African Crop Science Journal, Vol. 1, No. 1, pp. 31–37, 1993
Printed in Kenya. All rights reserved

USE OF PSEUDOSTEM TRAPS AND COEFFICIENT OF INFESTATION (PCI) FOR ASSESSING BANANA INFESTATION AND DAMAGE BY *COSMOPOLITES SORDIDUS* GERMAR

OGENGA-LATIGO, M.W. and R. BAKYALIRE
Department of Crop Science, Makerere University, P.O. Box 7062, Kampala, Uganda

(*Received* 4 *May* 1993; *accepted* 2 *June* 1993)

ABSTRACT

The banana weevil borer, *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae), is a nocturnal pest and larvae tunnel into banana rhizomes. Infestation and damage are assessed mainly by pseudostem trapping of adults, and the determination of coefficient of infestation. Deficiencies of these methods were identified and field experiments and destructive sampling of bananas carried out to answer some of the questions raised.

Variation in trapping conditions, such as trap length, placement, duration of trapping, and soil moisture conditions significantly influenced weevil catches in pseudostem traps. The relationship between external rhizome tunnelling, indexed as Percent Coefficient of Infestation (PCI), and internal rhizome damage by *C. sordidus* varied among the banana types and with the parameters used to quantify damage. There was also a poor correlation between weevil trap catches and rhizome damage.

For trap to be statistically comparable, trap size and trapping conditions should be defined and standardized. Proper use of the PCI requires that correlations between external tunnelling and internal rhizome damage be established for a given banana type or cultivar.

***Key Words*: *C. sordidus*, Curculionidae, pseudostem trapping, PCI.**

INTRODUCTION

The banana weevil borer, *Cosmopolites sordidus*, is an important pest in all major banana and plantain growing countries of the world. In the Lake Region of eastern Africa, recent decline in banana productivity has been attributed to damage by *C. sordidus* and nematodes (1). Upsurge in the weevil problem in Africa has led to renewed interest in research into its bioecology and strategies for control. This effort is, however, being constrained by deficiencies in methods of assessing weevil populations and plant damage.

Because of the nocturnal and secretive nature of adults, and tunnelling of larvae into rhizomes and pseudostems, evaluation of banana infestation and damage by the weevil has relied on relative methods; mainly pseudostem trapping of adults, and Percent Coefficient of Infestation (PCI) score for damage (7; 12). Where used, direct estimate of rhizome damage is restricted to wind toppled plants or those sampled after harvest.

Use of the two relative methods of weevil assessment brings to mind important questions that need to be critically addressed. Firstly, to what extent do these methods provide simple and dependable ways of not only estimating weevil populations and determining levels of infestation, but also assessing banana damage and potential yield losses? Secondly, what are some of the limitations of existing assessment methods, and how can their effectiveness be improved?

Pseudostem trapping. Two primary trap types used in the evaluation and control of weevil adults is the disc-on-stump and pseudostem traps. The disc-on-stump trap is made by cutting harvested stump 15–25 cm above ground level and placing a 5–10 cm thick pseudostem disc on top of the stump (6; 7; 12). The split pseudostem trap, on the other hand, is made from pseudostem pieces split longitudinally in two halves and placed near a target plant with split surface on the ground (6). Disc-on stump traps are believed to catch three to four times more weevils (6), but are inflexible in use as they can only be set from harvested, broken or discarded plants. Split pseudostem traps, in contrast, are easy to make and set under the widest range of field conditions, and trap materials are readily available. They have thus been recommended and used extensively to assess borer populations in banana fields (1; 7; 10), to determine the effectiveness of applied insecticides (2), and in practical weevil control (1; 4; 12).

It is recognized that factors such as trap size, material, duration of trapping, environmental conditions and physiological state of the weevils may influence adult catches in pseudostem traps (4; 5; 7). Given the importance and extensive use of these traps, therefore, it would be expected that sufficient effort has been made to define specific trapping conditions necessary to yield optimum and comparable results, as well as the establishment of efficiency in the use of trap materials and time. Review of available literature, however, shows that critical studies covering these parameters are lacking, and standardization has not been attempted.

With little functional justification, a wide range of trap size, placement and duration of trapping are used or recommended. Common trap lengths range from 30 to 60 cm, and duration of trapping from one to seven days (7). Hord and Flippin (4) and Mitchell (7), for instance, used 18" (45 cm) long traps set flat side down in pairs, on cleared soil at the base of each mat trapped, and read once 5–7 days after setting. A recent technical workshop on the weevil (1) recommended the use of 30–50 cm long traps, with cut parts placed over soil and checked weekly over two weeks. Due to these large variations in procedure, trapping results have remained highly inconsistent, statistically unreliable, and difficult to compare (11). There is, therefore, a critical need to undertake comprehensive definition of trap characteristics and trapping conditions.

Coefficient of infestation. Where interest is in direct estimation of weevil damage on bananas, rather than weevil population *per se*, the Coefficient of Infestation or Percent Coefficient of Infestation (PCI) methods are used. The Coefficient of Infestation (14) was the first procedure used to quantify the degree of banana attack and rhizome damage by *C. sordidus*. It consists of clearing the base of the banana plant to expose weevil tunnelling points and estimating infestation and rhizome damage on the basis of these points. This procedure has since been modified to encompass assessment of whole rhizomes for damage (13), or the establishment of Percent Coefficient of Infestation (7). The PCI is basically a template conversion of external tunnelling points into a percentage index representing the degree of banana infestation by the pest. This procedure is the most practical, and is widely recommended and used. It, nevertheless, has important deficiencies.

A primary statistical limitation of the PCI is the dependence of its values on the surface distribution of weevil tunnels (3), with the possibility of there being many PCI scores for the same level of tunnelling. Where clumping is high, for example, template readings tend to underestimate the degree of infestation. More importantly, however, in using the PCI as a direct measure of banana damage by weevils, the assumption that external tunnelling is an accurate representation of the more important internal rhizome damage by weevil larvae is taken as a fact. There is no established basis for this assumption.

In spite of recognized shortcomings (7), the PCI is used extensively in weevil assessment. A 1987 workshop on the weevil problem in Africa (1), for example, recommended the use of "Vilardebo's Coefficient of Infestation to obtain quantified data on weevil occurrence and damage". The general acceptance of the PCI is most likely due to the ease with which it can be applied, and to the fact that it converts otherwise highly variable counts of weevil tunnelling points into percentages that are easy to compare. More importantly, perhaps, is the fact that it serves as a convenient measure of banana infestation and damage by weevils, parameters that are otherwise impossible to compare without destroying the plant. However, to what extent does the PCI constitute a measure of weevil "occurrence" and/or banana damage?

Clearly, many factors influence the relationship between surface tunnelling and rhizome damage by weevils: (i) rhizome resistance (hardness etc.) may limit the extent of internal damage but enhance the level of surface probe. In a susceptible cultivar, the reverse may be true. (ii) initial tunnelling points may subsequently serve as main points for egg deposition and entry/exit of weevils, thus masking the true extent of rhizome infestation and damage. (iii) rhizome size may influence the extent of internal damage for a given population of weevils. (iv) environmental factors such as mulching, soil type and drought may influence weevil behaviour and the distribution of entry/exit points. These relationships have not been evaluated. To what extent, therefore, can the PCI be effectively applied for weevil assessment under conditions of extreme banana diversity obtained in Uganda and other parts of East Africa?

MATERIALS AND METHODS

Study site. The study was based on field experiments conducted at Makerere University Agricultural Research Institute, Kabanyolo, located about 10 km north of Kampala, and destructive sampling of bananas in Mpigi and Masaka districts of Central Uganda during the rainy seasons of 1991. This region experiences bimodal rainfall; the main rains occur from March to June while the short rains fall between September to December. Sampling was carried out in fields where the main cultivars grown, the East African Highland cooking types *Matooke* (AAA-EA), was interplanted with plantains (AAB), Gros Michel (AAA), Lady's Finger (AB), Bluggoe (AB) or beer types (AAA-EA or ABB).

Pseudostem trapping of weevils. The extent to which trap size, duration of trapping and soil moisture levels influence pseudostem trap catches of *C. sordidus* was assessed. Adult weevils were trapped from the East African highland cooking bananas, these being the most susceptible cultivars, in the country. Half piece traps were made from *Matooke* pseudostems split lengthwise and laid singly in mats showing visible signs of weevil infestation.

To assess the effect of trap size, pseudostem traps of 5, 15, 25, 35, 45 cm lengths were set against banana plants either lengthwise, with one cut end placed against sample plants, or crosswise, being placed sideways against the plants. Traps were set in four replicates, between 1800 and 1900 hr, and checked after 36 hr.

The influence of duration of trapping on weevil catches was evaluated by setting 25 cm long traps crosswise against fruiting banana plants and determining weevil catches over a 168 hr period. 150 traps were randomly set in batches of ten; one batch was checked every 12 hr, while the others were checked only once, 12, 24, 36, 48, 60, 72, 84, 96, 108, 120, 144, 156 and 168 hr after setting. The trial was repeated two times.

Soil moisture level is probably the single most important environmental variable whose daily and seasonal fluctuations may directly affect weevil trap catches. In the dry period of June 1991, 20 weevil infested banana mats were selected, ten of which were watered to field capacity, between 1800 and 1830 hr, just before trap setting. Traps were laid singly against late vegetative or fruiting plants, and the number of weevils caught recorded after 36 hr. The trial was repeated ten times.

Relationship of PCI to rhizome damage. In this assessment, fields with mixed banana types were preferred. Plants from a total of 50 mats of the cooking, *Matooke* (AAA-EA); beer, *Kayinja* (ABB); dessert, *Ndizi* — Lady's Finger (AB); *Bogoya* — Gros Michel (AAA) bananas, and "False-horn" plantains (AAB), were sampled. Single 25 cm-long half-piece pseudostem traps were set against all plants in the evening and the number of adult weevils recorded after 36 hr. Template PCI readings, plus the actual number of tunnelling points, were recorded for each plant. The plants were uprooted and whole rhizomes pared. The rhizomes were then cut length-wise, and cross-sectionally at the crown and mid-length, and tunnel numbers as well as the percent rhizome damage established. Determination was made of the relationships between weevil trap catches, number of tunnelling points and actual rhizome damage by weevils for plants in the late vegetative and fruiting stages.

RESULTS

Pseudostem trapping of weevils. Catches of *C. sordidus* adults increased with trap length (Table 1). For traps placed crosswise, weevil catches increased with increase in trap length, with catches in traps of 5–25 cm length being significantly different from each other and, except for the 25 cm trap, significantly fewer than for the 45 cm trap. For traps placed length-wise, there were no significant increases in the number of weevils trapped with increase in trap lengths beyond 15 cm.

The number of *C. sordidus* adults caught in traps increased significantly up to 60 hr after setting, with a minor increase up to 96 hr, before declining (Fig. 1). Optimum duration of trap setting was 2.3–4.0 days. Watering of mats before trap setting significantly increased trap occupancy and weevil catches during dry periods (Table 2).

Relationship of PCI to rhizome damage. There were wide variations in overall correlations between the PCI scores and parameters of weevil infestation and banana damage when data for all

TABLE 1. Trap catches (means ± S.E.) of *C. sordidus* (adults/5 traps) as influenced by length and placement of half-piece pseudostem traps

Trap length (cm)	Length-wise	Cross-wise	Overall means
5	4.4 ± 0.4a	2.5 ± 0.5a	3.0
15	8.4 ± 0.5b	7.1 ± 0.9b	7.8
25	7.8 ± 0.8b	11.8 ± 0.6cd	9.7
35	8.1 ± 0.8b	22.0 ± 0.6d	10.1
45	8.0 ± 0.3b	23.2 ± 0.5d	10.8
Overall mean	7.3	9.3	

LSD(0.05) between trap placement means = 2.6 weevils.

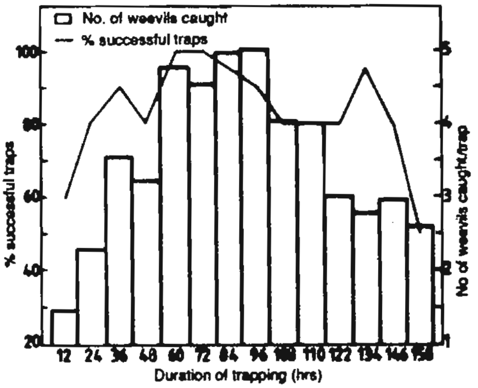

Fig. 1. Variation in number of *C. sordidus* caught per trap and percent trap occupancy when pseudostem traps were set for durations of 12 to 168 hours.

TABLE 2. Pseudostem trap catches (means ± S.E.) of *Cosmopolites sordidus* adults from dry and watered stools

	Watered	Dry	LSD (0.05)
Weevils/trap	3.3 ± 0.4	2.0 ± 0.2	1.5
% trap occupancy	68.3 ± 6.4	34.7 ± 4.8	16.0

TABLE 3. Coefficients for overall correlations between parameters of weevil infestation and damage of bananas and plantains

Sample parameters	1	2	3	4	5	6	7	8
1. Pseudostem trap catches	1.00							
2. No. of tunnelling points (surface)	0.38	1.00						
3. Template estimate of PCI	0.27	0.83	1.00					
4. No. of tunnelling points (X-section)	0.08	0.71	0.70	1.00				
5. % Damage (X-section)	0.05	0.47	0.54	0.76	1.00			
6. No. of tunnelling points (L-section)	0.41	0.72	0.67	0.66	0.61	1.00		
7. % damage (L-section)	0.28	0.66	0.68	0.81	0.85	0.89	1.00	
8. % X-section damage (mid-corm)	0.22	0.62	0.68	0.78	0.82	0.85	0.36	1.00

TABLE 4. Variation in surface(S) and cross-sectional (CS) tunnel points and internal and mid-corm cross-sectional and longitudinal (LS) damage by *C. sordidus* among five major banana types

Banana types	Trap catches	Tunnel point(S)	Tunnel point(CS)	Percentage damage CS	LS
Kayinja	0.9 ± 0.1	6.6 ± 1.7	1.2 ± 0.3	2.7 ± 0.4	3.2 ± 0.4
Matooke	1.8 ± 0.1	22.8 ± 3.4	5.0 ± 0.6	31.8 ± 4.2	34.2 ± 5.1
Ndizi	2.6 ± 0.2	25.2 ± 3.5	1.8 ± 0.4	4.5 ± 1.2	7.5 ± 0.4
Bogoya	0.5 ± 0.1	5.2 ± 2.0	1.1 ± 0.2	1.6 ± 0.5	0.7 ± 0.4
Plantains	2.5 ± 0.2	22.5 ± 4.1	4.0 ± 0.3	10.7 ± 1.3	13.5 ± 2.6

banana types were pooled (Table 3).The PCI readings were poorly correlated with the number of weevils trapped (*r*= 0.27), and percent cross-sectional rhizome damage (*r*=0.54). Correlation between PCI and the other damage parameters were similar (*r* range 6.7–7.0), suggesting that any of the parameters could be used to index rhizome damage.

The correlation between PCI scores and the actual counts of external tunnel points from which they were derived (*r*=0.83) was not as high as expected (Table 3). Furthermore, great variations in the relationship between the number of external tunnel points and internal rhizome damage were obtained when the data for the major banana types were separately analyzed (Table 4). For instance, while the number of external tunnel points for *Matooke* (AAA-EA), *Ndizi* (AB), and plantains (AAB) were 22.8, 25.2, 22.5, respectively, the corresponding internal longitudinal rhizome damage averaged 31.8, 4.5, and 10.7%.

DISCUSSION

In the present study, weevil trap catches varied widely in relation to the various factors tested. On the basis of the total number of weevils caught per trap, longer half-piece traps placed cross-wise are certainly to be preferred, as reflected in the recommendations by Hord *et al.* (4) and Mitchell (7). However, this may not necessarily be the ideal strategy.

Firstly, in terms of efficient use of trap material, the 15 cm half piece traps placed length-wise, or 25 cm traps placed cross-wise seemed ideal as they gave the highest catch per unit length of trap (Table 1). Secondly, because they extended to different plants in a mat, longer traps probably attracted borers from plants other than those against which they were placed. The number of weevils caught in these traps were therefore strongly influenced by the number, position and infestation levels of other plants in a mat. In any case, if mat infestation was being assessed, many

15–25 cm traps would provide a more accurate assessment of weevil numbers than pairs of 45 cm length.

Similarly, significant variations in the number of weevils caught were obtained when traps were set between 1800 and 1830 hr, and checked every 12 hr over seven days (Fig. 1). Trap occupancy reached a maximum level 60 hr after setting, while highest number of weevils were caught 60–96 hr after trap setting. A significant decline in the number of weevils found in the traps occurred after the fourth day. There seems therefore to be no justification for traps being inspected 6–7 days after setting as is commonly recommended.

By wetting the mats before trap setting during the dry season, dramatic increases in percentage trap occupancy and the number of weevils caught occurred (Table 2). Available trapping studies (7; 10) make no reference to soil moisture conditions or watering of stools before trap setting. It is likely that difference in trap catches due to environmental variables have been mistaken for true dynamics of weevil populations.

Amongst the major banana types grown in Uganda, there are marked differences in the relationship between PCI scores and parameters of external and internal rhizome damage. For instance, although *Matooke* (AAA-EA cooking) and *Ndizi* (AB Lady's Finger) had 22.8 and 25.2 tunnelling points, respectively, various measures for internal rhizome damage ranged from 20.3 to 34.2% for *Matooke*, but only 2.4 to 7.5 for *Ndizi* (Table 4). For the latter, the PCI led to a gross misrepresentation of banana infestation and rhizome damage.

The present study highlights major difficulties related to the use of trapping and PCI methods for the assessment of weevil infestation and damage on bananas. The many questions raised emphasize the extent to which basic studies are needed to streamline and develop these methods as research and management tools. An efficient and well established trapping procedure is potentially important for (i) quick monitoring of weevil populations, (ii) direct weevil control, and (iii) delivery of chemical and microbial control agents. Detailed definition of trap characteristics and trapping conditions that ensure efficiency and reliability of the pseudostem trap are therefore needed.

The study also showed that the estimation of banana damage by weevils using the PCI method as previously recommended may lead to gross errors due to variation in the relationships between the PCI and specific measure of internal rhizome damage among the various banana types and cultivars, and probably under different management and ecological conditions. For each situation, therefore, the actual relationship between PCI and banana damage should first be verified.

ACKNOWLEDGEMENTS

Ideas contained in this paper were first presented at a banana pest management workshop in Benin in 1991. The study was carried out under the Makerere University Banana Improvement Project financed by the Rockefeller Foundation. We thank all those who have supported us.

REFERENCES

1. Anonymous 1986. Recommendations of the banana weevil work group. In: *Nematodes and the Banana Weevil in Bananas. Present Status of Research and Outlook.* Proceedings of a workshop held in Bujumbura, Burundi, 7–11 December, 1987. Inibap, 1988 pp.23–25.
2. Bujulu, J., B. Uronu and C.N.C. Cumming, 1985. The control of banana weevils and parasitic nematodes in Tanzania. *East African Agriculture and Forestry Journal* 49:1–13.
3. Delattre, P. 1980. Recherche d'une methode d'estimation des populations du charancon du bananier *Cosmopolites sordidus* Germar (Coleoptera Curculionidae). *Acta Oecologia; Oecologia Applicata* 1:83–92.
4. Hord, H.M.V. and R.S. Flippin, 1956. Studies of banana weevils in Honduras. *Journal of Economic Entomology* 49:296–300.
5. Ityeipe, K. 1986. Studies on the host preference of banana weevil borer *Cosmopolites sordidus* Germ. (Coleoptera Curculionidae). *Fruits* 41:375–379.
6. Mitchell, G.A. 1978. The estimation of

banana borer population and resistance levels. *WINBAN Technical Bulletin* (2), 34 pp.

7. Mitchell, G.A. 1980. *Banana Entomology in the Windward Islands.* Final Report, 1974–1978. Centre for Overseas Research, London, 1980. 216 pp.
8. Perrier, X. and D. Munsch, 1985. Remarques statistiques sur le "coefficient d'infestation" des charancons. Rep. reunion annuelle. *IRFA* 9:3.
9. Seshu Reddy, K.V. 1988. Studies on banana weevils. *16th Annual Report,* the ICIPE, Nairobi. p.4.
10. Shillingford, C.A. 1988. Review of Parameters used for evaluating nematode and borer damage in banana and plantain. In: *Nematode and the Borer Weevil in Banana. Present Status of Research and Outlook.* Proceedings of a workshop held in Bujumbura, Burundi, 7–11 December, 1987. Inibap, 1988. pp. 87–90.
11. Simmonds, N.W. 1982. *Banana.* 2nd Edition, Longman, London.
12. Turner, T.W. 1974. Notes on the assessment of damage to banana corms by the borer *Cosmopolites sordidus* Germar. Unpublished Report, 2pp.
13. Vilardebo, A. 1973. La coefficient d'infestation, critere d'evaluation du degre d'attache des bananeraies pur *Cosmopolites sordidus* Germ. le charancon noir du bananier. *Fruits* 28:417–426.
14. Vilardebo, A. 1974. Crop assessment methods. In: *FAO Manual on the Evaluation and Prevention of Losses by Pests, Diseases and Weeds.* Chiarappa, L. (Ed.). Commonwealth Agricultural Bureaux, Farnham Royal, Slough.