

Cultivar	*PD(%)*	*CD(%)*	*PTP*	*CTP*
Osoboaso	4.5	10.8	3.9	3.0
Asamienu	5.8	9.0	4.0	3.1
Borodewuio	7.0	16.0	6.0	5.1
Obino L'Ewai	4.0	8.3	3.9	2.9
Apantu-pa	11.0	12.8	4.5	2.8
Agbagba	12.3	21.8	6.3	3.1
LSD (P<0.05)	0.79	1.05	0.32	0.33

management practices (Swennen, 1990).

The plantains investigated in this study were all susceptible to the banana weevil in weevil oviposition and insect development within their host. For corm damage, *Agbagba* and *Borodewuio* were more susceptible to the weevil borer attack than the other cultivars, with *Obino L'Ewai* and *Osoboaso* being the least susceptible. *Agbagba* and *Borodewuio,* with shorter number of cropping cycles, are likely to experience more severe corm damage within the second and subsequent years of cropping. As such, cultivating any of the two plantain cultivars would be less profitable after the first year of cropping. This notwithstanding, *Borodewuio,* a drought-tolerant cultivar (Afreh-Nuamah, 1994), has long been grown in the communities for decades (Karikari, 1971), probably because its drought-tolerant properties do compensate for its susceptibility to weevil borer attack. Cultivating *Osoboaso*, a false horn plantain that produces many hands with large fruits, should be encouraged because the cultivar was observed to be less susceptible to weevil borer attack in the field. Schill *et al*. (1996) reported that the cultivar is prevalent in all five plantain-growing regions of the rainforest belt of Ghana and is rated high for preparing 'ampesi' and 'fufu'.

Obino L'Ewai was also observed to have high sustainability potential. It was less susceptible to corm damage by banana weevils. This cultivar was rated excellent for consumption as 'ampesi' (Afreh-Nuamah, 1994); so its cultivation should also be encouraged. In addition, because of its size the crop would be more tolerant to toppling and snapping during windy conditions, a major production constraint in plantain cultivation especially in the rainforest belts of Ghana (Afreh-Nuamah & Hemeng, 1991). Also, its relatively smaller plant size compared to the *Apems* suggests that its post-harvest waste would be much easier to dispose of than those of the bulky local *Apems.*

Cultivating *Asamienu* and *Apantu-pa* should be encouraged because they were observed to be intermediate in susceptibility to corm damage by the banana weevils. These two cultivars are very popular within the plantain-farming community in Ghana because of their suitability not only in 'fufu' preparation, but also in preparing other staples and delicacies (Karikari, 1971). In addition, these plantains have a short maturation period (about 12 months) with a relatively higher sucker production and ratoon longevity (Schill *et al*., 1996).

In cultivating any of the above-recommended plantains, yield sustainability in the subsistence farming system can be greatly enhanced if integrated with good management practices such as planting of clean and healthy planting materials generated from split corms at the right time, use of weevil-free fields, maintenance of good farm sanitation before regular weeding and proper disposal of post-harvest plantain remnants, frequent weevil trapping using split pseudostems, use of firm props to minimize yield loss due to toppling, and snapping of the crop caused by wind, nematodes or banana weevils or both. Adherence to these recommendations would also minimize or even eliminate the use of insecticide against the banana weevil pest.

Acknowledgement

The principal author was sponsored by DAAD of Germany through the ARPPIS sub-regional Centre for West Africa at the University of Ghana, Legon. The authors thank staff of the Department of Crop Science, Legon and Agricultural Research Centre (ARC), Kade for helping in diverse ways. Professor Kwadwo Ofori assisted in analysing data.

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