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Cultural control of banana weevils in Ntungamo, southwestern Uganda

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Abstract

The International Institute of Tropical Agriculture and the Uganda National Banana Research Programme tested and evaluated selected cultural management options for the banana weevil through on-farm farmer participatory research in Ntungamo district, Uganda between 1996 and 2003. A farmer adoption study of these cultural practices was also undertaken. Tested technologies included: (1) pseudostem trapping; (2) soil fertility and water management practices (grass mulch, soil and water conservation bunds and farm yard manure); and (3) crop sanitation (destruction of crop residues that serve as breeding grounds for banana weevils). This paper reports on the efficacy of these controls, as well as farmers' observations on the feasibility of their adoption. The difficulties in carrying out farmer participatory research in highly heterogeneous banana stands is also discussed.

Introduction

The banana weevil is a key production constraint of East African highland bananas (AAA-EAHB) (Gold *et al*, 1993, 1999). Currently, farmers rely on cultural practices for weevil control (Seshu Reddy *et al*., 1998; Gold *et al*., 2001), but few data are available on the efficacy of these practices, their costs and benefits, and factors influencing farmer adoption. These limitations have demanded testing and validation of the technologies' on-farm conditions.

Available cultural practices for banana weevil control include use of clean planting material, cropping systems management, pseudostem trapping, mulching and crop sanitation (Gold *et al*., 2001). The use of clean planting material technologies (paring, hot-water treatment, tissue culture plantlets) takes advantage of the banana weevil's limited dispersal capability by keeping the pest out of new fields. Field studies suggest that clean planting material is likely to provide benefits for only a few crop cycles and cannot be seen as a permanent solution (Gold *et al*., 2001). This is because some clean planting methods (paring, hot-water treatment) greatly reduce, but do not elimi-

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nate the pest (Gold *et al.*, 1998). Seshu Reddy *et al.* (1995) observed that trapping can significantly reduce weevils in farmers' fields. However, sustained use of trapping by farmers was not achieved.

The International Institute of Tropical Agriculture (IITA) and the Uganda National Banana Research Programme (UNBRP) tested and evaluated selected cultural management options for the banana weevil through on-farm farmer participatory research in Ntungamo district, southwestern Uganda between 1996 and 2003.

Materials and methods

The studies were carried out in Kikoni parish, which lies between longitudes 30°13.66'E and 30°13.85'E and latitudes 0°52.88'S and 0°53.79'S at an elevation of 1300-1560 masl. Farm holdings in the area were generally small, averaging 0.85 ha (range 0.4-5.9 ha) in our surveys. Bananas occupied more than 60% of the cultivated land and were mostly from contiguous plantations in a complex topography including hills, valleys and uneven terrain (Okech *et al.,* 1998). The area has a bimodal distribution of rainfall (800-1500 mm) falling between March to mid-May, and September to December. Banana weevil populations and damage in the study area ranged from light to very high (Gold *et al*., 1997).

Tested technologies included: (1) pseudostem trapping, (2) soil fertility and water management practices (grass mulch, soil and water conservation bunds), and (3) crop sanitation (destruction of crop residues that serve as breeding grounds for banana weevils). A farmer adoption study of these and other practices for banana weevil control was also undertaken. The efficacy and implementation feasibility of these controls, as well as farmers' observations, are presented and discussed.

A Participatory Rural Appraisal (PRA) and diagnostic survey (DS) conducted from December 1995 to May 1996 preceded research activities in the area. The PRA, involving group discussions and key informant interviews, identified farmers' perceptions of banana production constraints and served as a means for developing researcher-extension-farmer collaboration. Subsequent group discussions were undertaken before each on-farm research activity. The DS verified farmers' perceptions, quantified pest status of banana weevils and nematodes, characterized banana-based cropping systems, and generated data used in identification and selection of the research farms.

In the initial survey, 50 farms were haphazardly selected from seven villages, namely Buhandagazi, Kamunyiga, Karegeya, Kyangara, Musaana, Ruguma and Ryagusha. Agronomic practices including cropping systems, application of soil amendments (mulches and/or manure), sanitation (i.e. removal, shredding, spreading of corm and spent pseudostems) were characterized as described by Gold *et al.* (1997). Weevil populations were estimated using mark and recapture methods developed by Southwood (1978) and modified for the banana weevil by Gold and Bagabe (1997). Weevil damage was estimated on 20 newly harvested plants/farm using the scoring method developed by Gold *et al.* (1994). Three approaches to control weevils were tested.

Pseudostem trapping. Researcher-managed plots and farmer-managed ones were compared with regards to their effectiveness in reducing banana weevil populations and corm damage between June 1996 and July 1997 (Gold *et al.*, 2002). Researcher-managed trapping (9 farms) was intensive, involving placing a trap on every mat once every month. Farmer-managed trapping (9 farms) was at the farmers' discretion and was undertaken piece-meal (placing 0.1-0.6 traps/mat without following a regular time interval). Controls (9 farms) consisted of farms where trapping was not practiced. Baseline data on weevil populations and corm damage were taken before the implementation of treatments. Banana weevil populations were subsequently estimated 6 and 12 months later, while corm damage was scored regularly on freshly harvested plants.

Soil fertility and water management. Various practices were investigated to observe how low yielding, moderately weevil-infested old banana plantations would respond to cultural soil and water productivity improvements, such as conservation contour bands, mulch and/or farmyard manure. The study tested the hypothesis that the construction of soil and water conservation bunds along the farm contours, as well as the application of mulch or farmyard manure, could increase stand productivity while also reducing banana weevil pressure. During a period of four years, the effects of mulch and contour bunds were evaluated by three treatments on 13 randomly selected farms. An area measuring 36 x 36 m was delineated in each of the farms and subdivided into three equal plots (i.e. 12 m x 36 m) containing 50 to 55 mats. The three treatments, (i) control, (ii) contour bunds only and (iii) contour bunds plus swamp grass mulch, were randomly assigned to the plots. The treatments were implemented in August-September 1996 (at the beginning of the second rainy season). Contour bunds were 45 cm wide and 30 cm deep. The bunds were stabilized by planting *Seteria splendida* grass, which also served as a source of mulch or fodder. Grass mulch (10 cm thick) was applied to the third treatment at the beginning of the trial and placed 50 cm away from the banana mats. A new layer of mulch was added once every year (in August) until the conclusion of the study. Other cultural management practices such as weeding, desuckering to leave three plants/mat, and crop sanitation (removal and shredding of the residues within two weeks of plant harvest) were uniformly applied to all treatments. Weevil populations were estimated from each plot in June of each year using the mark-release-recapture method as described above. Banana weevil damage was assessed in corm cross sections continuously from every harvested plant in each plot.

Crop sanitation. Crop residues that serve as breeding grounds for banana weevils (Masanza 2003) were destroyed to evaluate its effect on banana weevil populations and corm damage. The study ran from 1999 to 2003. A baseline survey was carried out on 60 farms to characterize crop sanitation levels being practiced by the farmers and to measure the initial weevil population abundances and corm damage. Levels of sanitation were categorized as low, moderate and high, based on the frequency and intensity of sanitation practices. Volunteer farmers in the low and moderate sanitation levels were asked to increase their levels of sanitation for the period of the study (i.e. low to moderate, low to high, and moderate to high), while other farmers maintained their baseline levels. Weevil populations and corm damage were estimated at three month intervals using the methods of Gold and Bagabe (1997) and Gold *et al.* (1994) respectively.

Farmers' knowledge was partly investigated by trying to understand their perceptions and knowledge of the banana weevil and its biology. Farmers in Ntungamo were categorized into three groups (bottom, middle, top) according to wealth indicators and interviewed individually using semi-structured questionnaires.

Farmers' management practices included sanitation, trapping, pesticides, and biorationals (ash, urine, etc.). Sanitation was defined to include leaf sheath removal, splitting of pseudostems, corm removal, corm covering and stump removal. Trapping included placement of split pseudostem traps at the base of the mats and covering the harvested corm with banana leaf.

Resource allocation to the activities was estimated based on the man-hours/acre that were dedicated to each of the different practices.

Results

Pseudostem trapping

Results showed that there was a general decline in weevil populations in Ntumgamo, including controls, during the course of the study. After one year, populations were 61%, 53% and 38% lower in researcher-managed, farmer-managed and controls, respectively. Adjusting for the overall decline in the weevil population during the course of the study showed that trapping contributed to a reduction of 38% of the weevil population in the researcher-managed plots and 27% in the farmer-managed plots (Table 1). The study further observed that there was no clearly defined trend at the individual farm level in numbers of weevils removed by trapping or reduced populations. Plantation management, surrounding land use and weevil immigration from neighbouring farms may have partly mitigated against trapping effects. Researcher-managed trapping resulted in reducing corm damage by 49%, while farmer-managed trapping had

Table 1. Mean percentage of banana weevil population changes following one year of pseudostem trapping in farmers' fields in Ntungamo district, Uganda (Gold *et al.* 2002).

	June 1996- January 1997	January 1997- July 1997	Overall change
Population changes			
Control	-42%	12%	-38%
Farmer-managed	-50%	-9%	-53%
Researcher-managed	-49%	-42%	-61%
Adjusted reductions			
Farmer-managed	-14%	-19%	-27%
Researcher-managed	-12%	-52%	-38%

no effect on damage during the course of the study. Therefore, it should be noted that population reduction through trapping may have been gradual, as a lag time would be expected between population change and corm damage reduction. At the termination of the study, farmers recognised the benefits of trapping, though expressed concerns about the feasibility of this method due to the labour and resource requirements, let alone weevil immigration from neighbouring farms possibly offsetting its usefulness.

Soil fertility and water management practices

Weevil adult populations in the contour bunds and mulch trial fields at the beginning of the trials (1996) ranged from 8000 to 9000 weevils/ha (Figure 1). In 1997, the densities significantly increased to 11 000-12 000 weevils/ha in the plots with contour bunds and those with mulch, but remained at the same level in the control plots. These relative increases were attributed to the greater soil-moisture holding capacity in these two treatments which is more favourable to banana weevils. A general decline in weevil populations was observed between 1997 and 1999 in all the treatments, although populations in contour bunds,

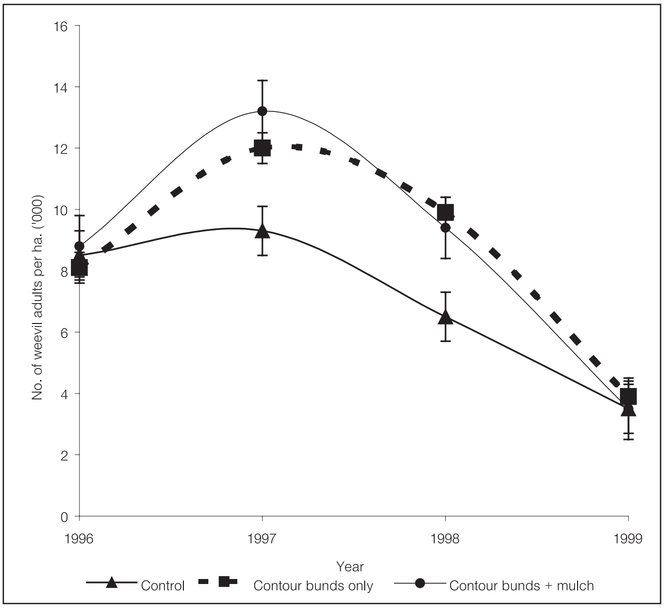

Figure 1. Banana weevil populations under different soil fertility management practices at Ntungamo, Uganda. (Okech *et al.*, unpublished)

and contour bunds plus mulch treatments, remained higher than the controls. However, these treatment differences were not significant by the end of the study.

Banana corm weevil damage at the beginning of the study (1996) ranged from 4% to 4.5%, which was rated as moderate (Gold *et al.*, 1994). The damage levels declined uniformly in all the treatments from moderate to low (< 2.5%) between 1997 and 1999 (Figure 2), though the differences between the treatments were not significant. There was a general increase in yield in all treatments in the first two years of the study, but contour bunds and mulch treatments had significantly higher yields than the controls by the fourth year of the study (Figure 2).

Crop sanitation

Weevil populations increased greatly on most farms during the course of the study. In the initial 26 months, densities increased slightly and were similar among treatments. Subsequently, the highest population increases occurred on banana stands maintained at low sanitation levels, peaking at 52 000 weevils/ha (Figure 3). By contrast, densities on the farms upgrading from low to moderate sanitation levels were only 13 000 weevils/ha, while populations on farms upgraded from low to high sanitation levels remained at about 2000 weevils/ha throughout the study.

The difference in corm damage between low and high sanitation practicing farms increased over time (Table 2). By 2002, total damage for the high sanitation farms

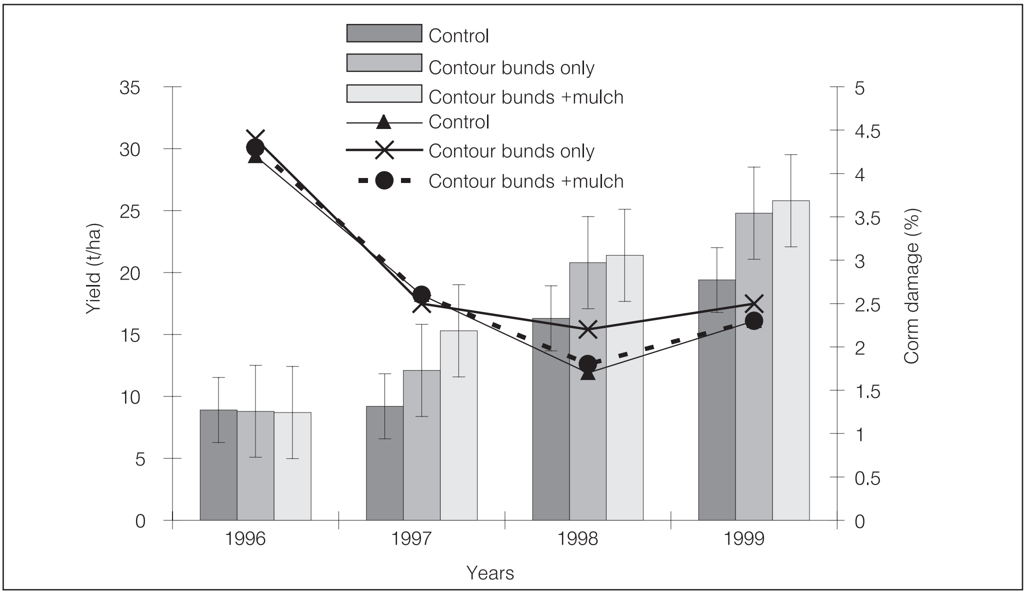

Figure 2. Changes in banana corm damage by weevils (line graph) and yield (bar graph) in soil conservation bunds plus mulch trial at Ntungamo, Uganda. (Okech *et al.*, unpublished)

throughout was 1.5%, while damage on low sanitation farms averaged 3.6%. Lower levels of corm damage were observed on farms which upgraded their sanitation levels, i.e. total damage decreased by 41% and 43% on farms upgraded from low to high, and moderate to high, respectively. In contrast, total damage remained at the same levels on farms that maintained low levels of sanitation throughout the study. On farms achieving moderate and high sanitation levels, total damage decreased by 23% and 35%, respectively.

Farms using high levels of crop sanitation also produced the largest bunch weights (> 20 kg), although these were not significantly different from those implementing moderate levels of sanitation (about 15 kg). Farms with the lowest levels of sanitation produced the smallest bunch weights (about 12 kg).

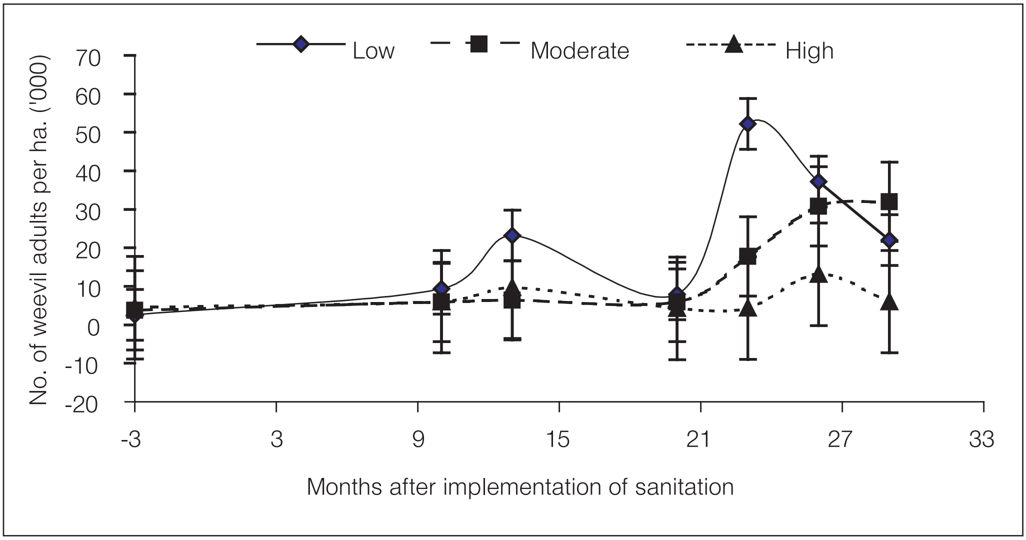

Figure 3. Changes in weevil populations in crop sanitation study at Ntungamo, Uganda (Masnza, 2003)

Table 2. Corm damage in farms employing various crop sanitation treatments, including groups of farmers increasing sanitation intensity from baseline levels, Ntungamo district, Uganda (Masanza, 2003).

Sanitation level[1]	Total corm damage (%)			
	1999 (baseline)	2000	2001	2002
L-L	3.6±0.42	4.0±0.30	3.5 ± 0.29	3.6 ± 0.56
L-M	3.8±0.27	3.0±0.20	3.6 ± 0.19	2.9 ± 0.41
L-H	2.7±0.52	1.6±0.37**	2.1 ± 0.36**	1.6 ± 0.73**
M-M	2.6±0.66	2.0±0.46*	2.5 ± 0.46	2.0 ± 0.93
M-H	2.1±0.74	1.6±0.52**	1.6 ± 0.52**	1.2 ± 1.04*
H-H	2.3±0.85	1.2±0.60**	1.6 ± 0.60**	1.5 ± 1.20

Means in a row followed by * or ** are significantly different from baseline data by Dunnett's test at $p \leq 0.05$ or $p \leq 0.01$, respectively.
[1]L=Low; M=Moderate; H=High. e.g. L-M: farmers who employed low sanitation during baseline survey and implemented moderate sanitation during study.

Table 3. Farmers' knowledge and understanding of the biology of banana weevil in Ntungamo District, Uganda (Bagamba *et al*., unpublished).

Weevil lifecycle	**Proportion (%) of farmers in each socio-economic stratum capable of identifying the weevil development stages**			
	Top	**Middle**	**Bottom**	**Overall**
Egg-adult	18.2	4.0	2.0	4.7
Larva-adult	9.1	6.0	40.0	29.1
Egg-pupa-adult	0.0	8.0	6.0	5.8
Egg-larva-pupa-adult	27.3	44.0	18.0	26.7
Do not know	45.5	28.0	20.0	33.7
No response	18.2	16.0	14.0	15.1

Farmers' knowledge of the weevil

At Ntungamo, the majority of farmers (74%) rated the weevil problem as either of moderate or high importance. However, most farmers did not fully understand the biology of the weevil (Table 3). Overall, less than 30% of the interviewed farmers were able to describe its four life stages (egg, larva, pupa and adult), while many farmers did not recognise that the larva and adult were different forms of the same insect. A higher proportion of farmers in the middle economic stratum could describe the complete life cycle. In addition, the majority of farmers in the lower and middle strata considered the adult as the most destructive stage, while the majority in the top stratum considered both adult and larva as the most damaging. This limited understanding of the weevil's biology may be one of the factors contributing to the low adoption of cultural methods for its control.

Farmers' management

Sanitation practices were the most widely known and used among the IPM technologies. Overall, about 90 % of the farmers interviewed used them to a varying extent (Table 4). However, of the 59 % of the farmers who had tried weevil trapping, 24% had subsequently abandoned this method. Covering harvested corms with banana leaves was the most common trapping method in use. The utilisation of biorationals was rarely practiced, while pesticides were not employed. Corm removal was rated as the most effective control, followed by stump removal, corm covering and leaf sheath removal (Table 5). Biorationals were rated as least effective.

Resource allocation

Labour was the major production input, mainly used in weeding, crop sanitation and soil fertility improvement. Those in lower and middle economic strata allocated most

Table 4. Proportion (%) of farmers knowing and using different banana weevil IPM technologies in Ntungamo district, Uganda (Bagamba *et al*., unpublished).

Technology	Top stratum			Middle stratum			Bottom stratum			Aggregate		
	K	U	T/A	K	U	T/A	K	U	T/A	K	U	T/A
Leaf sheath removal	100	100	0	83	97	0	100	97	0	98	98	0
Split pseudostem	100	100	0	100	94	6	97	97	2	98	96	0
Corm removal	100	75	17	90	84	13	97	85	14	95	84	14
Corm covering	100	83	8	89	94	3	93	74	12	94	81	9
Stump removal	100	100	0	100	100	0	97	97	2	98	98	33
Mulch placement	75	92	0	91	89	0	87	83	0	86	86	0
Trapping	50	42	8	60	34	25	62	34	26	57	35	24
Chemical (Furadan)	80	0	75	100	0	0	33	2	72	36	1	0
Ash	100	25	0	85	19	3	77	14	0	81	17	1
Urine	100	8	58	55	0	0	69	6	0	69	5	1

K= People who know; U= People using technology; T/A= People who tried and abandoned.

of their labour to sanitation, followed by weed control and a lesser extent, soil fertility improvement (Table 6). Those in the top socio-economic stratum allocated more labour to soil fertility improvement. Lower allocation of labour input into weeding by households in the top socio-economic stratum might be linked to the heavy mulching and the associated plant biomass from pseudostems.

Discussion

Cultural controls, including trapping and crop sanitation, have been widely recommended for the control of banana weevil (Gold *et al.*, 2001). However, few data are available on the efficacy, costs and feasibility at the farm-level for these methods. Our studies in Ntungamo district, Uganda confirm that systematic trapping can be an effective method for controlling the banana weevil, and even whose value is recognised by many farmers. However, few farmers adopt this method because of labour (perceived as "drudgery") and material requirements. Farmers also considered that the hours required for weevil trapping competed with other crop activities and leisure time. In addition, pseudostems for traps are often in short supply, especially during periods of low harvest.

Sanitation was rated by farmers as highly effective against banana weevils and consequently received greater labour resource allocation despite its drudgery. Vigorous, healthy looking plants and larger bunches influenced the farmers' perceptions. Similar observations were reported by Masanza (2003) from farms that maintained high levels of sanitation. Okech *et al.* (1998) observed greater banana residue biomass accu-

Table 5. Farmers' perceptions of effectiveness of banana weevil IPM technologies in Ntungamo district, Uganda (Bagamba *et al.*, unpublished).

Technology	Farmers' perceptions (%)			
	Very effective	Moderate	Low	Do not know
Leaf sheath removal	54	24	21	2
Split pseudostem	37	28	33	2
Corm removal	89	7	3	1
Corm covering	78	14	6	1
Stump removal	80	17	2	1
Mulch placement	31	12	55	2
Trapping	61	28	9	2
Chemical (Furadan)	50	0	36	14
Ash	2	12	83	3
Urine	5	3	90	2
Cultivar selection	12	26	60	2
Clean suckers	39	39	17	6

Table 6. Labour used by farmers in each socio-economic stratum in Ntungamo District, Uganda (Bagamba *et al*., unpublished).

Activity	**Labour (man-hours/acre)**			
	Top	**Middle**	**Bottom**	**Overall**
Weed control				
Hand hoeing	336	357	594	495
Mulching	52	17	13	18
Sanitation				
Sheath removal	48	144	177	154
Deleafing	46	144	187	159
Desuckering	51	169	152	14
Stump removal	96	118	200	164
Split pseudostems	85	55	51	56
Corm removal	63	151	130	129
Soil fertility improvement				
Manure application	278	5	6	7
Compost/residue application	167	17	10	12
Total	**1221**	**1176**	**1520**	**1341**

mulation in farms with careful management including sanitation. The larger bunches reported by Masanza (2003) may have been due to a combination of benefits such as the mulching effect of banana residues and the associated recycling of nutrients and increased organic matter.

Soil conservation bunds, mulch and farmyard manure are soil fertility management practices and are not expected to control banana weevils. In fact, mulching appears to increase the incidence of banana weevil (Rukazambuga *et al*., 2002). The results indicate that soil conservation bunds, mulch and manure had additive effects on banana yields over crop sanitation. Farmers in the high socio-economic stratum obtained greater yields and income mainly because they used manure and mulch. Thus, this reinforces the recommendation that it is worth investing in soil fertility amendment activities to benefit from the overall banana production, including weevil control. Farmers use sanitation methods because there is little expense involved besides labour, which can be provided by the family. However, practices such as mulching and manuring involve some capital investment, thus reducing their use and adoption.

Farmer adoption of cultural controls reflects a number of factors including commercial versus subsistence objectives, levels of available resources, understanding of banana weevil biology and perceptions of its importance. In addition, the perceived efficacy and benefits of IPM methods, as well as their costs remain important. Farmers in Ntungamo district are subsistence growers who market part of their production. It is likely that farmers in more commercial growing areas, such as Mbarara district would be more willing to adopt controls, including weevil trapping and crop sanitation.

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