IPM for Plantain/Coffee Agro forestry System in Northwestern Ecuador: A land use Alternative to Low-Quality Pasture Within a Fragile Agro-ecosystem

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Abstract

Pest and disease monitoring was continued through year 2001 until August 2002 on field experiments set at the Orongo farm in the Andean slopes. This monitoring helped develop basic information on incidence of Black Sigatoka on plantain and the effects of different cropping systems and soil amendments on disease and pest incidence. Both cropping systems and the amendments used (sugarcane ash and bagasse) are available in the region. An underlying objective of this work is to develop production systems that meet the economic goals of farmers without further degrading the environment, especially through excessive use of chemicals and increased erosion on Andean slopes.

The experimental sites were established in 1999 (old plantation) and 2000 (new agro forestry plantation). Black Sigatoka (*Micosphaerella fijiensis*), and weevils (black banana and striped) are main constraints to Maqueño plantain and they are being monitored. A moth larva (*Amauta cacica*) is also a prime object of research. Soil and root analyses were used to determine the status of the nematode population with relation to treatments and planting design, while a survey of selected elements of the insect communities focuses on actual and potential pests as well as parasitoids and predator guilds.

Black Sigatoka in the old plantation continues showing same pattern as in former years indicating that soil amendments do not have any influence. The situation was different in the agro forestry plantation, where an analysis of the Area Under Disease Progress Curve (AUDPC) showed differences between some treatments compared to the year before, with plantain monocultures presenting the largest infected area.

Observations on weevil and nematode populations have continued. In 2001, bagasse treatment significantly reduced populations of pest nematodes and increased populations of beneficial nematodes. During the record drought year, from November 2001 through March 2002, the nematode patterns changed dramatically. Pest nematode populations generally increased, the bagasse treatment showed no suppressing effect, and spatial variation in nematode population counts increased.

Objectives

Long term:

To develop an IPM Program for economically sustainable crop production in the fragile Sub-tropical ecosystem of the Andean slopes.

Immediate:

1. To develop basic information on the incidence of aerial plant pathogens, mainly M. fijensis, the causal agent of Black Sigatoka disease, in monoculture plantain plantations and within a polyculture agro forestry system.
2. Determine incidence, seasonality and relative abundance of pests and diseases within six different crop systems on the Andean North Occidental slopes;
3. Determine the effect of bagasse and ash amendments to root-damaging and predator nematode populations;
4. Study the life cycle and ecological preferences of *Amauta cacica*, a potentially destructive pest of plantain in the region.

IPM Constraints

This highly vulnerable Andean region requires production systems that simultaneously offer an economic activity to farmers and minimize damage to the environment. Sugarcane is a major land use activity in the region, but bagasse and ash byproducts now constitute a source of contamination; few attempts have been made to find alternative uses for them. Farmers do not have many productive alternatives in the area. Farmers now have a mixture of coffee, "banana", citrus and a low-quality pasture, *Setaria*. Coffee, banana and citrus are scattered in farms with high mortality within orchards caused by pest and diseases. The region may produce good-quality coffee and citrus. The potential for this agro-forestry system is good, provided farmers can solve their ecological (mainly soil erosion) and phytosanitary constraints.

In this environment, a constraint which is not always visible is that agricultural practices upset the equilibrium, especially when management practices designed for lower and richer soils are used.

Research Methods

Plots were established at Orongo, a Maquipucuna farm, with a combination of some of the area's widely cultivated crops. Selected crops were Maqueño plantain, coffee var. Red Caturra, an Arabic type, and lemon var. Meyer. Plots consist of single crops and combinations. There are four replications of each crop combination. Black Sigatoka disease was monitored weekly on treatments that include plantain. All plots are monitored at monthly regular intervals for the presence of insects, mites and symptoms of diseases. Soil and root analysis was done in February and August of 2002 to determine the status of the nematode population. A survey of the insect communities focused on actual and potential pests as well as parasitoid and predator guilds. Pests are being hand-collected, and yellow pan trapping is being employed to collect parasitoid and predator guilds. Traps are placed to capture variation in insect communities due to different combinations of crop plantings. Established plots of each cropping system were managed uniformly, with minimal use of chemical pesticides. All other agronomic best management practices (BMPs) ([4]Fischersworring & Robkamp) were applied.

To improve non-chemical control methods for the Banana weevil (*Cosmopolites sordidus;* Coleoptera: Dryopthalmidae), life history observations were made at Orongo and in the lowlands at Pichilingue and El Carmen. Biological studies on the banana weevil began last year in hopes of getting information that can be used to develop improved trapping methods. Studies on the banana weevil showed that the V trap (a trap made from two pieces of plantain trunk separated by a V-shaped cut) catches high numbers of weevils. For this reason this kind of trap was used in Orongo. However, to assess the effectiveness of the trap, the background adult population must be known. Cut plantain stems and dug out corms left on the ground in plantain stands at Orongo, El Carmen, and Pichilingue were searched for adult banana weevils; when these were found the relative degree of decay of the stem was noted.

When larvae of Castniidae were first found in plantain at Orongo, we assumed, based on the literature, that they were *Castniomera humbolti*, reported from elsewhere as attacking plantain and banana. Because this moth has not been systematically studied and belongs to a family about which relatively little is known, a "bottoms-up" life history study was begun at Orongo Station, where larvae cause moderate damage to mature plantain stems and where pesticides are not used for insect control. Pupae were successfully reared to adults in Spring 2002. Some specimens were sent to Dr. Jacqueline Miller (Allyn Museum, Sarasota, Florida) who identified the moth as *Amauta cacica*, not *Castniomera*. *Amauta* has never been identified as a pest species. Numbers of damaged stems were surveyed and more specimens of mature larvae and pupae were collected. Stems were cut down and destroyed as soon as evidence of an infestation was noted.

Results

Black Sigatoka. - Disease incidence continues to show the same pattern at Orongo, no matter whether ash or bagasse were applied as soil amendments. An analysis of the AUDP (Area Under Disease Progress, a measure of infestation used in the banana industry) between the treatments that included plantain in the new system is shown in Table 1 and Figure 1. Plantain + citrus (Treatment 3) presented the lower Disease Index; double-row plantain (Treatment 4) had a slightly higher index. There was statistically significant ($\alpha = 0.05$ with Duncan´s multiple range test) difference between both treatments where plantain was associated to coffee. In treatments with coffee, plantain also showed more infection when planted in single rows. This suggests that the disease is favored by planting distances as is the case with single and double row + coffee, where there was a larger diseased area.

Table 1. Median Area Under Disease Progress Curve of Black Sigatoka in the Agro forestry trial (Plantain-Coffee-Citrus) at Norwest Pichincha. Orongo-Maquipucuna. INIAP-IPM CRSP. 2000-2001.

Treatment*	AUDPC
1	6962.4
2	6985.8
3	6538.1
4	6703.1
C.V	**6.82 %**

*1= Plantain, double row + Coffee; 2= Plantain, single row + Coffee; 3 = Plantain + Citrus; 4= Plantain double row.

Black weevil and "Banana Screwworm". The moth *Amauta cacica* (Lepidoptera: Castniidae) was surveyed in plantains at Orongo Station. The moth was found to cause moderate damage on plantain at this locality, but rigorous pruning of infected stems (which can be recognized by their damaged terminal leaves) may lower levels of infestation. Mature larvae were found in March and July, the first instars were found in August and living pupae were found only in March. An adult was seen in early August, possibly ovipositing. Larvae have also been found in *Heliconia griggsiana*, a probable native host plant for this moth. *Heliconia griggsiana* is a native of Ecuador but is widely cultivated as an ornamental in Costa Rica and other tropical countries.

[4] Ecological Agriculture Guide. Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), 2001

Interestingly, *Amauta cacica* has just been discovered in plantain in northwestern Costa Rica. There, the immature stages and life cycle are being studied as part of the Moths of Guanacaste Project.

Because *Amauta* is a large insect with presumably a long life cycle, sanitation may be a practical control method; over the past two years a decrease in the number of infested stems has been observed at Orongo. Another, less appealing option might be destruction of stands of the *Heliconia* hostplant growing near plantain stands.

As for *C. sordidus*, since environmental conditions of the Andean slopes are quite different from the normal habitat of this pest, the efficiency of "V" traps was first established. Traps were scattered through the plantain systems in Orongo, where weevils were counted at 7h00 during 8 mornings. Despite low temperatures reached at night, good counts of both insects were obtained. *C. sordidus* gave larger populations during 48 hours (Fig 2), while from *M. hemipterus* larger (16 to 13) numbers were registered up to the fifth day. Moisture content of the trap seems to be the key factor for *C. sordidus*, while *M. hemipterus* seems to be able to continue feeding from partially dehydrated tissue. On the other hand, adult weevils were found to be common in cut stems and uprooted corms in platanales at the three localities. Weevils appeared to prefer intermediate levels of moisture and an intermediate stage of decay in the plantain wastes they selected for their diurnal hiding places. Life history studies on both pests will continue.

V" traps for *C. sordidus* were placed at each treatment in the new plantation in Orongo. In all the treatments including treatment 5 (Coffee alone) and treatment 6 (Citrus alone) black weevils were trapped. In the new plantation black banana weevils were recovered from V traps in all crop combinations. Even in T5 (Coffee only) and T6 (citrus only) weevils were found in the traps, which were 30 meters form the closest plantains. The data suggest that the spacing and combinations of other crops with plantain used in the new plantation had no effect on the distribution and activity of the Black weevil. (Fig 3)

<u>Nematode population</u>.- Nematofauna of trials at Maquipucuna are proving to be closely related to the different planting systems, and to the soil amendments in the old plantation. Eight-plant parasitic nematode genera were found associated with the old plantation (Figure 4); however, only two of them predominated in each treatment (Figure 5). *Helicotylenchus* , a root lesion nematode, and *Meloidogyne* were significantly present in all treatments, but quantities vary.

In 2001, ash treatment alone presented the largest number of nematodes for all treatments, with definite predominance of *Meloidogyne* spp (N=12 000) (Figure 5). On the other hand, bagasse has a strong suppressive effect against all genera of parasitic nematodes. During the drought months November 2001-March 2002, the pattern changed dramatically. Pest nematode populations showed no treatment effect and beneficial nematodes declined.

On the Agro forestry plantation, the nematofauna was related to the crops involved. The actions of pathogens in plantain were clear, reaching a high 20,000 nematodes/100 g of roots in the treatment with the double row of plantain + coffee. The predominant genus was *Helicotylenchus*. In the treatment with the single row + coffee, however, the predominant genus was *Meloidogyne*. One interesting feature observed was that despite high number of *Meloidogyne*, roots did not present as many galls as expected; in plantain + lemon and plantain alone the predominant genera were *Helicotylenchus* and *Meloidogyne*, with similar population levels.

In the second year (2001) of our project we found remarkable results on the effects of adding sugarcane stalk residue (bagasse) as a soil cover around plantain. Beneficial nematodes (predators) increased while pest nematodes decreased. In the third year (2002 through March) of this project, the pattern shifted and beneficial nematodes generally declined while pest nematodes generally increased. No treatment effects were significant. Because this third year was a record drought year, we hypothesize that the drying soil negatively affected the beneficial nematodes more than the pest nematodes.

We reasoned that free-living predatory nematodes would suffer increased mortality in the dry soil (and, no doubt, some would form resistant stages and be under-sampled). Pest nematodes on the other hand gain moisture from their plant hosts and some inhabit the host root tissue as well. With increased plant stress from the drought we also expect that nematode damage to roots would have a larger negative effect on the host plants.

Pest and disease monitoring

This year, the effect of planting systems start showing effects with relation to pest and diseases other than Black Sigatoka and the Banana stem borers; besides monitoring the systems in Orongo, occasional surveys on farms of the region allow confirmation of our results as follows:

Virosis in plantain

Symptoms resembling those viruses identified for banana and plantain (i.e Cucumber mosaic virus-CMV- and Banana streak virus –BSV) were clearly observed in Orongo and other places around it; although no attempts were made to confirm diagnosis, its incidence was registered. Figure 6 shows incidence within the plantain-coffee-citrus system, where clear differences between treatments emerge. Larger incidence was found when plantain was associated with citrus. Both coffee plantain associations had lower symptomatic plantain plants.

Pest and disease incidence in coffee and citrus.
Figures 7 to 8 show type and level of main disease and insects respectively found on coffee and citrus in the trial. For coffee (Fig 7.), foliar diseases caused by species of *Cercospora* sp., *Phoma* sp. and *Mycena* sp. are most common. *Cercospora* and *Phoma* reach highest incidence (%) values when coffee grows alone. Another pest that has been introduced in relatively recent years is coffee fruit borer caused by a coleopteran (*Hypothenemus hampei*). This pest is alarming to organic coffee farmers. If organic Arabica coffee is to be produced in the region, development of IPM alternatives or adaptation of those already available would be necessary and urgent. An evaluation of fruits harvested from the coffee-plantain system showed up to 51% of fruits bored (Fig.8) and may be representative of what is happening in the region. Ash and bagasse amendments do not seem to have any effect on it (Fig. 8).

As for citrus (Fig 9) a wider range of pests and diseases were observed on trials and throughout nearby farms. Those caused by fungi, *Alternaria* sp seemed to be causing more damage, followed by aphid incidence. *Alternaria* sp and aphids attack more when lemon is fully exposed, while in association, the disease is under control and there is less incidence of aphids. The opposite was observed for *Elsinoe* sp. Which was more intense on the associated plot. Other cropping systems and more common diseases found are presented in Table 2.

Monitoring of insect populations as a biological baseline information for the zone has continued during year 9, and there is a good estimate of the response of three different trapping systems, relative quantities of insect found in the area and main order and genera present (Table 3-A/B). Specimens are kept in the laboratory of the Experimental Station at Pichilingue.

Table 2. Diseases that affect different crops from North Western Ecuador. Orongo, F. Maquipucuna, INIAP-IPM CRSP, 2002

Crop	Organ affected	Agent of Damage
Corn	Leaves	*Fusarium* sp.
Sugar cane	Leaves	*Leptothyrium* sp.
		Phyllosticta sp.
Coffee	Leaves	*Colletotrichum* sp.
		Cercospora sp.
Lemón	Leaves	*Pestalotia* sp.
		Alternaria sp.
Pawpaw	Leaves	*Colletotrichum* sp.
Aliso	Leaves	*Pestalotia* sp.
		Macrophoma sp.
Elephant grass	Leaves	*Cercospora* sp.
	Shoots	*Colletotrichum* sp.
Bean	Leaves	*Fusarium* sp.
Plántain	Leaves	*Mycosphaerella fijiensis.*

Impact

As other details of the life cycles of *Amauta* and the banana weevil are filled in, the information will be useful for designing trapping methods and other non chemical control methods. A particular focus of future research will be looking for parasites and predators of these pests. When predators and parasites are identified, plantain stands can be managed to augment their populations, or at least ensure that other control measures are modified to minimize damage to the beneficial insects. *Heliconia griggsiana* has been found as another host for *A. cacica* opening new roads of possibilities for its management.

Information related to the systems under study on this activity is being applied to identify and suggest management methods to farmers of the region and even beyond the immediate area.

On both systems a wide variation of beneficial nematodes was found, with more in the old plantation. Genera included predators, *Mononchus*; bacteriophages, *Prismatolaymus*; omnivores, *Eudorilaymu*

Networking Activities

A workshop about organic coffee was presented. In this meeting many members from different communities around the area of the Choco-Andes Corridor received basic information about the IPM research. This is a first formal step in order to disseminate the IPM knowledge in the zone. The instructors were Ing. Duicela from COFENAC), Ing. Fischerworring from German Technical Assistant (GTZ) ,Ing. Echeverriia from Maquipucuna and Ing. Belezaca from INIAP.

Table 3 Number of insects and related captured with different types of traps and main orders and families represented within agroforestry systems on the Andean. Hda. Orongo. Fundación Maquipucuna. Noroccidente de Pichincha, Ecuador. IPM CRSP, 2002.

A : Orongo, 2001

Trampa	Fecha de captura	Sistema *	Total de insectos	Orders and Families
Malaise	Agosto 2001	SPCC	5248	Lepidoptera: Noctuidae, Pyralidae. Coleoptera: Tenebrionidae, Scarabaeidae, Chrysomelidae, Coccinellidae. Hymenoptera: Braconidae, Vespidae, Ichneumonidae, Braconidae. Díptera: Syrphidae, Tachinidae, Tephritidae. Hemiptera: Reduviidae, Pentatomidae. Blattarea, Homoptera: Aphididae, Cicadellidae, Membracidae. Mantodea: Orthoptera: Gryllidae, Acrididae. Tettigoniidae.
Malaise	Octubre 2001	SPCC	1222	
Malaise	Diciembre 2001	SPCC	10124	
Malaise	Agosto 2001	SPC	2341	
Malaise	Octubre 2001	SPC	1577	
Malaise	Diciembre 2001	SPC	9356	
Yellow pan	Agosto 2001	SPC**	363	

* SPCC = Plantain cofee-citrus system.
* SPC = Plantain-coffee system.
** Only from 10 yellow traps

B: Orongo, 2002

Trampa	Fecha de captura	Sistema *	Total de insectos	Orders and Families
Malaise	Febrero 2002	SPCC	3500	Lepidoptera: Noctuidae, Hesperiidae, Pyralidae, Coleoptera: Chrysomelidae, Coccinellidae, Scarabaeidae, Cerambycidae, Tenebrionidae, Curculionidae, Lymexylionidae, Scolytidae. Hymenoptera: Vespidae, Ichneumonidae, Formicidae, Chalcididae, Braconidae. Díptera: Tachinidae, Syrphidae, Tephritidae, *Anopheles*. Hemiptera: Pentatomidae, Reduviidae. Homoptera: Cicadellidae, Delphacidae, Aphididae. Orthoptera: Gryllidae, Acrididae, Tettigoniidae. Dermaptera: Blattarea: Mantodea.
Malaise	Agosto 2002	SPCC	766	
Malaise	Febrero 2002	SPC	5584	
Malaise	Agosto 2002	SPC	3497	
Yellow pan	Febrero 2002	SPCC **	1345	
Yellow pan	Agosto 2002	SPCC **	197	

* SPCC = System Plantain coffee-citrus.
* SPC = Plantain-coffee system.
** From 24 yellow traps

Training Output

Seven days of collaborative field work were spent with Dr. Flowers, Ing. Belezaca, Ing. Echeverria, and Veronica de la Torre (member of the Community of Palmitopamba) at Orongo. Basic entomological collecting and trapping techniques were reviewed.

Project Highlights

The castniidae moth *Amauta cacica* is at least an occasional pest of plantain in two widely separate localities (Ecuador and Costa Rica). The moth may be invading cultivated plantain from wild and cultivated stands of *Heliconia griggsiana*, and possible other species of *Heliconia*.

In “normal” wet years, populations of pest nematodes appear to be suppressed and beneficial nematodes enhanced by the addition of sugarcane bagasse as a soil amendment. Drought appears to favor populations of pest nematodes. Thus, climate change can have major impacts on nematode control programs.

Fig. 1 Area Under Disease Progress Curve of Black Sigatoka in the new plantation under differetn crooping systems during 2002. Orongo-Maquipucuna.INIAP-IPM/CRSP.

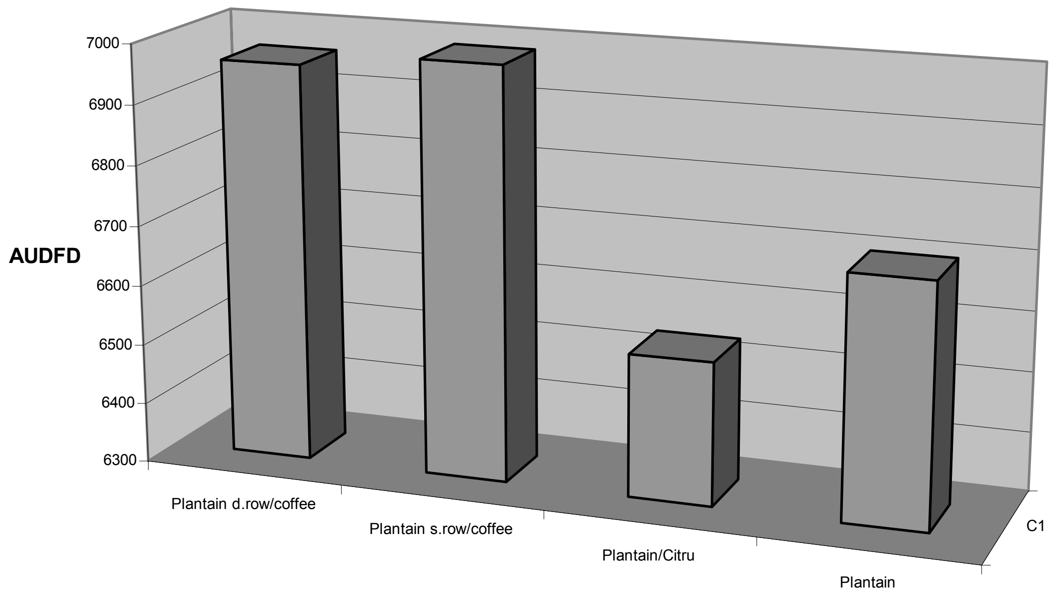
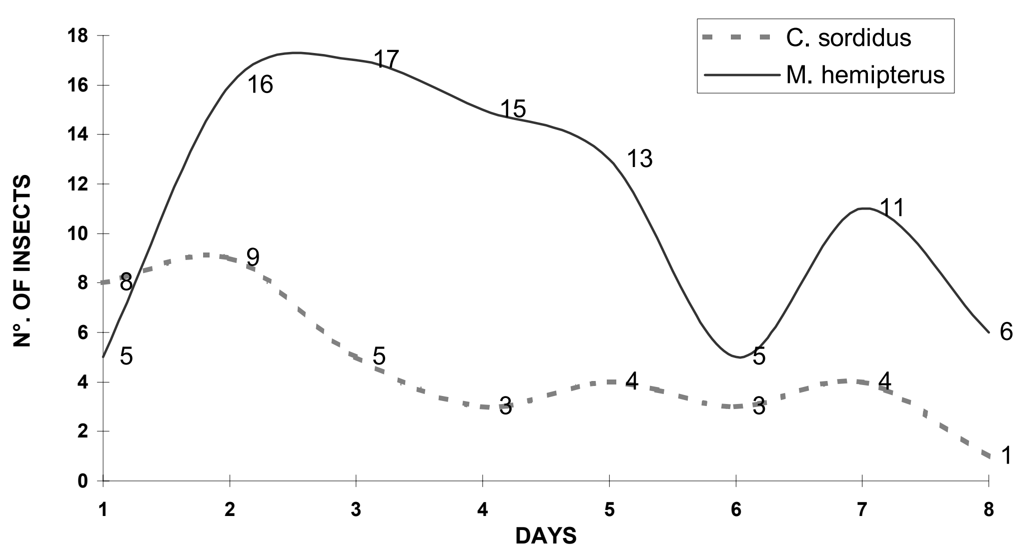
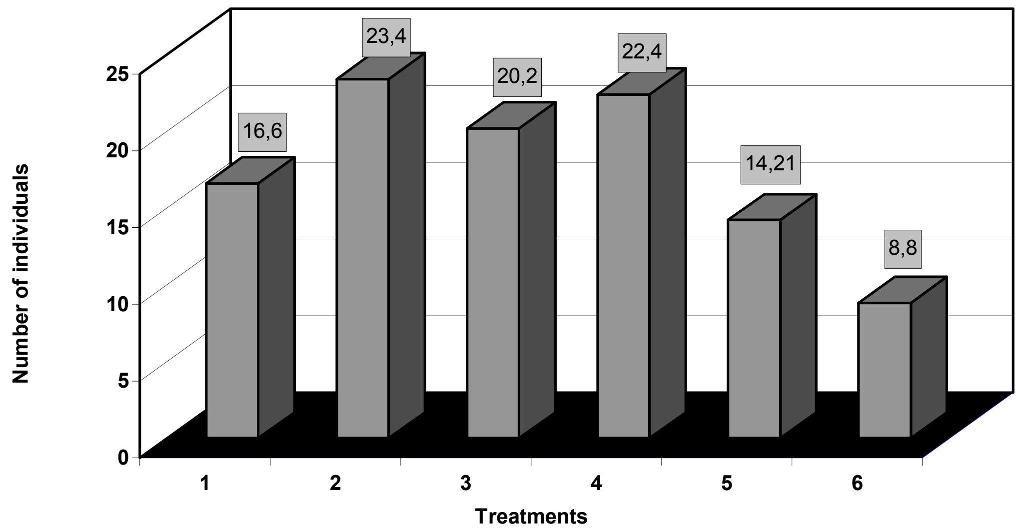


Fig. 2. Efficiency (days) of pseudostem type "V" traps for Black and Stripped weevils. Hda. Orongo. Fundación Maquipucuna. INIAP-IPM/CRSP, 2002.



1. Plantain double row + coffee; 2. Plantain single row + coffee; 3=Plantain + Lemon; 4=Plantain + Lemon; 5. Coffee alone; 6=Lemon alone

Fig. 3 Numbers of black banana weevils trapped in different crop combinations in New plantation. Orongo Farm-Maquipucuna. INIAP-IPM/CRSP. 2002



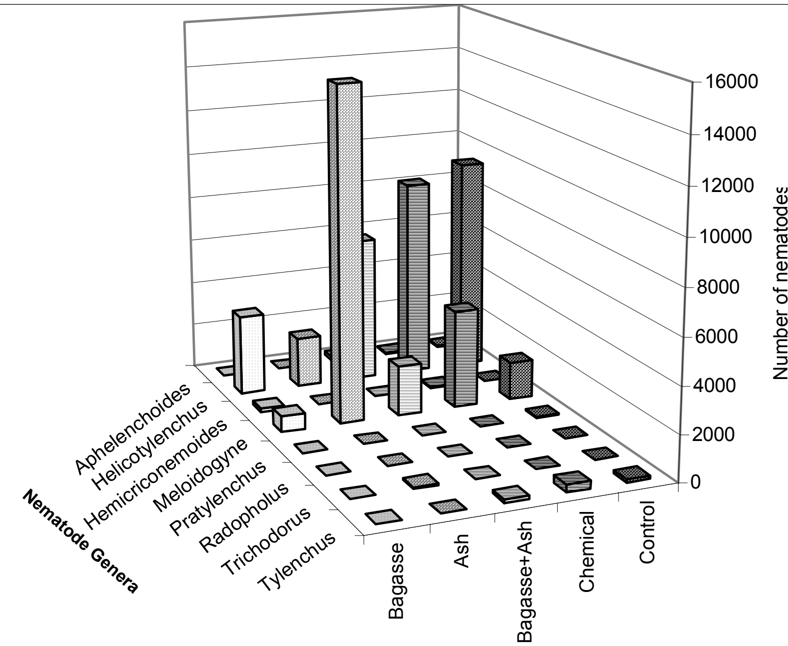


Figure 4. Average number of phytoparasitic nematodes presents in four treatments in 100 g. of plantain roots. Plantain Maqueño-Coffe System Trial,a land use alternative to low quality pasture. Orongo-Maquipucuna.2001. INIAP-IPM/CRSP.

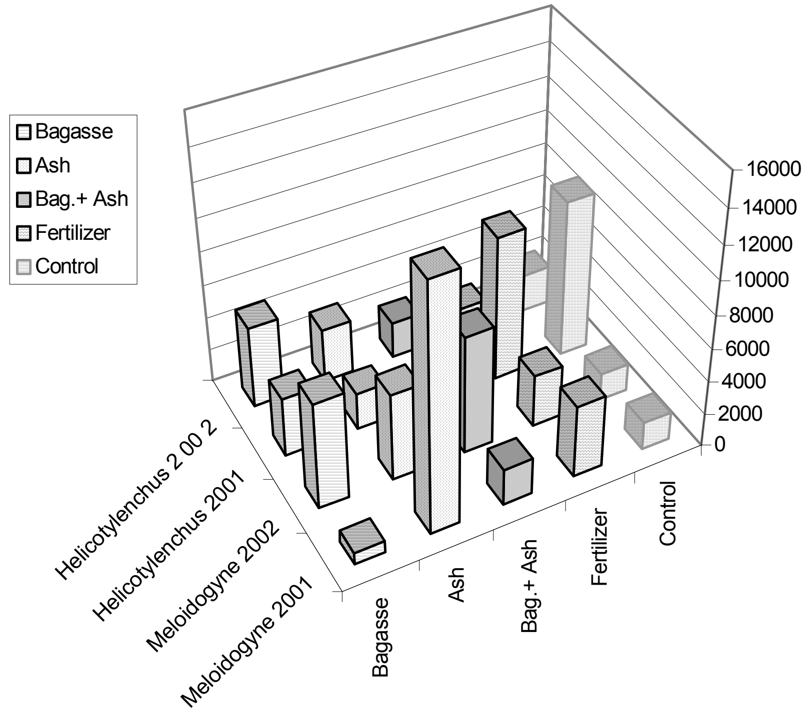


Figure 5. Average number of parasitic nematodes presents in four treatments in 100 g. of plantain roots. Plantain Maqueño-Coffe System Trial,Orongo-Maquipucuna.2001-2002. INIAP-IPM/CRSP.

Fig. 6. Virus incidence on plantain within tho agroforstry sistem coffee & citrus. Orongo. Fund. Maquipucuna. Ecuador. INIAP-IPM CRSP, 2002.

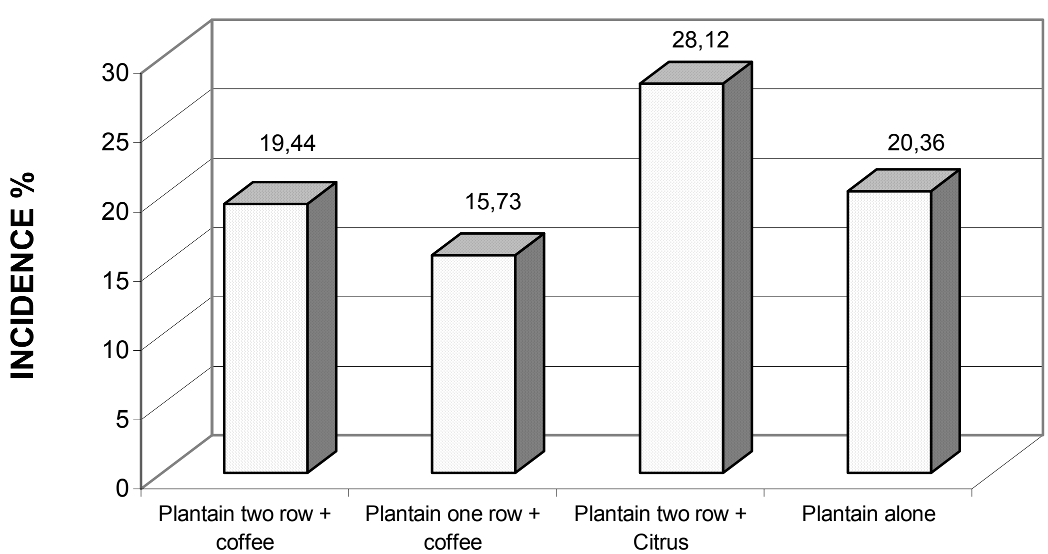


Fig. 7. Disease incidence registered in *Coffea arabiga* in Plantain - Coffee - Citrus system. Hda. Orongo. Fundación Maquipucuna. INIAP-IPM/CRSP, 2002.

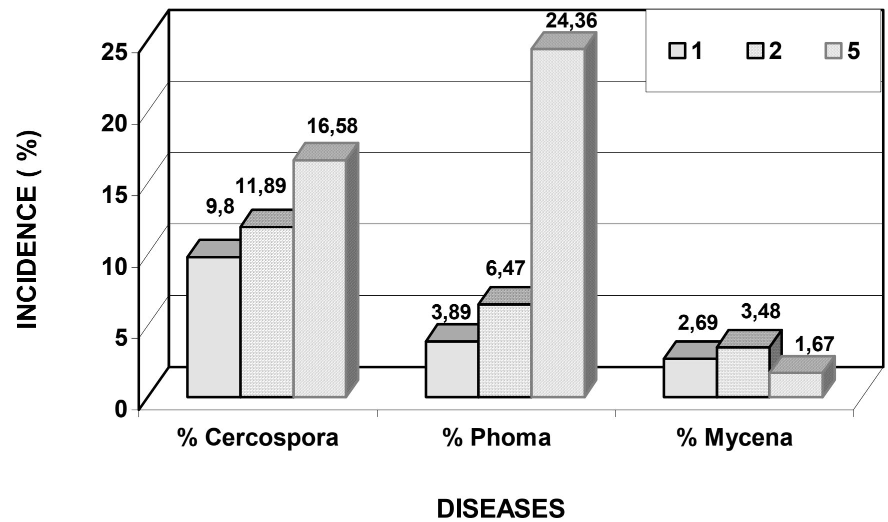
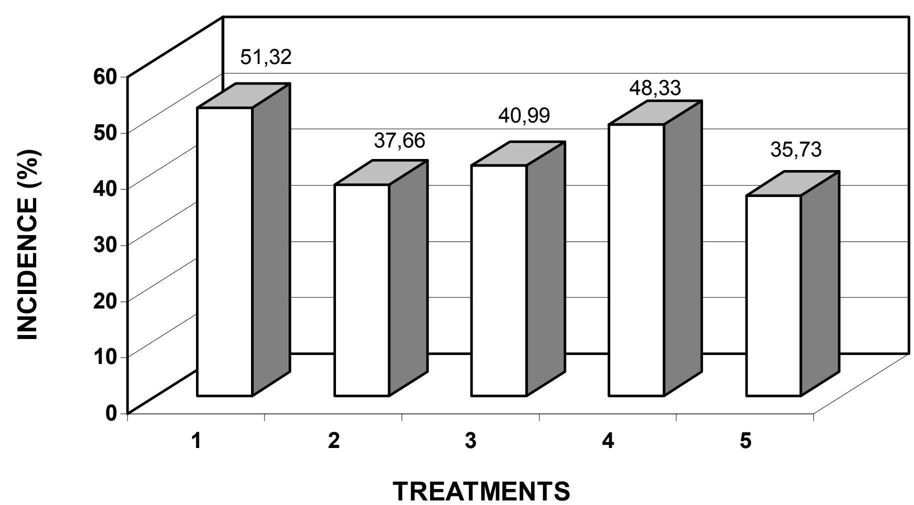


Fig. 8. Incidence of fruits bored by *H. hampei* in Coffee. Hda. Orongo. Fundación Maquipucuna. INIAP-IPM/CRSP, 2002.



Soil amendments: 1=Bagasse; 2=Ash; 3=Bagasse + Ash; 4=Nothing; 5=Fertilizer

Fig. 9. Incidence of diseases and pests registered in Citrus (Lemon cv. Meyer) in Plantain - Coffee - Citrus. Orongo, F. Maquipucuna, Ecuador. INIAP-IPM CRSP, 2002.