ATLANTIC ZONE PROGRAMME

Report No.46
Field Report No. 93

INVESTIGATIONS IN PLANTAIN

1) A study on the relation between Black sigatoka severity and soil type

2) A study on nutrient removal from the soil

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CENTRO AGRONOMICO TROPICAL DE
INVESTIGACION Y ENSEÑANZA - CATIE

UNIVERSIDAD AGRICOLA
DE WAGENINGEN - UAW

MINISTERIO DE AGRICULTURA Y
GANADERIA DE COSTA RICA - MAG

Location of the study area.

PREFACE

General description of the research programme on sustainable Landuse.

The research programme is based on the document "elaboration of the VF research programme in Costa Rica" prepared by the Working Group Costa Rica (WCR) in 1990. The document can be summarized as follows:
To develop a methodology to analyze ecologicaly sustainable and economically feasible land use, three hierarchical levels of analysis can be distinguished.
1. The Land Use System (LUS) analyses the relations between soil type and crops as well as technology and yield.
2. The Farm System (FS) analyses the decisions made at the farm household regarding the generation of income and on farm activities.
3. The Regional System (RS) analyses the agroecological and socio-economic boundary conditions and the incentives presented by development oriented activities.

Ecological aspects of the analysis comprise comparison of the effects of different crops and production techniques on the soil as ecological resource. For this comparision the chemical and physical qualities of the soil are examined as well as the polution by agrochemicals. Evaluation of the groundwater condition is included in the ecological approach. Criterions for sustainability have a relative character. The question of what is in time a more sustainable land use will be answered on the three different levels for three major soil groups and nine important land use types.

Combinations of crops and soils

	Maiz	Yuca	Platano	Piña	Palmito	Pasto	Forestal I II III
Soil I	x	x	x		x	x	x
Soil II						x	x
Soil III	x			x	x	x	x

As landuse is realized in the socio-economic context of the farm or region, feasibility criterions at corresponding levels are to be taken in consideration. MGP models on farm scale and regional scale are developed to evaluate the different ecological criterions in economical terms or visa-versa.

Different scenarios will be tested in close cooperation with the counter parts.

The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

PREFACE

My stay in Costa Rica at the Atlantic Zone Programme from July 30th 1992 to January 12th 1993, was my first in a tropical country and I have to say that I liked it very much. Costa Rica, of course, is not as underdeveloped as most countries in the Third World, however there are still a lot of problems to deal with, especially in agriculture. Many organisations have done investigations in Costarican agriculture, but very few results have been presented to the farmers. This has led to a distrust of the farmers in investigators, a problem with which I had to deal with during my work. However, I would like to thank the farmers who did trust me and helped me collecting information. I hope that my work in one way or another will contribute to the improvement of their situation or at least will help improving the confidence of farmers in investigators. Also I would like to thank don Mario, Luis, Pipi, Guillermo, Harald L. and Harald A. for their assistance during the fieldwork and Dr. R. Power (IAHL), Ir. H. Frinking (AUW) and Dr. J. Galindo (CATIE) for making it possible for me to go to Costa Rica. Finally I would like to thank Dr. H.J. Veltkamp for his support from the Netherlands and Ir. D. Jansen for his supervision in Guápiles.

Eelco Gilijamse

Guápiles, Costa Rica
January, 1993

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1 INTRODUCTION

Plantain is a crop in the Atlantic Zone that has become more and more important for export during the last decade. This has led to a demand for a higher quality product and therefore to a more intensive management by the farmers. Groups of farmers have formed small cooperatives to commercialize their product and make their position somewhat stronger in the competition with the big banana multinationals.

Most plantations in the Atlantic Zone are relatively small (1-10 ha) and not very capital intensive which make them sensitive to all kind of problems like diseases, price fluctuations, damage due to climate etcetera. The three major problems with the plantain varieties of today are their low productivity due to little bunches, the high length of the plants, which is one of the reasons that there is a lot of wind damage (up to 20 % in Honduras, Stover, 1987) and their susceptibility to the fungal disease Black sigatoka. This disease has become a serious threat to all plantain growers, but so far, most studies on it have been done in relation to banana, which is more susceptible, and only very little in relation to plantain. The first part of this report deals with the study I did on the severity of Black sigatoka in plantain in relation with soil type.

At the same time I was asked to collect information about the harvesting of plantain. This meant finding out the amount of plantain for export, for local markets, for home consumption and the amount rejected in order to look at the amount of nutrients removed from the soil. The data of this study can be found in the second part of the report.

Both studies are within the framework of the Atlantic Zone Programme, which aims at the rational use of natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner in order to create a model for sustainable landuse. The two investigations are within the plant-soil relation part that forms the base of the project.

After a few weeks of reading reports and other literature and writing my workplan, the fieldwork started at 11-9 and continued until 26-11. The writing of the report took place at the same time and the weeks afterwards.

2 CULTIVATION OF PLANTAIN IN THE ATLANTIC ZONE OF COSTA RICA

2.1 description of the plant

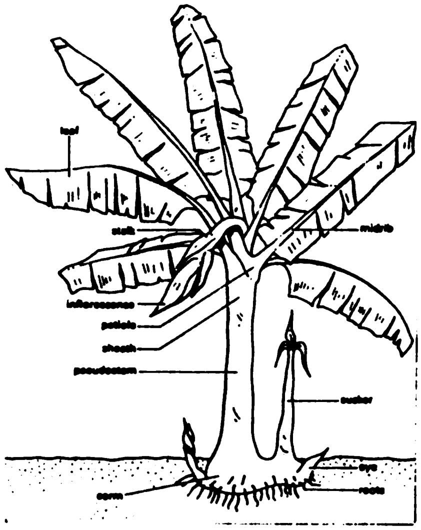
Plantain, *Musa* spp., is a perennial that originated in South East Asia (Purseglove, 1985). After Colombus discovered the New World in 1492 it was introduced in several countries of Central and South America of which Costa Rica was one. The variety that became most important here is Curraré (AAB) also known as the Horn Plantain, a hybride of *Musa acuminata* and *Musa balbisiana* (Soto, 1985; Figure 2.1)

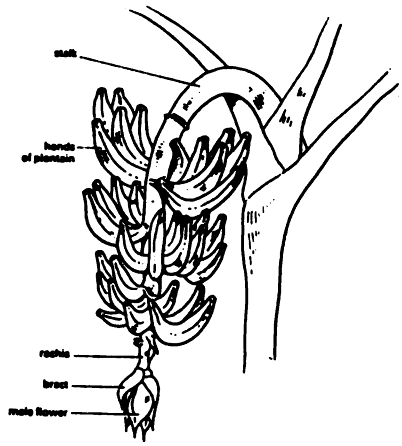
CLASIFICACION DE LOS BANANOS COMESTIBLES

Orden:	ZINGIBERALES		
Familia:	MUSACEAE		
Género:	*MUSA*		
Sección: (Serie)		(Número cromosómico básico)	
EUMUSA		(11)	
Especies:		GRUPOS ACUMINATA (CLASIFICACION 15-23)	
Musa Acuminata			CLONES
(A)	(15)	1- Diploide AA	"Lady's Finger"
		2- Triploide AAA	
		(a) Gros Michel	"Gros Michel"
		(b) Subgrupo Cavendish:	
		(b) (1) Dwarf Cavendish	"Dwarf Cavendish"
		(b) (2) Giant Cavendish	"Gran Enano"
		(b) (3) Robusta	"Valery"
		(b) (4) Lacatán	"Lacatán"
		(c) Red y Green Red	"Banano Morado" "Guineo Negro"
		3- Tetraploide AAAA	"Bodles Altafort"
		GRUPOS HIBRIDOS (CLASIFICACION 26 O MAS)	
(Hibridación)		1- Triploide (26-46) AAB Subgrupo Plantain	(1) "French Plantain" (Plátano Dominico) (2) "Horn Plantain" (Plátano Curraré)
		2- Diploide (49) AB	"Lady's Finger"
		3- Triploide (59-63) ABB	"Guineas", "Pelipita" "Cuadrado"
		4- Tetraploide (67) ABBB	"Tiparot"
Musa Balbisiana			
(B)	(75)		

Figure 2.1 Classification of bananas (Soto, 1985)

The plant has an underground stem (corm, bulb, rhizome) with eyes that develop into suckers. A pseudostem is formed out of the sheaths of the leaves until a height of about 4 m. After 7-8 months the terminal bud of the corm develops, rises in the pseudostem and produces the inflorescence (Figure 2.2). Horn plantain seldom produces a male bud and when it does this bud degenerates soon after fruit setting. The sterile female flowers develop in 5 or 6 hands on the stalk and produce parthenocarpic, seedless, fruits (du Montcel, 1987, Figure 2.3). After 80-95 days the bunch is ready for harvesting and the plant is cut down. Roots develop only until flowering and often remain grouped together in the top layer (± 30 cm) of the soil about 50 cm around the base of the plant.





Figures 2.2 and 2.3 Structure of plantain plant and inflorescence of plantain (du Montcel, 1987)

To produce an even quantity of plantain over the year, farmers let one sucker develop when the adult plant reaches a specific age (often about 6 months). After harvesting and cutting down the adult plant, the sucker will take over production. This proces of letting one or two suckers develop before the adult plant has set fruit can be continued for a long time, however when pressure of diseases is high, farmers may replant after 2-3 ratoons (du Montcel, 1987).

2.2 <u>ecology</u>

rainfall. Areas with an anual rainfall of less than 120-160 mm per month or with a dry period of more than 3-4 months should be avoided. Since rainfall in the Atlantic Zone on average exceeds 4000 mm per year and no clear dry seasons are present, this is not a constraint. Only when young suckers are planted in a period with little rain, some problems may appear. This happens for instance when suckers are planted after a storm on places were old plants have fallen out.

temperature. The optimal mean temperature is around 27 °C (du Montcel, 1987). Temperatures below 16 °C and above 38 °C will limit growth or cause damage to both plants and fruit (Figure 2.4).

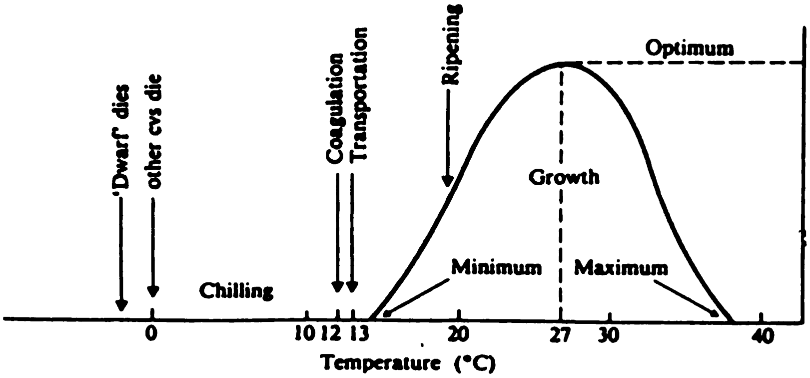


Figure 2.4 Relation between temperature and plant growth

The mean temperature in the Atlantic Zone is around 25 °C which is close to the optimal temperature, so also this factor is not a constraint. Small daily or weekly fluctuations in temperature however seem to be beneficial to yield.

wind. This climatic factor is an important problem in the Atlantic Zone since strong winds appear several times a year causing significant damage to plantain, due to its superficial root system. Velocities of only 25 km per hour already can cause a lot of damage.

light. Sunlight is an important factor since it is beneficial to plant growth and it curtails the development of fungal parasites. In the lower parts of the Atlantic Zone where plantain plantations are concentrated, sunshine is abundant throughout the year.

soil. In general plantains require a light, deep soil with few stones to enable the roots to develop unhindered. This makes them also less susceptible to wind damage. Furthermore a pH value of 5-6.5 and a high percentage of organic matter are important for plant growth. Areas liable to flooding should be avoided and artificial drainage canals often will be necessary. The most important minerals are nitrogen, potassium and magnesium (du Montcel, 1987) which should be applied if not sufficiently present. Organic matter should be applied additionally when all plant materials are taken away from the field. However on most plantations leaves, pseudostems, rejected bunches and stalks are left on the field to guarantee a high level of organic matter. The volcanic soils in the Atlantic Zone with their high levels of most minerals are often ideal to grow plantain. Only in areas with heavy soils where drainage is a constraint, problems may arise.

2.3 pests and diseases

Like other crops that are grown in monoculture, plantain is subject to a lot of pests and diseases. Not all of them are of great importance in the Atlantic Zone. An important pest is the banana weevil, *Cosmopolites sordidus*, a 12-14 mm long beetle that lays eggs in the upper part of the corm (Figure 2.5).

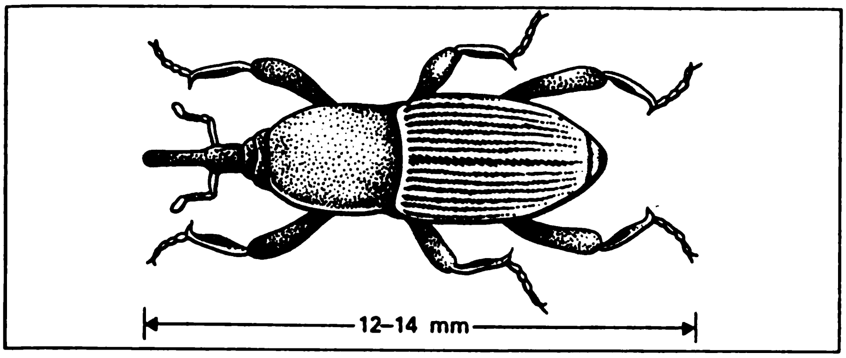


Figure 2.5 The banana weevil (du Montcel, 1987)

After hatching, the larvae bore tunnels in the corm often causing the plant to fall even at low wind speeds (du Montcel, 1987). Only on few farms in the Atlantic Zone insecticides are used to fight the banana weevil. Information on economical damage caused by this insect is not known for the Atlantic Zone.

A more important pest is the nematode *Radopholus similis* which causes lesions on the roots that are rapidly invaded by micro organisms like fungi, bacteria, etc. Heavy infestation leads to:
* a poorly developed root system making the plants more susceptible to wind damage
* general weakening of the plant
* retarded growth and development
* the production of small, poorly formed bunches

(du Montcel, 1987)

To determine the need for application of nematicide, a regular sampling of roots is needed to assess nematode population densities. In the Atlantic Zone this is not commonly done in plantain and only a few farmers apply nematicide.

The most important disease of plantain in the Atlantic Zone is Black sigatoka caused by the fungus *Mycosphaerella fijiensis* var. *difformis*. This disease reduces the photosynthetic area of the leaves resulting in premature ripening of the bunch with an abnormal color and taste of the fruit. More information on Black sigatoka can be found in Chapter 3.

Other diseases that appear on some farms in the Atlantic Zone are: Rhizome rot caused by the bacteria *Erwinia* sp. and Moko disease caused by the bacteria *Pseudomonas solanasearum* (de Vriend, 1992). The economic importance of these diseases however is low.

In relation with the above, weeds can be a serious threat to plantain. In the first place as a competitor of plantain for water and nutrients availability and in the second place as a host for insects and diseases. Weed control therefore is necessary in the first four or five months after planting, when the plant canopy is not yet closed. In the Atlantic Zone it is done by hand using a machete and chemically using a knapsacksprayer.

2.4 plantain farms in the Atlantic Zone

2.4.1 introduction

In order to get a clear view of the cultivation of plantain in the Atlantic Zone of Costa Rica I gathered information on this by reading literature, doing observations, talking with the farmers and living in the field. With the information from reports of other students and the above I could give a picture of this rather important form of small-scale agriculture.

In general the plantations are not very large (1-10 ha) and in most cases family business. This means that all the work is done by members of the family, sometimes helped by labourers. On average one man per 1-2 ha is needed, depending on the level of management. The variety that is grown in the Atlantic Zone is Curraré (Horn plantain), because this is the only one suitable for export to Europe and the United States of America. On the majority of the farms the plantation is permanent, which means that suckers of the mother plant take over production every time. When there is a lot of wind damage, new plants (corms or sword suckers) are interplanted on the places where old plants have fallen out. Only on one farm of the ten of the investigation, the farmer replants the whole plantation after three harvests. He also has a higher plant density of 3333 plants per ha (Colombian system) compared to the 1800 plants per ha on the majority of the farms which is recommended on highly fertile soils. On soils which are less fertile and on sandy soils in general, higher densities are recommended by Stover (1987).

The cropping cycle is on average 10-11 months, depending on climate, soil fertility and management (Figure 2.6). In general when a plant is 6 months old, one or two suckers are left on the corm and get the chance to develop (Roseboom et al., 1990). In this way, with a uniform field, it is possible to obtain production from a specific plot, every 6 months. When a plantation has more plots, planted at different dates, it would be possible to obtain an even yield throughout the year. This controlled system is not yet commonly used in the Atlantic Zone. Most plantations still use the uncontrolled system with plants in different stages of development in the same plot.

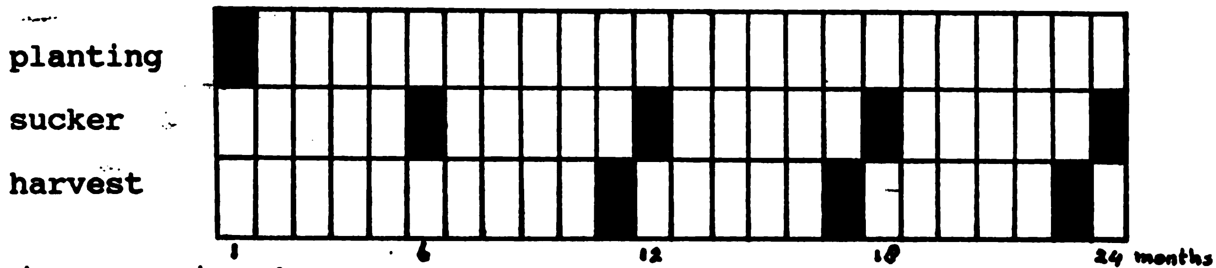


Figure 2.6 Cropping cycle

2.4.2 planting

The planting material most often used by the farmers is the corm (Figure 2.7). Sword suckers are split from the mother plant and the beginning of the leaves is cut of to get a more uniform field. The corms are planted in holes of 30 cm deep and some farmers apply a nematicide. After that, the corm is covered with soil and can start to develop again from the heart. Sometimes farmers use the whole sword sucker when only a few plants are interplanted in the plantation. Advantage of these methods is that they are easy and cheap, because little management is needed.

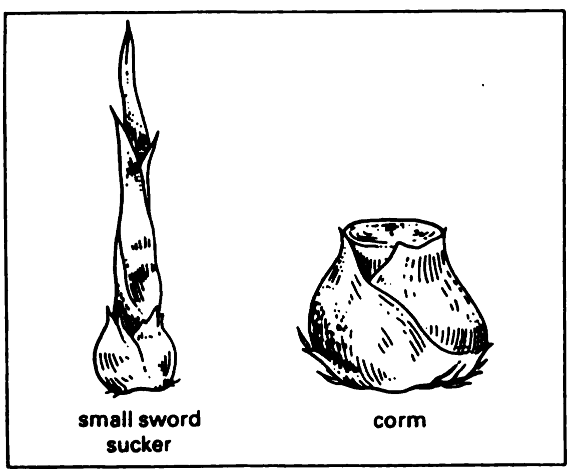


Figure 2.7 Types of planting material (du Montcel, 1987)

When there is not enough planting material, farmers cut the corms in pieces and use the parts to develop into new plants. The bits are put in plastic bags with soil, fertiliser, a fungicide and an insecticide (against the banana weevil). The bags are put in a nursery and after 4 weeks when the plants have developed 5-6 leaves, they are transplanted in the field. Advantage of this method is that the plants are much more uniform than when complete corms are used, however more management is needed.

2.4.3 pest and disease management

Control of pests and diseases starts immediately after planting at some plantations with an application of nematicide. Not all farmers use nematicides, however in the area close to Limón where strong winds are not uncommon, it is recommendable. During my field visits, I saw up to 10 % of the plants damaged by wind. Insecticides are used at some farms against the banana weevil about 3 months after planting a corm. When bits are planted in plastic bags, the insecticide is put in the bag immediately. In general it can be said that the use of insecticides and nematicides is low. Only on the farms with a high management a regular control can be found.

By far most attention is put on the control of Black sigatoka. Every 26 days (14 times per year) fungicides are applied by plane which is arranged by the cooperative of which most plantations are member.

2.4.4 weed control

On all plantations some kind of weed control is present, however the frequency differs a lot. On most farms the frequency is every three months with machete and three to four times per year by knapsacksprayer (Roseboom et al., 1990). Most common herbicide is paraquat.

2.4.5 use of fertilisers

On most farms this begins two weeks after planting when the roots begin to develop and is continued every 1-2 months depending on soil type and farm management. Fertilisers are applied as granulars in a cirkel of 30-50 cm around the base of the plant (Figure 2.8).

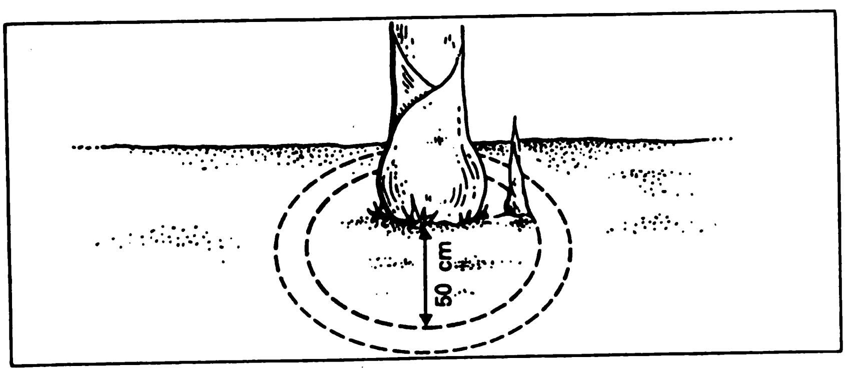


Figure 2.8 Fertiliser application (du Montcel, 1987)

The most common fertilisers are urea (47.5 % N) or nutran (33.5 % N), however on plantations with a more intensive management other fertilisers are used as well. A list of fertilisers and pesticides used in the Atlantic Zone can be found in Appendix A.

2.4.6 other crop care

Common is removing bad or wrong placed suckers, cutting leaves as a cultural practice to control Black sigatoka (Chapter 3) and sleeving the bunches. The advantage of sleeving is:
- protection of the bunch for attacks by insects which can be vectors for diseases like "punta de cigarro" caused by the fungus *Trachysphaera frutigena*
- protection of the fruit for damage caused by leaves
- creating a micro climate to reduce the time between flowering and harvest

(Roseboom et al., 1990)

Other practices are removing old leaf sheaths around the pseudostem in order to make it easier for fungicides, etc. to reach the living parts of the plant and supporting plants with rope or bambu sticks to protect them for wind damage. However the latter practice, which is very common in banana plantations, is hardly found in plantain plantations, because it is costly and labour intensive.

2.4.7 harvesting plantain

On the plantations in the Atlantic Zone, plantain is harvested every week. Depending on the size of the plantation, the time of the year, management on the farm and wind damage, the number of bunches harvested per week varies between 10 and 200. The average weight per bunch is 9.3 kg with about 30 fingers per bunch. When bunches are sleeved, they get a colored ribbon. Every week another color is harvested. Bunches are harvested by machete, first cutting the plant to let the bunch come down and than the bunch is cut of. Of the mother plant about 1.2-1.5 m is left to support the sucker for 2-3 weeks. After that it is cut down to 0.2 m above the ground (Roseboom et al., 1990). The bunches are transported to the packing site by horse, by horse and cart or, however not often, by cable like on banana plantations. In the first cases the bunches are cut into fingers on the field leaving stalk and rejected fruit behind, in the latter it happens on the packing site. The fingers are washed in a solution of water and soap followed by a bath in a solution of water and a fungicide which cures the cutting wound and prevent the entrance of fungi. The fingers are packed in carton boxes, which have a weight of 22,72 kg with a plastic layer on top. On average there are about 65 fingers or 3.1 bunches in a box (Roseboom, et al., 1990). The boxes are transported to the harbour by the cooperative and shipped to Europe and the USA. The temperature on the ships should be around 15 °C to delay the time of ripening.

2.5 marketing of plantain

In November 1987 a cooperative for plantain was founded in Estrada to make the position for the small scale farmer in the Atlantic Zone stronger. With the Banana Development Company (BANDECO) they have a contract for 112 ha of plantain to produce for export. Every week the boxes are shipped to Europe or the USA by Del Monte. The gross price the farmers receive is $ 9 per box which includes a $ 1 subsidy for Black sigatoka control. The net price is about 700 colones ($ 5,20). The difference between gross and net is used to pay the fungicide applications, membership of cooperative, etc..The last 5 years export of plantain has increased a lot til more than 11000 tonnes in 1991 (Figure 2.9). However, export should increase much more to make it possible for more farmers to produce for export and improving their income.

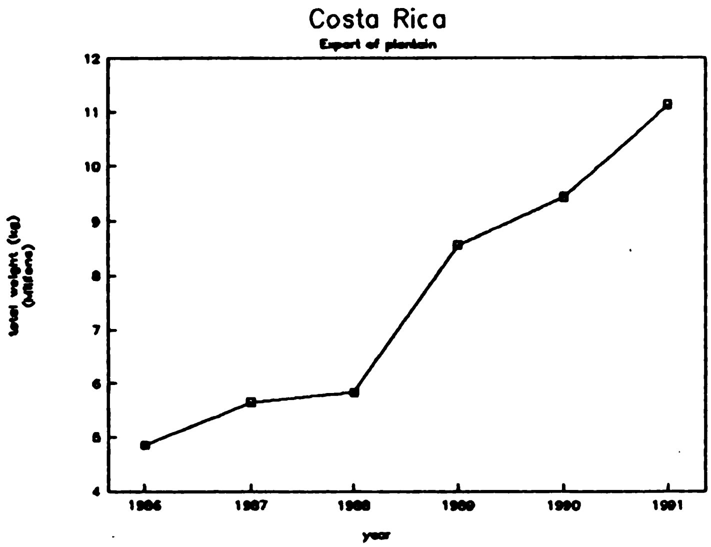


Figure 2.9 Costa Rica, export of plantain (CENPRO, 1992)

3 THE RELATION BETWEEN BLACK SIGATOKA SEVERITY AND SOIL TYPE

3.1 introduction

Black sigatoka was first detected in Honduras in 1972 and arrived in the Atlantic Zone in October 1979 (Stover, 1987, Figure 3.1).

Localidad	Primer Informe Confirmado	
Honduras, Valle de Sula		1972
Honduras, Valle del Aguán	Febrero	1978
Belice		1975
Guatemala	Enero	1977
Nicaragua		1979
México, Chiapas	Noviembre	1980
Costa Rica, Zona Atlántica	Octubre	1979
Costa Rica, Zona del Pacífico	Agosto	1981
Panamá, Zona Atlántica	Febrero	1981
Panamá, Zona del Pacífico	Septiembre	1981
Colombia, Area de Turbo	Octubre	1981
Colombia, Chaco, Córdoba	Septiembre	1986

Figure 3.1 Spread of disease (Stover, 1987)

Within a few years it reduced the total area of plantain by 50 %. In 1990 the area in the Atlantic Zone left with plantain was 4200 ha (Stover, 1987). The disease is caused by the fungus *Mycosphaerella fijiensis* var. *difformis*, which is a possible mutant of *Mycosphaerella musicola* that causes Yellow sigatoka in banana. The third similar disease is Black leaf streak caused by *Mycosphaerella fijiensis*. However Black sigatoka is the most virulent and causes most damage because natural resistence among cultivars with the B genome, like plantain, is low.

3.1.1 symptoms

The first symptoms of Black sigatoka appear on the lower surface of leaf 4 or 5 as small streaks, 20 x 2 mm, with a deep brown to red colour. The streaks elongate becoming darker until black and finally develop into elliptical, necrotic streaks with a grey center, bordered with a thin black ring around which is a yellow halo (Frossard; Stover & Simmonds, 1987 and Photo 3.1)

Photo 3.1 Black sigatoka infection on leaf (photograph by the author)

Under optimum conditions for the fungus it will take only 3 to 4 weeks from the first symptoms to the death of the entire leaf (Figure 3.2).

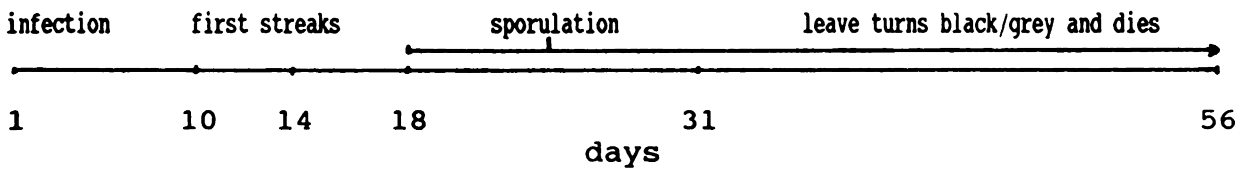


Figure 3.2 Development of the disease after germination of the spores

Defoliation of the plant is the direct damage resulting from the disease, followed by a premature maturation of the fruit leading to a smaller bunch. Most authors mention the latter without giving hard data. There seems to be a very strong relation between number of leaves at flowering and weight of bunch (Torres, in preparation).

3.1.2 epidemiology and transmission

The fungus has both an imperfect and a perfect state in which respectively conidia and ascospores develop. The conidia form on both surfaces of the brown and black spots whereas ascospores are formed in perithecia in the grey spots of the final stage only. If conditions are favourable, the brown and black spots can produce several crops of conidiospores. Optimum conditions are a film of water covering the leaf or a humidity of more than 98 % R.H. on dry leaves and a temperature between 24 and 30 °C (Frossard). The conidia are released by rain or dew and in most cases infect the young and small leaves of the suckers which are below the mother plant. The ascospores are also released when leaves are wet, but can be carried away over long distances when caught in air currents. It is said that especially the lower surface of the 'cigar' is very sensitive for infection although older leaves can be infected as well (Frossard; Stover & Simmonds, 1987). Germination takes place when there is a film of water covering the leaves (conidiospores) or when humidity exceeds 95 % R.H. (ascospores). The optimum temperature lies between 25 and 29 °C. The ascospores germinate faster (2 to 3 hours) than the conidiospores (6 hours) and incubation time varies between 15 to 70 days depending on the conditions. This explains why hardly any symptoms are found on the 'cigar' and the first 3 leaves especially on plants with a high rate of leaf formation. Only after flowering when leaf production stops, symptoms of the disease will be found on the youngest leaf when fungicide application is zero or low (which is usually the case in plantain cultivation).

3.1.3 control

The control of Black sigatoka can be divided in three parts:
* cultural practices
* resistance
* chemical control

cultural practices. The removal of leaves or parts of leaves which are over 33 % affected (stage 5 and 6 Stover scale) seems to be a useful practice (Stover, 1987), however it is very important to concentrate the leaves on the ground to limit the spread of ascospores. According to Stover (1987) infected leaves on the ground will keep the capacity to release ascospores for as long as 90 days. Improving drainage, using fertilisers, weed control, etc. are practices beneficial for plant growth, thus increasing resistence of the plant against the disease. Matching plant density to environmental conditions is a practice which had good results in banana (Stover, 1987). A closed canopy lowers the humidity caused by dew for the older leaves and suckers and fungicide applications are more effective. Also it lowers the temperature within the plantation, which is particularly important on sandy soils, making conditions for fungus development less favourable. The ideal plant population on fertile and well drained soils where plant growth is faster and more leaves are produced, is 1700 to 1800 units (mother and sucker) per ha, whereas on less fertile soils it can be up to 2000-2500 units per ha (Stover, 1987). Also plantations that replant after every 2 or 3 ratoons can have a higher plant density.

resistance. Although plantain is less susceptible to Black sigatoka than banana, it is affected heavily by the disease. Different institutions in the world (e.g. CATIE) are trying to find a variety that is resistant. Because cross breeding of plantain and banana is very time consuming, a real breakthrough has not been found yet.

chemical control. The use of chemicals in disease control is not very popular in a time of a growing environmental awareness, however for the moment it seems inevitable. The problem is the growing resistance of the fungus for the different chemicals. For instance the widely used systemic fungicide Benlate (a.i. benomyl) has almost lost its effect. Oil is used in combination with a lot of fungicides because:

- it improves the spreading and sticking properties of all fungicides
- it enhances the penetration of systemic fungicides
- it has profound effects on the pathogen inside the leaf

(Stover, 1989)

Different investigations have shown that in periods with high rainfall and high ascospore production systemic fungicides in combination with oil are very effective whereas during periods of low rainfall and low ascospore production protectant fungicides are favourable (Stover, 1989). Therefore it is important to know the rainfall pattern in order to reduce the number of applications and to use the most effective fungicides. The advantage of systemic fungicides is that they penetrate the leaf tissue, thus also protecting the unfurled 'cigar' against infection by the disease. To prevent the fungus becoming resistant for specific fungicides, cocktails of different chemicals are used more and more. Table 3.1 shows the most important fungicides that are applied in the Atlantic Zone.

trade name	active ingredient	type	dosage (kg a.i./ha)
Dithane 45	dithiocarbamate	protectant	0.75-1.5
Vondozeb	,,	protectant	0.75-1.5
Bravo 500	clorothalonil	protectant	1.5
Benlate	benomyl	systemic	0.15
Calixin	tridemorph	systemic	0.3
Tilt	propiconazole	systemic	0.1
Punch	flusilazole	systemic	0.1

Table 3.1 Most important fungicides applied in the Atlantic Zone
Source: Romero & Cubero, 1987

3.2 metodology of the investigation

The investigation was set up to find the relation between soil type and the severity of Black sigatoka in plantain in order to look for possibilities to optimize applications of fungicides, thus reducing the total amount of fungicides applied. This in the framework of creating a model for sustainable landuse. Ten farms were selected in the area around the villages Estrada and Zent about 30 km west of the Caribic Ocean (Figure 3.3).

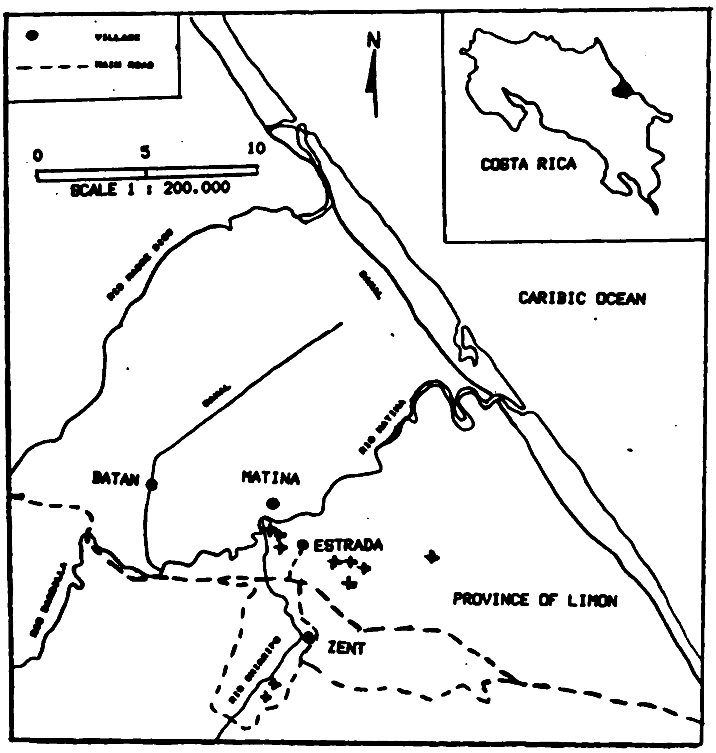


Figure 3.3 map of area of investigation (+ = location of farms)

Five of the farms had a sandy-loam and five a clayey-loam soil, all of them well drained. Nine farmers were members of the cooperative which means that they have 14 fungicide applications on their plantation per year. One farm was without applications. Differences were between the intensity of other management (e.g. weed control, cutting of infected leaves), distance to banana plantations and possibly climatic features, although that was not a part of the investigation. The farms were divided into two groups and each group was visited alternately every two weeks from 11 Oktober to 26 November (Figure 3.4).

group 1 (sandy-loam soil)	group 2 (clayey-loam soil)
Danielo Spencer	José Villegas
Theophylus Foster	Carlos Villegas
Francisco Ricketts	Ollman Villegas
Juan Salazar	Adelina
Carlos Alberto	Luis Nuñez

Figure 3.4 Division of farms in groups

On every plantation 4 sites with 5 plants each were selected by random selection for an unbiased sampling. Locations near drainage canals, paths or borders of the plantation were avoided. At the beginning of the investigation all plants were about 2 months (± 2 weeks) before flowering. They were marked with a white ribbon indicating date of selection, number of the site and plant number.

Because of wind damage, some new plants had to be selected on several plantations, however they were very close to the other plants with the same stage of development so it is expected that influence on the results will be minimum.

During the bi-weekly visits to the farms, records were made of the stage of Black sigatoka on the individual plants, using the Stover scale, modified by Gauhl. Every leaf, starting with the first fully furled (number 1) was examined for its percentage of infection which is translated in a grade of infection (Figure 3.5).

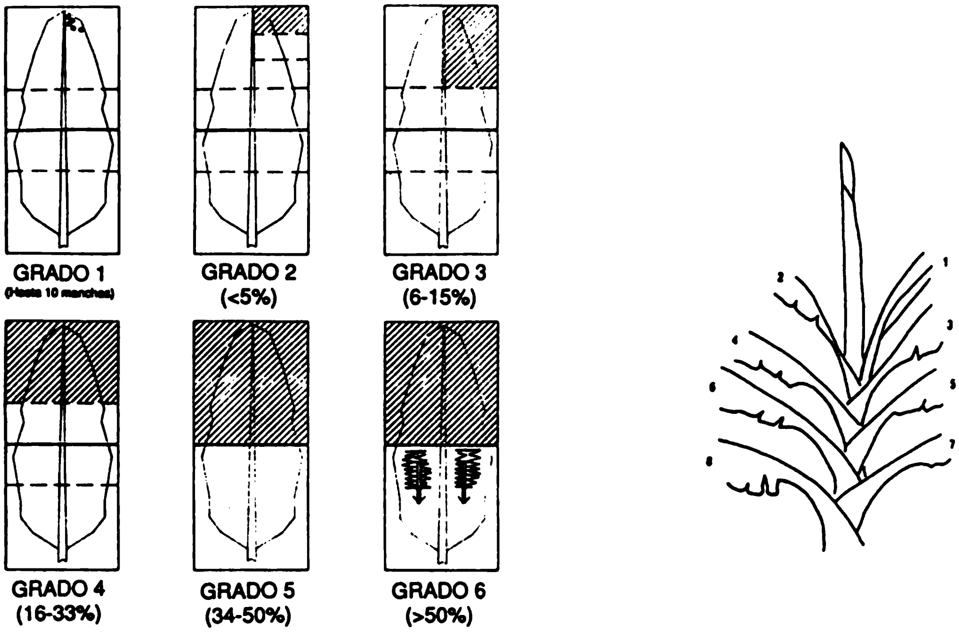


Figure 3.5 Stover scale and numbering of leaves

Of each individual plant, observations were made of the number of leaves (H/P), the youngest leaf infected (grade 1, HMJE), the youngest leaf with necrosis (usually grade 2, HMJN) and the number of leaves in a specific infection grade (Appendix B). Of every group of 5 plants the average was calculated as is shown in Figure 3.6.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	H/P	HMJE	HMJN	0	1	2	3	4	5	6
1	0	0	0	0	2	2	2	4	6							9	5	5	4	0	3	0	1	0	1
2	0	0	0	1	2	2										6	4	5	3	1	2				
3	0	0	0	1	2	2	2	4	4	5						10	4	5	3	1	3	0	2	1	
4	0	0	0	0	0	1	2	4	6							9	6	7	5	1	1	0	1	0	1
5	0	0	0	1	2	2	3	5	6	6	6					11	4	5	3	1	2	1	0	1	3
															TOTAL	45	23	27	18	4	11	1	4	2	5
															PROM.	9,0	4,6	5,4	40	9	24	2	9	4	11

Figure 3.6 Example of using form for investigation for a group of 5 plants (vertical left). Up to 15 leaves per plant can be observed, recording leaves per plant (H/P), the youngest leaf infected (HMJE), the youngest leaf with necrosis (HMJN) and the number of leaves in the different grades of the Stover scale (0 to 6)

With the percentages of leaves in a specific grade, the P.P.I. (Promedio Ponderado de Infección or mean weight of infection) could be calculated using the following formula:

$$P.P.I. = \frac{\Sigma(\%\ leaves\ with\ grade\ x\ number\ of\ grade)}{100}$$

For the example of Figure 3.6 the P.P.I. is:

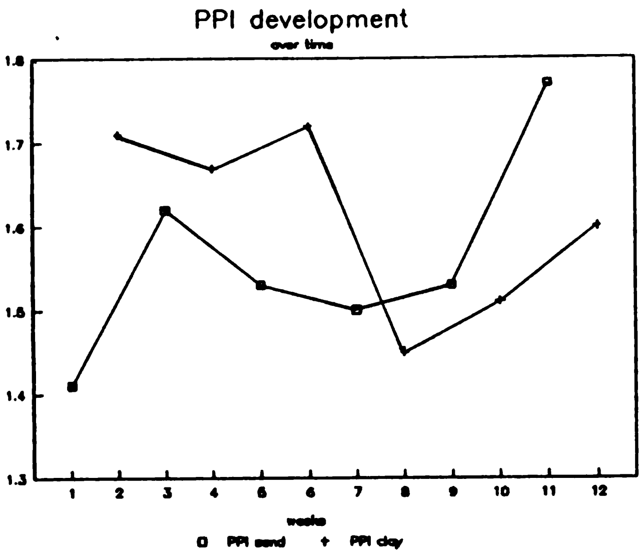
$$P.P.I. = \frac{40x0 + 9x1 + 24x2 + 2x3 + 9x4 + 4x5 + 11x6}{100} = 1{,}85$$

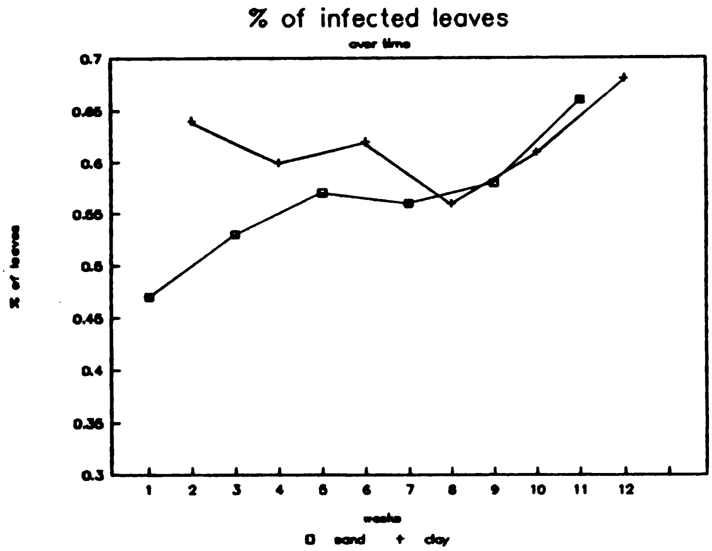
This value is supposed to indicate the severity of infection with Black sigatoka in a plantation and is usually between 1 and 2. Low infestation is under 1 and high infestation over 2. Per week the average was calculated per farm, using the P.P.I.'s of the 4 sites, and per group of farms with the same soil, using the average P.P.I.'s of the 5 farms. These values were used to find the relation between the soils and Black sigatoka severity.

3.3 results

The main parameter of the investigation, the P.P.I. (paragraph 3.2) was calculated per week (group of 5 farms with similar soil) and per farm (details in Appendix C). P.P.I. over time is fluctuating (Figure 3.7; Table 3.2); around weeks 7 and 8 it is lower and it increases afterwards. This is related to the intensive leaf cutting on the majority of the farms (esp. in group 2) in those weeks. Leaves in grades 5 and 6 of the Stover scale were removed, which has a great impact on the P.P.I.. Compared with Figure 3.8 we see that in the same weeks the percentage of infected leaves decreases much less. The cutting of leaves does not have the same impact on this parameter (removing one leaf of a plant that had 10 of which 6 infected, decreases % infected only from 60 % to 55.6 %). The increase of the P.P.I. ,starting in weeks 9 and 10, can be explained by the fact that after flowering (around week 8) no new leaves are formed and the ones present will only be more affected until harvesting. The same can be seen in figure 3.8 where the percentage of infected leaves increases after week 8 and in Figure 3.11 were HMJN decreases. The latter means that a younger leaf has necrotic spots.

A visual comparison of the soil types (Figures 3.7 & 3.8) shows no clear differences between them. Until flowering P.P.I. and % of infected leaves on the sandy soils is somewhat lower, whereas after flowering values are more or less the same on both soil types or even higher on sandy soils. However, during the final weeks precipitation was extremely low (Figure 3.14), which may have influenced plant growth on the sandy soils making the plants more susceptible to the disease.



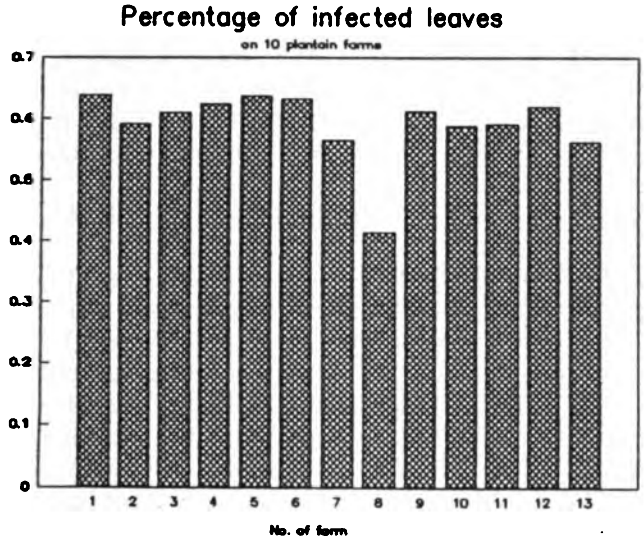


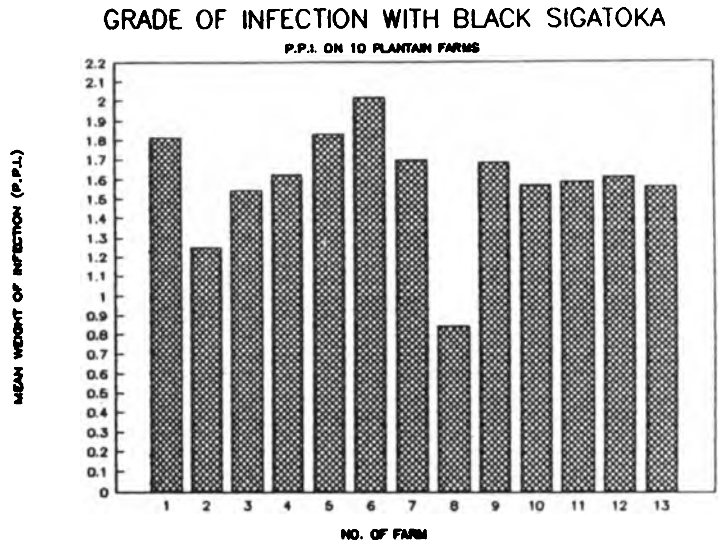
Figures 3.7 and 3.8 Development of average P.P.I. and development of % leaves infected from 11-9 to 26-11 1992 on 10 plantain farms in the Atlantic Zone of Costa Rica (week 1 = 11/9)

Table 3.2 Several parameters in relation with Black sigatoka in plantain as observed between half September and end of November on 10 farms in the Atlantic Zone of Costa Rica.

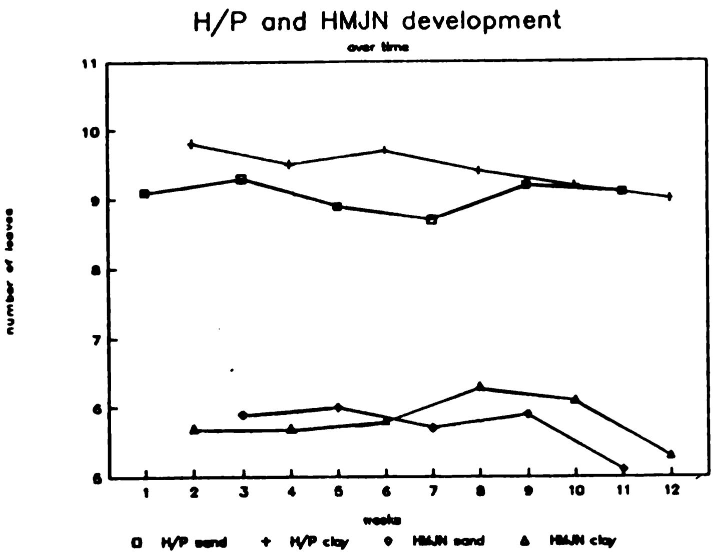
farm	plant density/ha	P.P.I.	% leaves infected	HMJN	H/P	group
1.J.Villegas	1700	1.81	64	5.6	9.3	2
2.Adelina	1800	1.25	59	6.5	9.8	2
3.C.Villegas	1800	1.54	61	5.7	9.1	2
4.Nuñez	1800	1.62	62	5.5	8.9	2
5.O.Villegas	1800	1.83	64	5.9	10.1	2
6.Ricketts	1900	2.02	63	4.3	7.4	1
7.Foster	2000	1.70	57	5.2	8.7	1
8.Spencer	2400	0.85	41	8.3	10.5	1
9.Alberto	2600	1.69	61	4.8	8.6	1
10.Salazar	3333	1.57	59	5.7	10.0	1
11.tot. ave.	2113	1.59	59	5.8	9.2	
12.ave.clay	1780	1.61	62	5.8	9.4	2
13.ave.sand	2447	1.56	56	5.7	9.0	1

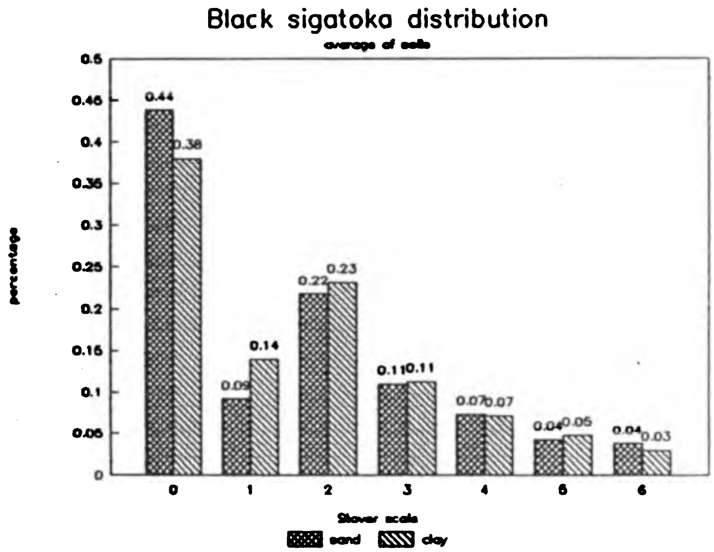
Note: The values for P.P.I., % leaves inf., HMJN and H/P are the averages over the whole period of investigation.





Figures 3.9 and 3.10 P.P.I. and % of infected leaves per farm from 11-9 to 26-11 1992 on 10 plantain farms in the Atlantic Zone of Costa Rica (see also Table 3.2)





Figures 3.11 and 3.12 Development of H/P and HMJN and distribution of leaves over grades of the Stover scale from 11-9 to 26-11 1992 on 10 plantain farms in the Atlantic Zone of Costa Rica

Comparing the averages of P.P.I. and % of infected leaves between the farms over the whole period, does not show big differences either (figures 3.9 and 3.10). Only farms 2 and 8 of Table 3.2 show a P.P.I. that is much lower, but they are situated immediately next to a banana plantation and received additional fungicide applications when the wind blew towards their farm during aerial application in the banana farms. Farm 6 shows a P.P.I. that is higher, which can be explained by the fact that no fungicides are applied. Figure 3.12 shows the averages over the period of the percentages of leaves in a specific grade of the two soil types. Also looking at this figure it is clear that differences between the soils are small to nil.

3.4 discussion and conclusions

The influence of management (esp. leaf cutting) is very obvious in the mean weight of infection (P.P.I.). The P.P.I. can therefore not be used purely to describe the development of the disease. Percentage of leaves infected is a better parameter for this purpose since it is less influenced by leaf cutting. The most accurate parameter is the youngest leaf with necrosis (HMJN), because it is determined by counting from the top of the plant downwards, so there is no influence of leaf cutting, which happens only at the oldest leaves. The youngest leaf infected (HMJE) is not very reliable, because it is difficult to determine whether a leaf is infected or not when it is about 3 m above the person who is observing. Therefore I did not use this parameter at all. In general I found that investigating Black sigatoka on different farms is very complex because too many factors (e.g. management, distance to banana plantation, climate, etc.) which are difficult to determine, have influence on the results.

Using P.P.I., % of infected leaves and HMJN it appears that until flowering severity of Black sigatoka on sandy soils is less. However, the difference with clayey soils is small. After flowering the difference is nil or even in favour of clayey soils. It should be noted that plants on sandy soils might have suffered from the relative drought in the Atlantic Zone during November. In general however, I did not find a strong relation between soil type and severity of the disease. An important reason for this, to my opinion, is that the soils in the region of the investigation do not differ a lot at all. In principle they are loamy soils, suitable for cultivation of plantain however, some with a higher sand fraction, other with a higher clay fraction. The latter are all well drained, so this factor will not have a great impact on the severity of the disease. Stover (1987) and González (1987) already stated that poor drainage increases humidity in the plantation, thus optimizing conditions for the development of Black sigatoka.

Stover and Simmonds (1987) described that spotting intensity increases between flowering and harvest. This is confirmed by Figures 3.8 and 3.11. The percentage of leaves infected increases after flowering (± week 8) and the youngest leaf with necrosis (HMJN) is younger than it was before flowering.

Looking at plant density of the farms (Table 3.2), it appears that this is higher on the plantations with sandy soils. Stover

(1987) already stated that plant density on poorer soils can be higher, because plant development is less. Sandy soils are warmed up faster by the sun than clayey soils so in order to reduce temperature within a plantation, plantdensity should be higher to prevent sunlight to reach the soil. However a density that is too high increases humidity, thus making conditions for development of the disease better. Therefore an optimum density should be found depending on quality of the soil. Using data on plantdensity and P.P.I. collected during the investigation, I did not find any relation between these parameters using linear regression, but as already mentioned too many factors had influence on the different parameters.

Coming back on the purpose of the investigation, looking for possibilities of reducing fungicide application, no reliable answers can be given. In a model for sustainable landuse, use of fungicides should be included, because for the moment this is the only way to protect plants for Black sigatoka. Optimizing fungicide application should be brought more in relation with climatic factors as rainfall and temperature, because the impact of these on the disease appears to be significant (Romero & Cubero, 1987; Stover, 1987). However, special attention should be paid on the commercial banana plantations where every 8-10 days fungicides are applied, whereas this is only every 26 days on plantain plantations.

3.5 additional investigation of Black sigatoka development in relation with rainfall

On demand of a farmer in Zent (Salazar, also in first investigation), I started an investigation on the development of Black sigatoka on young plants in relation with rainfall. This plantation is especially interesting because of the high plant density of 3333 plants per ha, which is almost double the common density of 1800 plants per ha. In order to get a better picture, this investigation will be continued by the farmer and a new student after I have left Costa Rica. In this paragraph the preliminary results are presented.

3.5.1 metodology

On a parcel of about 1 ha, plants were planted by the farmer on 4 different dates, thus forming 4 plots. On two plots the usual corms were used as planting material, on the others, plants from the nursery were used. These plants were propagated by planting bits of the corm in plastic bags and placing them in a nursery for about 4 weeks.

Half October, on every plot, 5 plants were selected that were somewhere in the middle of a plot. They were marked with a yellow ribbon with date of selection, group- and plantnumber. During 7 weeks every week observations were done.

Parameters were:
* leaves per plant
* leaves infected
* % of leaves infected
* length of plant
* HMJE
* HMJN
(Appendix D)

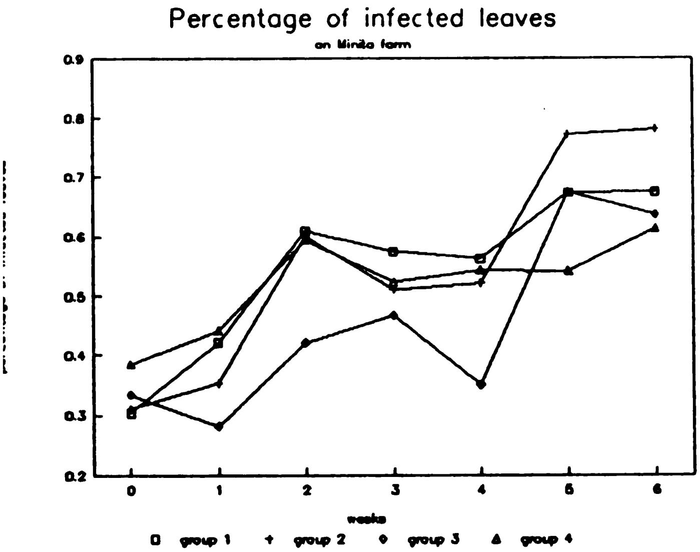
Also rainfall was measured daily by the farmer during the same period using a pluviometer.

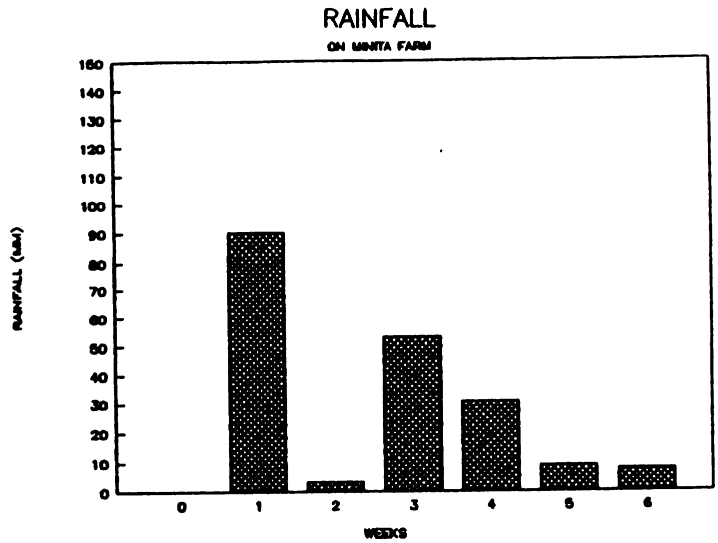
3.5.2 results and discussion

The detailed results of the investigation can be found in Appendix E. In this paragraph the main results are shown in graphs.

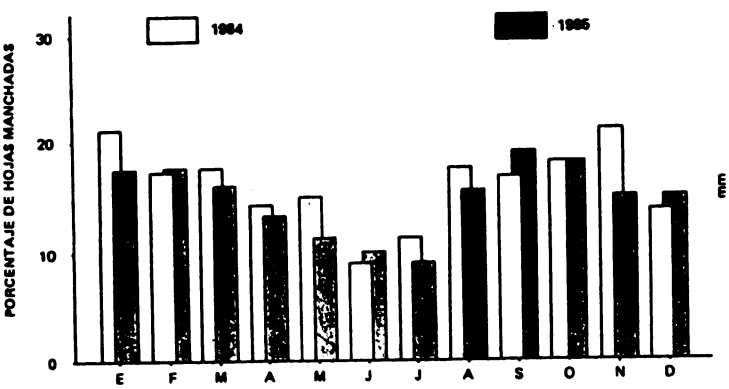
The parameter that appeared to be the same in terms of fluctuations for all plant groupes was percentage of leaves infected (Figure 3.13). It was determined by dividing leaves infected by leaves per plant and gives the percentage of all leaves infected, from only a few spots to fully necrotic.

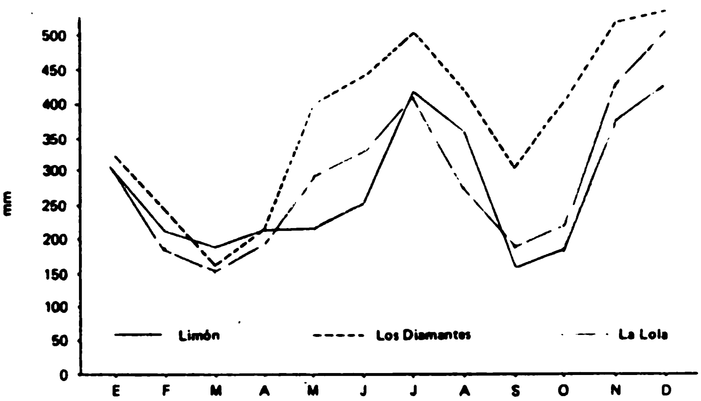
Comparing this parameter with rainfall over the period of half October to end November (Figure 3.14), very little can be said. Romero and Cubero (1987) found a strong relation between rainfall and incidence of Black sigatoka (Figures 3.15 and 3.16). From March to July disease incidence decreases, whereas from August to February it increases, thus in periods of high rainfall disease incidence is less and in periods with low rainfall higher. Spores need water to spread and to develop and therefore it appears that about a month after a period of high rainfall, disease incidence increases (e.g. December with high rainfall and January with high disease incidence). Note that the data of Romero and Cubero (1987) are of an investigation in banana where disease incidence is much lower, due to a higher frequency of fungicide applications. Also only the percentage of leaves with 'manchas' (severe infection) is used whereas I used the percentage of leaves with all forms of infection. Using data on % leaves infected of De Vriend (1992), collected on 9 farms in the Atlantic Zone during May, June, the decrease in disease incidence is present however, very small (from 65 % to 61 % leaves infected). The data collected on the farm are over too short a period to show some relation.





Figures 3.13 and 3.14 % Leaves infected and rainfall on a plantain farm in the Atlantic Zone of Costa Rica collected from half October to the end of November 1992





Figures 3.15 and 3.16 Percentage of leaves with manchas collected during 1984 and 1985 on 16 banana plantations in the Atlantic Zone and average rainfall on three locations in the Atlantic Zone (values are based on averages over more than 30 years).
Source: Romero & Cubero, 1987.

Interesting is the difference in growing rate between the different planting material (Figure 3.17). The plants from the nursery (groups 1 & 3) have an average growing rate of 13.1 and 8.0 cm per week, whereas this is 5.1 and 8.5 cm per week for corms planted directly (groupes 2 & 4). It should be brought in mind that planting date is different for the groups, which may have impact on the growing rate. Also it appeared that plants are more uniform when they are transplanted from the nursery.

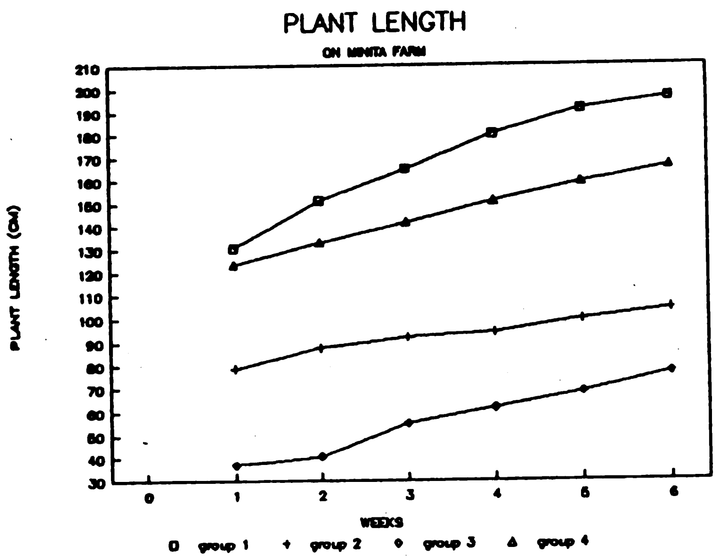


Figure 3.17 Length of plants collected on 4 different plots on a plantain farm in the Atlantic Zone from half October to the end of November 1992.

4 NUTRIENT REMOVAL BY PLANTAIN FROM THE SOIL

4.1 introduction

Removal of nutrients due to harvesting crop products, is one of the factors to be taken into account when calculating a nutrient balance on field or farm level. The Atlantic Zone Programme aims at quantifying balances for N, P and K as one of the indicators for the sustainability of a farm type.

Within this framework, I investigated the harvests on several plantations. I looked at the amount of fruit for export, for the local market, for home consumption and totally rejected fruit. Criteria for export as given by Del Monte are:
- minimum length of 9.5 inches or 24 cm
- width between 48 and 62 mm depending on destination
- length of stem minimum 2 inches or 5 cm
- maximum 3 siamese fingers in a box
- minimum weight of box 22.72 kg
- green color, no mature fingers
- no damage caused by diseases, transport, handling, etc.

Most important reasons for rejection were form matters; the 2 or 3 fingers on the lowest part of a bunch, where development of the fruit is slow, were rejected almost every time, because they were too small. Damage caused by transport or handling at the packing site was low (Bouma, 1991) and the same holds for damage caused by diseases. Mature plantain often was for home consumption. In order to check the quality of the fruit, samples are taken every harvest by the cooperative and by Del Monte, using forms on which defects can be written down. The percentage of fruit with defects is subtracted from 100 and a percentage of high quality fruit is obtained, according to which the farmer is paid.

Bunches fallen on the ground due to wind damage were left on the field, because, according to the farmers, it is not worthwhile to collect them. In the area of the investigation, wind can cause serious damage and I have seen parts of plantations where at least 10 % of bunches was lossed. Stalks and rejected fruit are normally left at the location where harvested bunches are concentrated. Transport from these locations to the packing site most often happens by horse.

The idea was to collect data on the same farms were I did the Black sigatoka investigation. However, because of difficulties with making appointments with the farmers and because of transport problems, the number of observations is rather low. Therefore I also used similar data, collected by students during the past years.

4.2 metodology

For the investigation farms were visited in the period between half September and the end of October 1992. During the harvest (always taking place on Saterdays) two types of samples were taken. One to measure weight and number of fingers, the other to determine the fraction for consumption (export, local markets and home) and the fraction of rejected fruit. For the first sample the idea was to measure 25 bunches, small and large (no specific criteria), per harvest per farm. However, on some farms the total number of harvested bunches was less so fewer bunches were taken in the sample. For the second sample the number of harvested bunches was counted and multiplied by the average weight of the bunches found with the first sample. The number of boxes for export was counted of which weight is known (22.72 kg) and the number of bunches for the other destinations (local markets, home consumption and rejected fruit). With this information the different fractions could be calculated. Also I looked at what happened with the rejected fruit and the stalks. Using information on nutrient contents of plantain and stalks of plantain from Du Montcel (1987) and Sattler (1990) it was possible to calculate the amount of nutrients removed from the field.

4.3 results and discussion

Table 4.1 Weight and number of fingers per bunch of plantain as observed during harvests between half September and end of October 1992 on 6 different farms in the Atlantic Zone of Costa Rica

farm	bunches examined	kilos/bunch			fingers/bunch			mean weight/ finger (gr)	bunches/box	fingers/box
		min	max	ave	min	max	ave			
Salazar (3333 plants/ha)	17	8.0	14.0	10.5	22	39	28.5	317 1)	2.5	72 2)
Salazar (1800 plants/ha)	35	7.0	16.0	10.3	22	37	29.6	299	2.6	76
Baltasar	18	7.0	14.0	8.8	19	39	25.9	281	3.1	81
Nuñez	25	7.0	13.0	10.4	21	37	28.2	316	2.6	72
O.Villegas	25	5.0	11.0	7.7	19	34	24.8	250	3.7	91
C.Villegas	20	5.0	15.0	9.4	19	37	29.2	271	2.9	84
E.Villegas	14	6.0	10.0	7.9	21	34	26.9	238	3.6	95
average	22	6.4	13.3	9.3	20	37	27.6	282	3.0	82

note: 1) in reality mean weight/finger for export plantain is higher. The value above is the average of all fingers, including those rejected for export because of their low weight
2) in reality fingers/box (box=22.72 kg) are less, because the above value is based on the value mean weight per finger, which is lower than in reality (see note 1)

Table 4.2 Destination of plantains harvested between half September and end October 1992 on 3 different farms in the Atlantic Zone of Costa Rica

farm	bunches	export		local market		home consumption		rejected	
		kg	%	kg	%	kg	%	kg	%
Salazar (3333 plants/ha)	154	1196	85.9	138	9.9	17	1.2	42	3.0
Salazar (1800 plants/ha)	150	812	63.0	391	30.3	35	2.7	53	4.0
Nuñez	58	409	81.5	93	18.5	0	0	0	0
C.Villegas	188	1306	87.9	45	3.0	0	0	134	9.1
average	138	931	79.6	157	15.4	13	1.0	45	4.0

The average weight of the total bunch is 9.3 kg which includes the stalk with an average weight of 1.5 kg, so weight of fruit per bunch is 7.8 kg. On average this can be divided in 6.2 kg (79.6%) for export, 1.2 kg (15.4%) for the local market, 0.08 kg (1.0%) for home consumption and 0.3 kg (4.0%) which is rejected for all purposes.

The export percentage of 79.6 % compares well with the 81.8 % found by Roseboom et al. (1990) and the 79.0-84.0 % found by Bouma (1991). The percentage home consumption is low, because in Costa Rica plantain is not a main food and the plantain eaten at home is often of an other variety, grown in small quantities in back yards. Only 4.0 % of the bunches harvested is totally rejected for all purposes and is left on the field.

With an average yield of 500 boxes (of ± 23 kg) per ha per year (COOPEPALACIOS, 1992) total weight for export is about 11500 kg and total yield per ha per year about 14000 kg of fruit. Total production per ha per year will be higher, because bunches lost (esp. by wind damage) are not counted. Using data on plant densities (paragraph 3.3) and on weight per bunch (Table 4.1), total fruit yield (without stalks) per ha per year is between 11160 and 16020 kg with an average of 13650, which comes close to the value above. Only on one farm where a part of the plantation had a plant density of 3333 plants/ha, yield per ha per year almost doubled.

Subtracting the 4 % for rejected fruit, which is left on the field, the total amount of fruit taken away from the field is ± 13500 kg per ha per year. What this means in terms of nutrient amounts of the main elements can be seen in Table 4.3.

Table 4.3 nutrient removal (kg) by plantain per ha per year

	nutrients		
kg plantain	N	P	K
1000	3.9 - 6.3	0.43 - 0.66	20.6 - 34.2
13500	52.7 - 85.1	5.8 - 8.9	278 - 463

Source: Du Montcel, 1987
Note: values of Curraré were not found, the given values are of an other variety of the AAB subgroup

In reality the values may differ from the above, because nutrient contents of pulp and skin are not the same. Smaller plantains relatively have a greater percentage of skin than large plantains. However, even though the ranges given in table 4.3 may be not exact, they will give an accurate view of the amounts of the main nutrients removed from the field by plantain. Especially the amount of potassium removed is high, whereas the soils in the Atlantic Zone do not contain sufficient K to meet the demand. Therefore potassium should be applied additionally especially during the final months of the vegetative phase, before flowering in month 9-10.

Since stalks and rejected plantains are left at the locations where harvested bunches are concentrated or are spread at the borders of plantations, on these sites nutrient removal will be less whereas inside the plantation removal will be higher. Stalks do contain a fairly high amount of nutrients, which possibly makes it worthwhile to spread them equally in the field (Table 4.4). However, more investigation should be done on this subject since labour is expensive and additional fertiliser might be cheaper. Corms, pseudostems and leaves are all left in the field for decomposition.

Table 4.4 nutrient content of stalk

	nutrients			
	N	P	K	
stalk (1.5 kg)	26.3	1.2	74.6	gr
1800 stalks/ha	47.3	2.2	134.3	kg

Source: Sattler, 1990

5 RECOMMENDATIONS

Working and investigating in the Atlantic Zone of Costa Rica for about five months I noticed several things which might have some importance for future investigations in agriculture. The first is that there is almost no cooperation between organisations working in agricultural projects. In relation to Black sigatoka in plantain, I found that besides myself; CATIE, MAG, CORBANA, EARTH, CINDE and probably many more, were working on similar investigations. Cooperation between these organisations will save a lot of time and money and makes the chance of finding a solution for the disease only greater.

The second is that feedback to the farmers is negligible. This had led to a distrust of farmers towards researchers, which makes it difficult to continue investigation. Feedback of information towards farmers is necessary to make future research possible.

In relation to Black sigatoka no recommendations can be given using the data collected during my investigation others than already given in paragraph 3.4 on the method of investigation itself. In terms of reducing Black sigatoka by cultural practices useful information was found in the literature; cutting of leaves that have more than 30 % necrosis might be a helpful method. However, leaves should be concentrated on the ground. Infected leaves keep their capacity of releasing ascospores up to 90 days (Stover, 1987), so when this practice is done wrong (when leaves are spread on the ground), the source of infection is only moved. A good drainage is important too, but most farms in the Atlantic Zone already have sufficient canals to make the soils well drained. In order to reduce the amount of fungicides in the fight against Black sigatoka one should work with the results of investigations on the relation between rainfall and disease incidence (Romero & Cubero, 1987). Apply fungicides only in periods that are favourable for Black sigatoka development, will reduce the use of them a lot. Costs will be less and the chance for the disease to develop resistance against the chemicals will be much smaller. However, one should start with this practice on banana plantations where fungicides are applied every 8-10 days whereas this is only every 26 days on plantain plantations.

A way to increase productivity per ha, to my opinion, is by planting in a higher density like it is done on Minita farm (farmer Salazar of the investigation). Also planting in plots where plants have about the same stage of development seems to be a good practice. In this way it is possible to spread specific practices to specific plots, for instance fertilising, harvesting, etcetera. This makes it easier to plan the work on a farm. However, it need to be investigated whether it is also economically interesting. To keep this system working, every 2 or 3 harvests the plantation should be replanted to maintain uniformity.

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SUMMARY

For small scale plantain farmers in the Atlantic Zone of Costa Rica the most important constraint is the disease Black sigatoka caused by the fungus *Mycosphaerella fijiensis* var. *difformis*. The disease destroys the leaves, thus reducing the photosynthetic area, resulting in premature maturation of the bunch. Several factors have got impact on Black sigatoka severity. The investigation, which was realised in the Atlantic Zone between September and December 1992, aimed at finding the relation of the disease with soil type. The second study, which took place in the same period, aimed at finding the quantities of nutrients removed from the field due to harvesting of plantain.

Appendix A

Most common fertilisers and pesticides used in the Atlantic Zone of Costa Rica

Names	dosages
Fertilisers:	
Amoniumsulphate	30 gr/plant 1 month after planting
15-3-26-6	30 gr/plant halfway cycle
10-30-10	30 gr/plant 2 weeks after planting
15-3-31	30 gr/plant 1 month before flowering
ureum or nutran	30 gr/plant 3 times per year
tripelsuperphosphate	2 gr/plant in nursery
Insecticides:	
Lannate	in the first three months after
Vidathe	planting
Ditane	
Nematicides:	
Counter	30 gr/plant 2 times per year
or Nemacur	same as counter
Herbicides:	
Gramoxone (paraquat)	4 times a year usually a combination
Roundup	of the three
Ranger	

Figures based on own observations and on Roseboom et al., 1990

Appendix B Form for Black sigatoka investigation

EVALUACION DE LA SIGATOKA NEGRA
PLANTAS PROXIMAS A PARIR

FINCA:______________ SEMANA:______________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	H/P	HMJE	HMJN	0	1	2	3	4	5	6
1																									
2																									
3																									
4																									
5																									
														TOTAL											
														PROM.											

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	H/P	HMJE	HMJN	0	1	2	3	4	5	6
1																									
2																									
3																									
4																									
5																									
														TOTAL											
														PROM.											

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	H/P	HMJE	HMJN	0	1	2	3	4	5	6
1																									
2																									
3																									
4																									
5																									
														TOTAL											
														PROM.											

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	H/P	HMJE	HMJN	0	1	2	3	4	5	6
1																									
2																									
3																									
4																									
5																									
														TOTAL											
														PROM.											

Appendix C Field observations of different parameters in relation with Black sigatoka on 10 farms in the Atlantic Zone of Costa Rica from 11-9-92 to 26-11-92

				% of leaves with stadium								
Spencer date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
11-9	10.2	7.5	-	0.64	0.10	0.14	0.07	0.05	0.00	0.00	1.00	0.79
24-9	10.1	7.5	8.7	0.64	0.13	0.16	0.04	0.02	0.02	0.01	1.02	0.74
8-10	10.5	6.9	8.3	0.56	0.15	0.19	0.06	0.05	0.00	0.00	1.01	0.89
22-10	10.8	7.2	8.0	0.57	0.10	0.20	0.08	0.04	0.01	0.00	1.00	0.94
05-11	10.5	7.1	8.5	0.59	0.13	0.20	0.08	0.01	0.01	0.00	1.02	0.81
19-11	10.7	6.5	8.0	0.52	0.16	0.24	0.09	0.00	0.00	0.00	1.01	0.91
average	10.5	7.1	8.3	0.59	0.13	0.19	0.07	0.03	0.01	0.00	1.01	0.85

				% of leaves with stadium								
Foster date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
11-9	8.5	5.8	-	0.56	0.02	0.10	0.08	0.08	0.09	0.08	1.01	1.69
24-9	8.7	4.7	5.0	0.44	0.04	0.28	0.06	0.07	0.05	0.08	1.02	1.75
8-10	7.9	4.8	5.5	0.47	0.11	0.17	0.16	0.09	0.01	0.00	1.01	1.34
22-10	8.5	4.6	5.3	0.42	0.08	0.17	0.12	0.13	0.04	0.04	1.00	1.72
05-11	9.1	4.4	5.3	0.38	0.10	0.23	0.14	0.08	0.04	0.04	1.01	1.74
19-11	9.7	4.3	5.0	0.34	0.07	0.29	0.10	0.09	0.08	0.04	1.01	1.93
average	8.7	4.8	5.2	0.44	0.07	0.21	0.11	0.09	0.05	0.05	1.01	1.70

				% of leaves with stadium								
Ricketts date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
11-9	6.9	4.2	-	0.46	0.02	0.19	0.18	0.08	0.03	0.06	1.02	1.74
24-9	7.6	4.2	4.6	0.42	0.05	0.14	0.06	0.10	0.09	0.14	1.00	2.19
8-10	7.0	3.7	4.8	0.39	0.13	0.19	0.12	0.08	0.08	0.02	1.01	1.70
22-10	7.6	4.0	4.4	0.39	0.05	0.23	0.09	0.07	0.11	0.07	1.01	2.00
05-11	7.7	3.5	4.2	0.32	0.09	0.25	0.10	0.08	0.07	0.09	1.00	2.06
19-11	7.6	2.8	3.4	0.23	0.08	0.30	0.14	0.09	0.07	0.10	1.01	2.41
average	7.4	3.7	4.3	0.37	0.07	0.22	0.12	0.08	0.08	0.08	1.01	2.02

				% of leaves with stadium								
Alberto date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
11-9	10.1	5.6	-	0.46	0.06	0.18	0.09	0.11	0.03	0.07	1.00	1.70
24-9	9.1	4.4	4.9	0.38	0.08	0.23	0.17	0.07	0.03	0.04	1.00	1.71
8-10	8.9	4.0	5.2	0.34	0.13	0.19	0.13	0.11	0.08	0.05	1.03	1.96
22-10	6.7	3.8	4.6	0.42	0.11	0.30	0.12	0.05	0.00	0.00	1.00	1.28
05-11	road blocked											
19-11	8.3	3.8	4.6	0.34	0.09	0.27	0.12	0.14	0.03	0.02	1.01	1.78
average	8.6	4.3	4.8	0.39	0.09	0.23	0.13	0.10	0.03	0.04	1.01	1.69

				% of leaves with stadium								
Salazar date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
11-9	10.0	6.2	-	0.52	0.10	0.21	0.13	0.04	0.01	0.00	1.01	1.11
24-9	10.9	5.8	6.2	0.46	0.02	0.21	0.13	0.10	0.06	0.03	1.01	1.70
8-10	10.1	5.1	6.1	0.41	0.10	0.18	0.13	0.05	0.08	0.06	1.01	1.77
22-10	10.0	5.1	6.4	0.41	0.15	0.18	0.14	0.06	0.07	0.01	1.02	1.54
05-11	9.6	4.8	5.6	0.39	0.09	0.32	0.09	0.08	0.03	0.01	1.01	1.49
19-11	9.3	3.7	4.4	0.28	0.12	0.35	0.14	0.07	0.03	0.02	1.01	1.80
average	10.0	5.1	5.7	0.41	0.10	0.24	0.13	0.07	0.05	0.02	1.01	1.57
average of sandy soils	9.0	5.0	5.7	0.44	0.09	0.22	0.11	0.07	0.04	0.04	1.01	1.56

				% of leaves with stadium								
VillegasJ date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
18-9	9.6	4.5	5.5	0.37	0.11	0.21	0.13	0.11	0.06	0.03	1.02	1.80
1-10	9.5	4.9	5.6	0.41	0.09	0.22	0.10	0.10	0.06	0.03	1.01	1.71
14-10	9.3	4.3	5.4	0.35	0.13	0.17	0.14	0.10	0.07	0.04	1.00	1.86
29-10	9.4	4.7	6.2	0.39	0.13	0.14	0.14	0.10	0.04	0.07	1.01	1.83
12-11	9.3	4.1	5.7	0.33	0.17	0.17	0.13	0.08	0.07	0.06	1.01	1.92
26-11	8.8	4.1	5.1	0.32	0.14	0.29	0.09	0.08	0.07	0.02	1.01	1.76
average	9.3	4.4	5.6	0.36	0.13	0.20	0.12	0.10	0.06	0.04	1.01	1.81

				% of leaves with stadium								
VillegasC date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
18-9	9.5	4.5	5.4	0.37	0.12	0.28	0.15	0.06	0.03	0.00	1.01	1.51
1-10	9.1	4.8	5.4	0.41	0.07	0.22	0.19	0.08	0.03	0.00	1.00	1.56
14-10	10.1	5.2	6.3	0.41	0.11	0.10	0.13	0.12	0.10	0.04	1.01	1.88
29-10	8.9	5.3	6.4	0.48	0.14	0.19	0.05	0.10	0.03	0.02	1.01	1.32
12-11	8.5	4.3	6.2	0.38	0.24	0.23	0.08	0.06	0.02	0.00	1.01	1.27
26-11	8.4	3.5	4.7	0.29	0.16	0.33	0.11	0.06	0.05	0.02	1.02	1.71
average	9.1	4.6	5.7	0.39	0.14	0.23	0.12	0.08	0.04	0.01	1.01	1.54

				% of leaves with stadium								
VillegasO date	H/P	HMJE	HMJN	0	1	2	3	4	5	6	check	P.P.I.
18-9	10.4	4.0	5.3	0.27	0.14	0.27	0.15	0.08	0.08	0.03	1.02	1.98
1-10	10.6	5.2	5.9	0.39	0.07	0.12	0.11	0.15	0.09	0.08	1.01	2.13
14-10	10.2	4.3	5.9	0.32	0.14	0.15	0.09	0.11	0.09	0.09	0.99	2.15
29-10	9.3	5.3	6.4	0.47	0.12	0.23	0.04	0.10	0.04	0.02	1.02	1.39
12-11	10.1	4.9	6.3	0.39	0.15	0.21	0.08	0.05	0.07	0.06	1.01	1.70
26-11	9.7	4.3	5.5	0.34	0.13	0.29	0.11	0.06	0.03	0.04	1.00	1.65
average	10.1	4.7	5.9	0.36	0.13	0.21	0.10	0.09	0.07	0.05	1.01	1.83

Adelina date	H/P	HMJE	HMJN	% of leaves with stadium 0	1	2	3	4	5	6	check	P.P.I.
18-9	10.4	5.3	6.9	0.42	0.16	0.20	0.10	0.08	0.05	0.01	1.02	1.48
1-10	9.6	4.8	6.3	0.39	0.19	0.24	0.15	0.03	0.01	0.00	1.01	1.26
14-10	9.6	4.7	6.0	0.38	0.16	0.38	0.06	0.02	0.01	0.00	1.01	1.21
29-10	10.2	5.2	6.5	0.41	0.14	0.30	0.12	0.03	0.01	0.00	1.01	1.26
12-11	9.2	5.3	6.5	0.46	0.14	0.33	0.07	0.01	0.00	0.00	1.01	1.02
26-11	9.8	4.9	6.8	0.39	0.20	0.24	0.12	0.03	0.02	0.00	1.00	1.25
average	9.8	5.0	6.5	0.41	0.17	0.28	0.10	0.03	0.02	0.00	1.01	1.25

Nuñez date	H/P	HMJE	HMJN	% of leaves with stadium 0	1	2	3	4	5	6	check	P.P.I.
18-9	8.9	4.0	5.5	0.36	0.18	0.18	0.09	0.05	0.09	0.06	1.01	1.80
1-10	8.9	4.5	5.1	0.39	0.08	0.26	0.13	0.05	0.03	0.06	1.00	1.69
14-10	9.1	4.7	5.6	0.42	0.10	0.23	0.15	0.07	0.04	0.01	1.02	1.52
29-10	9.3	5.0	6.1	0.44	0.12	0.22	0.11	0.07	0.03	0.02	1.01	1.43
12-11	8.9	4.3	5.8	0.37	0.18	0.19	0.13	0.04	0.06	0.05	1.02	1.66
26-11	8.3	3.4	4.6	0.28	0.16	0.34	0.12	0.06	0.03	0.01	1.00	1.63
average	8.9	4.3	5.5	0.38	0.14	0.24	0.12	0.06	0.05	0.04	1.01	1.62
average of clayey soils	9.4	4.6	5.8	0.38	0.14	0.23	0.11	0.07	0.05	0.03	1.01	1.61

Averages per week of field observations for the two soil types in the Atlantic Zone of Costa Rica from 11-9 to 26-11 1992

week	H/P sand	H/P clay	HMJN sand	HMJN clay	% infected sand	% infected clay	PPI sand	PPI clay
1	9.1				0.47		1.41	
2		9.8		5.7		0.64		1.71
3	9.3		5.9		0.53		1.62	
4		9.5		5.7		0.60		1.67
5	8.9		6.0		0.57		1.53	
6		9.7		5.8		0.62		1.72
7	8.7		5.7		0.56		1.50	
8		9.4		6.3		0.56		1.45
9	9.2		5.9		0.58		1.53	
10		9.2		6.1		0.61		1.51
11	9.1		5.1		0.66		1.77	
12		9.0		5.3		0.68		1.60

Appendix D Form for Black sigatoka investigation on Salazar farm

PO 1 (bolsas rebrote) fecha de siembra: 25-7-92

	H/P	H.I.	% Inf.	HMJE	HMJN	ALT.
1						
2						
3						
4						
5						
T						
P						

GRUPO 3 (bolsas rebrote) fecha de siembra: 15-9-92

	H/P	H.I.	% Inf.	HMJE	HMJN	ALT.
1						
2						
3						
4						
5						
T						
P						

PO 2 (semilla directa) fecha de siembra: 25-8-92

	H/P	H.I.	% Inf.	HMJE	HMJN	ALT.
1						
2						
3						
4						
5						
T						
P						

GRUPO 4 (semilla directa) fecha de siembra: 15-6-92

	H/P	H.I.	% Inf.	HMJE	HMJN	ALT.
1						
2						
3						
4						
5						
T						
P						

H/P= Hojas por planta
H.I.= Hojas infectadas
% inf.= Porcentage hojas infectada (H/P : H.I.)
HMJE= Hoja más joven enferma
HMJN= Hoja más joven necrosis
ALT.= Altura de la planta
T= Total
P= Promedio

APPENDIX E

INVESTIGACION DE SIGATOKA NEGRA Y LA RELACION CON LA PRECIPITACION
FINCA LA MINITA 2
AGRICULTOR: JUAN VINCENTE SALAZAR MORA

GRUPO 1
FECHA DE SIEMBRA: 25-7-92 (BOLSAS REBROTE)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	6.6	2.0	30.3%		5.6	
22-10-92	7.6	3.2	42.1%	130.6	5.4	6.8
29-10-92	8.2	5.0	61.0%	151.0	4.2	6.6
05-11-92	9.4	5.4	57.4%	165.0	5.0	5.8
12-11-92	9.6	5.4	56.3%	180.0	5.2	6.2
19-11-92	10.4	7.0	67.3%	190.8	4.4	7.0
26-11-92	9.2	6.2	67.4%	196.0	4.0	6.6

GRUPO 2
FECHA DE SIEMBRA: 25-8-92 (SEMILLA DIRECTA)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	5.8	1.8	31.0%		5.0	
22-10-92	6.8	2.4	35.3%	78.6	5.4	6.8
29-10-92	8.0	4.8	60.0%	87.4	4.2	7.2
05-11-92	9.0	4.6	51.1%	92.0	5.4	7.6
12-11-92	9.2	4.8	52.2%	94.0	5.8	7.0
19-11-92	9.6	7.4	77.1%	99.6	3.2	6.8
26-11-92	10.0	7.8	78.0%	104.0	5.2	7.2

GRUPO 3
FECHA DE SIEMBRA: 15-9-92 (BOLSAS REBROTE)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	4.8	1.6	33.3%		4.2	
22-10-92	6.4	1.8	28.1%	36.8	5.6	5.8
29-10-92	7.6	3.2	42.1%	40.6	5.4	7.4
05-11-92	9.0	4.2	46.7%	55.0	5.6	8.0
12-11-92	8.0	2.8	35.0%	61.6	6.2	8.0
19-11-92	8.6	5.8	67.4%	68.4	3.8	6.8
26-11-92	8.8	5.6	63.6%	76.6	4.2	7.8

GRUPO 4
FECHA DE SIEMBRA: 15-6-92 (SEMILLA DIRECTA)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	5.2	2.0	38.5%		4.2	
22-10-92	6.8	3.0	44.1%	123.4	4.4	6.0
29-10-92	7.4	4.4	59.5%	133.0	4.0	5.8
05-11-92	8.4	4.4	52.4%	141.6	5.4	6.2
12-11-92	9.2	5.0	54.3%	150.8	5.2	6.4
19-11-92	9.6	5.2	54.2%	159.0	5.8	6.4
26-11-92	8.8	5.4	61.4%	166.0	4.4	6.6

PROGRAMA ZONA ATLANTICA

INVESTIGACIONES SOBRE PLATANO

1) Un estudio sobre la relación entre el tipo de suelo y Sigatoka negra

2) Un estudio sobre la extración de nutrientes del suelo

Eelco Gilijamse

Guápiles
Enero, 1993

CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA - CATIE

UNIVERSIDAD AGRICOLA WAGENINGEN - UAW

MINISTERIO DE AGRICULTURA Y GANADERIA DE COSTA RICA - MAG

El Programa Zona Atlántica (CATIE-UAW-MAG) es el resultado de un convenio de cooperación técnica entre el CATIE, la Universidad Agrícola Wageningen (UAW) Holanda y el Ministerio de Agricultura y Ganaderia (MAG) de Costa Rica. El Programa, cuya ejecución se inició en abril de 1986, tiene, como objetivo a largo plazo la investigación multidisciplinaria dirigida a un uso racional de los recursos naturales, con énfasis en el productor pequeño de la Zona Atlántica de Costa Rica.

CONTENIDOS

PRESENTACION

El cultivo de plátano es muy importante en algunas partes de la Zona Atlántica. Durante la última década se incrementó el cultivo del plátano para exportación y se han creado asociaciones de pequeños productores quines comercializan el producto. Estas imponen estrictas condiciones de manejo de las parcelas, como fertilizar el suelo, y de la calidad del producto.

También hay muchas problemas para cultivar plátano. En la Zona Atlántica el viento es muy fuerte y causa mucho daño. Los tres plagas más importante son el nemátodo *Radopholus similis*, el picudo negro (*Cosmopolites sordidus*) y el hongo *Mycosphaerella fijiensis* var. *difformis* causante de la Sigatoka negra.

El desarollo de esta enfermedad era el tema de la investigación y la relación con el tipo de suelo.

La segunda parte del estudio era una investigación sobre la cosecha de plátano para obtener la cantidad de nutrientes que son extraidos del suelo por las frutas.

Los dos estudios se han realizado para el Progrma Zona Atlántica que tiene, como objetivo a largo plazo la investigación multidisciplinaria dirigida a un uso racional de los recursos naturales. El área de trabajo estaba en la Zona Atlántica de Costa Rica, cerca de lugares Estrada y Zent, 30 km oeste de Limón. Las observaciones se realizaron entre medio setiembre y fin de noviembre de 1992.

Sin la ayuda de los agricultores todo estos no era posible y por eso a ellos mi agradecimiento! También me gustaría agradecer a don Mario, Luis, Pipi, Guillermo, Harald L. y Harald A. por sus asistencia con el trabajo al campo y a Dr. R. Power (IAHL), Ir. H. Frinking (UAW) y Dr. J. Galindo (CATIE) por darme la possibilidad de ir a Costa Rica. Finalmente me gustaría agradecer Dr. H.J. Veltkamp por su asistencia de Holanda y Ir. D. Jansen por su supervisión en Guápiles.

Eelco Gilijamse

Guápiles
Enero, 1993

1 LA RELACION ENTRE EL TIPO DE SUELO Y SIGATOKA NEGRA

1.1 la enfermedad Sigatoka negra

La Sigatoka negra fue detectada en plátano en la Zona Atlántica de Costa Rica en octubre de 1979 y fue destruía cerca de 3000 ha de plátano. El causante de la enfermedad es el hongo *Mycosphaerella fijiensis* var. *difformis* que es muy similar a *Mycosphaerella musicola,* causante de Sigatoka amarilla y a *Mycosphaerella fijiensis*, causante de Pisca negra o Rayado negro de la hoja. Sin embargo Sigatoka negra es más virulenta y tiene un desarrollo más rapido que las otras enfermedas.

Los condiciones óptimas para el crecimiento del patógeno son una temperatura alrededor de 26°C y un humedad alta. Los primeros síntomas son visibles a simple vista en la superficie inferior de la hoja, como puntos café rojizos, menores de 0.25 mm de diámetro. Los puntos se alargan y forman estrías café rojizas, de hasta 20 mm de largo y 2 mm de ancho; en este estado son claramente visibles en el envés de la hoja. En condiciones de clima húmedo y caluroso estas estrías aparecen entre los 10 y 14 días después de la infección.

La estría se alarga ligeramente y hay un notable cambio de color, de café rojizo a café oscuro o casi negro, haciéndose claramente visible en la superficie superior de la hoja. Las estrías se agrandan, se hacen más anchas y adquieren forma elíptica, rodeándose de un borde café claro, acuoso alrededor de la mancha. Las lesiónes coalescen formando una gran mancha negra sin mostrar zonas amarillentas a su alrededor. El centro de la lesión se seca y se vuelve ligeramente gris. Si se presenta una gran densidad de lesiónes, éstas coalescen, la hoja se torna negra y muere, tres o cuatro semanas después de aparecer los primeros síntomas (fig. 1.1).

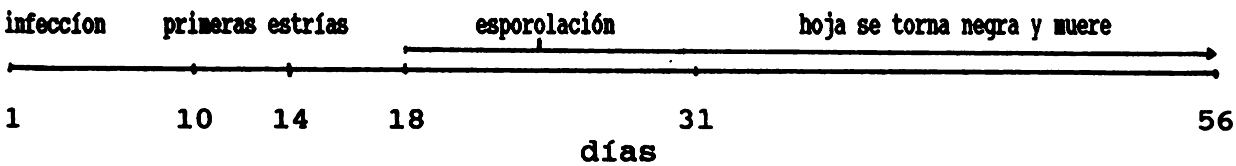


Fig. 1.1 Desarrollo de Sigatoka negra

Las esporas se propagan con el viento y con el agua de rocío o de lluvia. Estudios en la Zona Atlántica han demonstrado que existe una estrecha relación entre la incidencia de la enfermedad con la presencia de mayores o menores cantidades de lluvia por varias semanas consecutivas.

Otros cosas que favorecen la desarrollo de la enfermedad son un mal drenaje, mal control de malezas, drenajes sin limpieza y con agua estancada; asi mismo la no remoción de hojas altamente infectadas (más de 30 % necrosis), las cuales son importante fuente de inóculo, también favorecen su desarrollo. Sin embargo, las hojas en el suelo siguen produciendo ascósporas hasta por 3 meses, que son llevadas por el viento a las masas de aire superiores. Un metódo para reducir la liberación de ascósporas de las hojas en el suelo es para concentrar las hojas a algunas sitios en la plantación.

El efecto de la Sigatoka negra en la planta es la pérdida de área foliar. Esta tiene efectos severos en el crecimiento, producción y calidad de la fruta, lo que ocasiona retardos en la madurez fisiológica normal, racimos más pequeños que lo usual, así como dedos individuales pequeños y angulares con madurez prematura, esto provoca el consecuente rechazo de esta fruta en el campo o en la empacadora, pues no es apta para la exportación.

1.2 metodologia de la investigación

Para la investigación hemos seleccionado 5 plantaciones con un suelo limo-arenoso y 5 con un suelo limo-arcilloso. Cada 2 semanas un grupo de 5 plantaciones fue visitada para observar la desarollo de la Sigatoka negra (Fig. 1.2) en el periodo de 11 octubre hasta el 26 de noviembre.

grupo 1 (limo-arenoso)	grupo 2 (limo-arcilloso)
Danielo Spencer	José Villegas
Theophylus Foster	Carlos Villegas
Francisco Ricketts	Ollman Villegas
Juan Salazar	Adelina
Carlos Alberto	Luis Nuñez

Fig. 1.2 Los dos grupos de la investigación

A todos las plantaciones 4 sitios con 5 plantas cada uno fue seleccionado. Las plantas estaban mas ó menos 2 meses antes floración.

La evaluación de incidencia y severidad de Sigatoka negra estaba por medio de la metodologia de Stover modificada. Para esta evaluación se toman en cuenta todas las hojas presentes excepto la hoja candela. La hoja más cercana a la hoja candela se considera la hoja No. 1. Para determinar el área foliar afectada debe estimarse visualmente el área total cubierta por todos síntomas de la enfermedad en cada hoja. Para esto tenemos un modelo que divide la hoja en proporciones porcentuales y por medio de estas proporciones podemos clasificar los hojas en grados (Fig. 1.3).

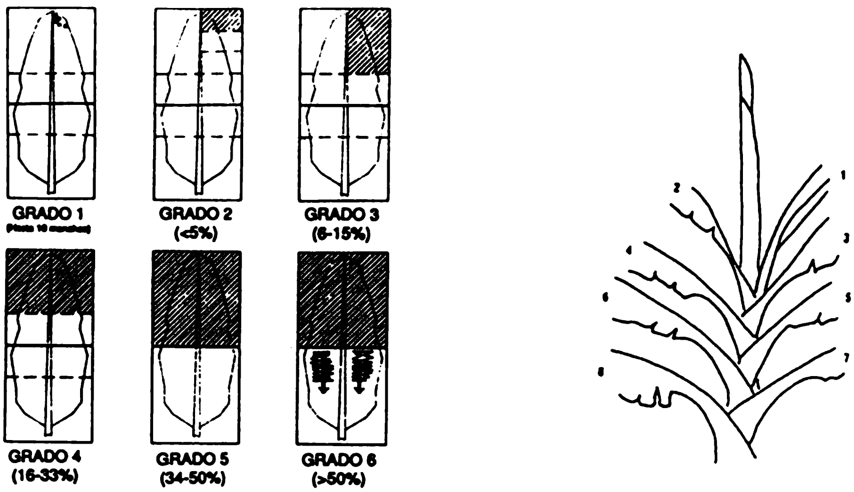


Fig. 1.3 Escala de Stover y el conteo de hojas en la evaluación de incidencia de la Sigatoka negra

A un formulario se escribe el número de hojas por planta (H/P), la hoja más joven enferma (HMJE) y la hoja más joven con necrósis (HMJN). La HMJE y la HMJN son indicaciones del progreso de la enfermedad. En otras palabras, cuanto más joven es la hoja con síntomas, mayor es la incidencia de la enfermedad.

Finalmente para la obtención del porcentaje de hojas infectadas por grado, se cuentan el número de hojas en cada grado, se divide entre el número total de hojas y se multiplica por 100. El porcentaje total de hojas infectadas se obtiene de sumar el valor de todos los grados del primero al sexto (Fig. 1.4).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	H/P	HMJE	HMJN	0	1	2	3	4	5	6
1	0	0	0	0	2	2	2	4	6							9	5	5	4	0	3	0	1	0	1
2	0	0	0	1	2	2										6	4	5	3	1	2				
3	0	0	0	1	2	2	2	4	4	5						10	4	5	3	1	3	0	2	1	
4	0	0	0	0	0	1	2	4	6							9	6	7	5	1	1	0	1	0	1
5	0	0	0	1	2	2	3	5	6	6	6					11	4	5	3	1	2	1	0	1	3
														TOTAL		45	23	27	18	4	11	1	4	2	5
														PROM.		9,0	4,6	5,4	40	9	24	2	9	4	11

Fig. 1.4 Ejemplo para usar el formulario de la investigación.

Para obtener un valor más preciso tenemos el promedio ponderado de infección (P.P.I.). Su cálculo se obtiene de multiplicar el porcentaje de hojas de cada grado por el correspondiente valor del grado en la escala de Stover modificada. Cada resultado se suma y el total se divide entre 100.

Ejemplo: Promedio Ponderado de Infección

$$P.P.I. = \frac{SUMA\ de(\%\ Hojas\ en\ cada\ grado\ x\ grado\ respectivo)}{100}$$

Con los valores de Fig. 1.4 el P.P.I. es:

$$P.P.I. = \frac{40x0 + 9x1 + 24x2 + 2x3 + 9x4 + 4x5 + 11x6}{100} = 1.85$$

1.3 resultados y discusión

Los datos detallados de la investigación se presentan en el Anexo A. La información principal por los productores y los promedios por los tipos de suelos se resume en el cuadro 1.1.

Cuadro 1.1 Promedios en relación con Sigatoka negra a 10 fincas de plátano entre 11-9 y 26-11 1992 a la Zona Atlántica de Costa Rica.

finca	densidad plantas/ha	P.P.I.	% hojas infect.	HMJN	H/P	grupo
1.J.Villegas	1700	1.81	64	5.6	9.3	2
2.Adelina	1800	1.25	59	6.5	9.8	2
3.C.Villegas	1800	1.54	61	5.7	9.1	2
4.Nuñez	1800	1.62	62	5.5	8.9	2
5.O.Villegas	1800	1.83	64	5.9	10.1	2
6.Ricketts	1900	2.02	63	4.3	7.4	1
7.Foster	2000	1.70	57	5.2	8.7	1
8.Spencer	2400	0.85	41	8.3	10.5	1
9.Alberto	2600	1.69	61	4.8	8.6	1
10.Salazar	3333	1.57	59	5.7	10.0	1
11.promedio	2113	1.59	59	5.8	9.2	
12.pro.clay	1780	1.61	62	5.8	9.4	2
13.pro.sand	2447	1.56	56	5.7	9.0	1

El valor principal, el P.P.I. fue calculado por semana como un promedio de un grupo de 5 fincas con un suelo similar y como un promedio por finca sobre los 12 semanas de la investigación (Fig. 1.5 y 1.6).

El P.P.I. por semana se fluctúa mucho; las semanas 7 y 8 el P.P.I. es más baja porque en este periodo la mayoría de los productores han cortado las hojas infectadas (hojas con el grado 5 y 6 de la escala Stover). Después de la semana 8 el P.P.I. sube, porque después la floración (mas ó menos en semana 8) no se han desarrollado nuevas hojas. Las viejas hojas son infectado más y más después de la floración. Lo mismo resulta con los datos de porcentaje de hojas infectadas (Fig. 1.7). También después de la semana 8 el gráfico sube. Entre los fincas no hay mucho diferencia. Solamente los fincas 2 y 8 tienen un P.P.I. que es más bajo, pero ellos estan cerca de un bananera y probablemente obtiene más fungicidas con el viento cuando hay aplicaciones a los bananeras. Más ó menos lo mismo resulta del gráfico de porcentaje hojas infectadas por finca (Fig. 1.8).

En general resulta que no hay mucho diferencia entre los fincas con un suelo limo-arenoso y con un suelo limo-arcilloso. Parece que antes de la floración la situación del primer grupo esta un poco mejor, pero después el segundo grupo tiene menos problemas con Sigatoka negra.

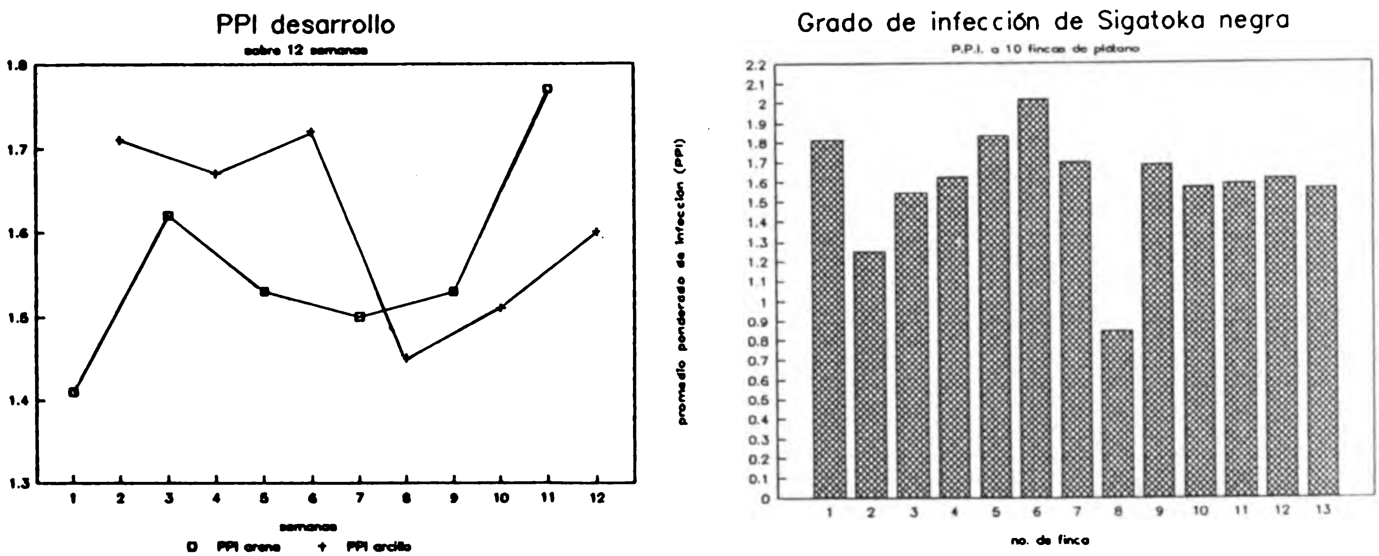
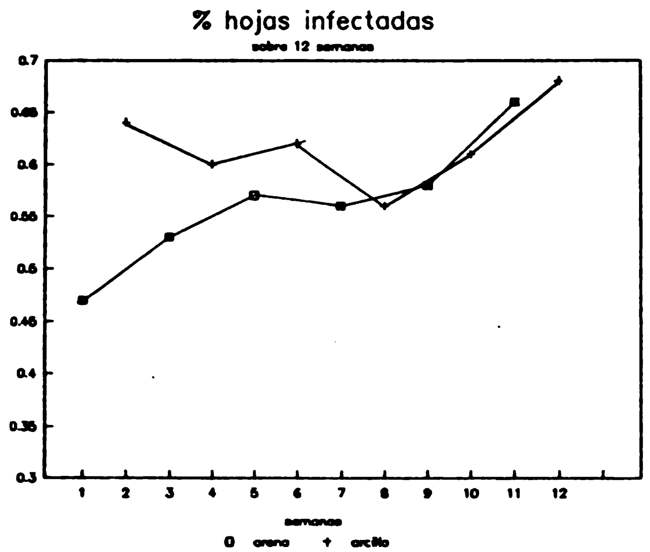


Fig. 1.5 y 1.6 La desarrollo de P.P.I. por semana por los dos tipos de suelos y el promedio P.P.I. por finca en la Zona Atlántica entre 11-9 y 26-11 1992 (semana 1 = 11-9)



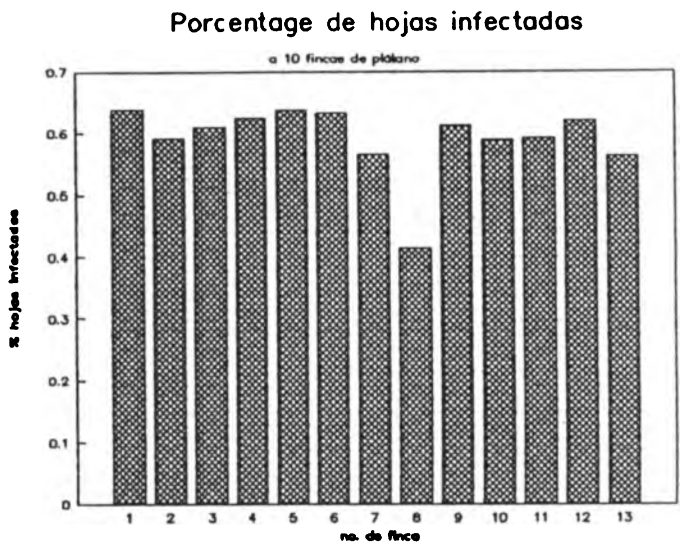


Fig. 1.7 y 1.8 La desarrollo de la porcentaje hojas infectadas por semana por los dos tipos de suelos y el promedio por finca en la Zona Atlántica entre 11-9 y 26-11 1992 (semana 1 = 11-9)

Cuando se compara el porcentaje hojas en cada grado por los dos tipos de suelos, también resulta que la diferencia es muy poco. El porcentaje de hojas en grado 0 es 44 % por los suelos limo-arenosos y 38 % por los suelos limo-arcillosos y el porcentaje en grado 1 es respectivamente 9 % y 14 %. Los porcentajes en los otros grados son más ó menos los mismos por los dos tipos de suelos (Fig. 1.9). El gráfico del desarrollo de H/P y HMJN (Fig. 1.10) muestra que después de la floración la HMJN baja, en otros palabras la hoja con necrósis es más joven. Este es logico, porque después la floración no se desarrollan nuevas hojas pero la enfermedad se desarrolla muy rapido y infecta también las hojas más jovenes las cuales no tenían necrósis antes. El número de hojas por planta tiene un promedio de 9 hojas por los dos tipos de suelos y no se fluctúa mucho en los 12 semanas.

En general se puede decir que no hay mucho diferencia entre los dos tipos de suelos. Sin embargo los dos son suelos limosos, un con un poco más arena, el otro con un poco más arcillo y todos tienen un buen drenaje entonces no existe mucho diferencia entre los suelos. Tal vez la situación de suelos muy arcillosos y con mal drenaje es menor.

También creo que el P.P.I. no es un metodo ideal para evaluar Sigatoka negra. Existen muchos aspectos, como la distancia hasta una bananera, nivel de manejo (por ejemplo cortar hojas), etcetera tienen un influencia bastante a el valor de P.P.I..

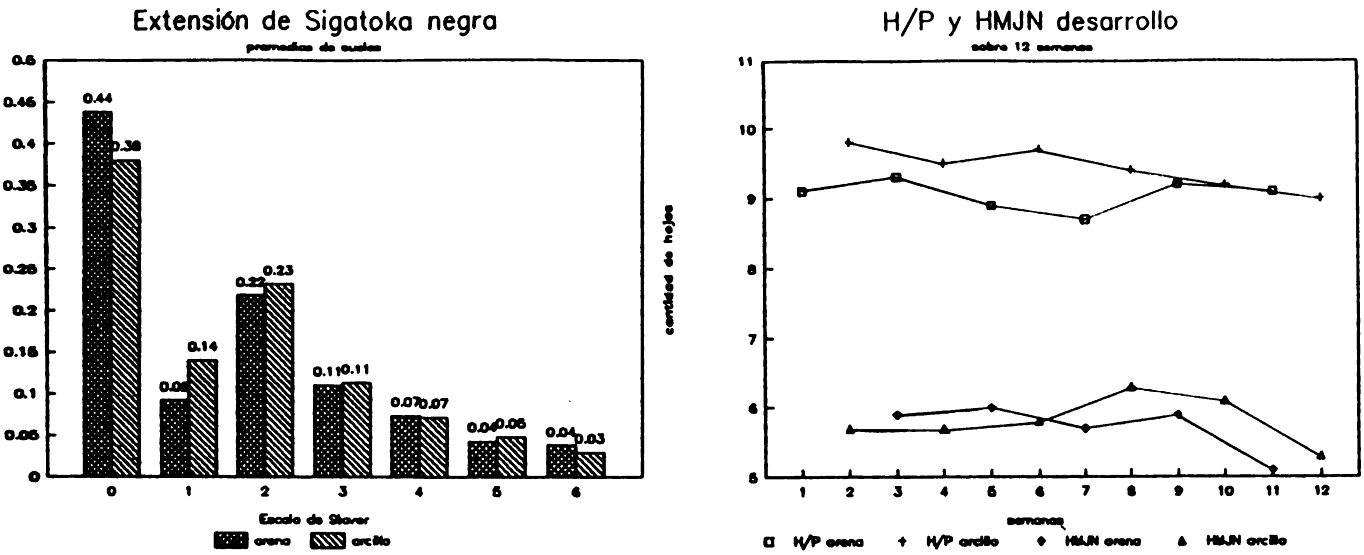


Fig. 1.9 y 1.10 Los porcentajes de hojas en cada grado del escala Stover como un promedio por los dos tipos de suelos y la desarrollo de H/P y de HMJN entre 11-9 y 26-11 1992 a 10 fincas de plátano en la Zona Atlántica de Costa Rica (semana 1 = 11-9)

La HMJN da una indicación más precisa del progreso de la enfermedad porque no tiene influencia de cortar hojas. Sin embargo, también usando este valor, no existe mucha diferencia entre los dos tipos de suelos.

1.4 investigation sobre la desarrollo de Sigatoka negra en relación con precipitación

En la finca Minita (Zent) de señor Salazar, se empezo una investigación para ver que existe una relación entre la desarrollo de Sigatoka negra y la precipitación en plátano. En este párrafo se presenta los resultados provisionales. La investigación se continúa por el agricultor y un estudiante.

1.4.1 metodología

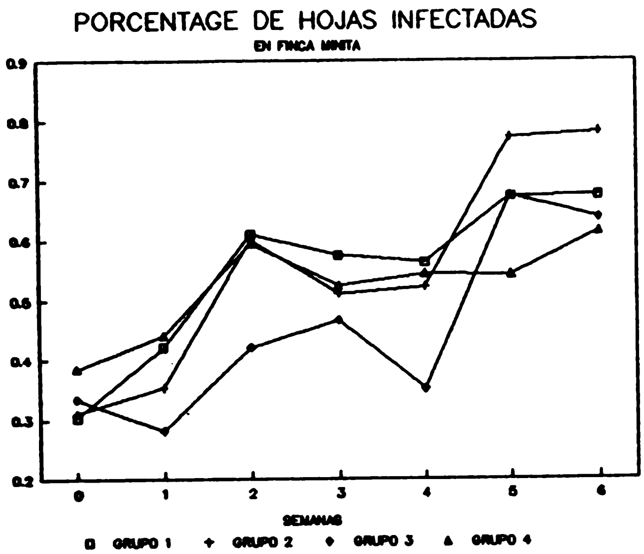
He seleccionado 4 sitios con 5 plantas. Las sitios tienen una fecha de siembra diferente y dos sitios tienen plantas de bolsas rebrote y las otras tienen plantas de semilla directa. Desde medio octubre hasta fin de noviembre cada semana he hecho observaciones. Las partes investigadas estubieron hechas en:
* hojas por planta (H/P)
* hojas infectadas (H.I.)
* % hojas infectadas
* altura de plantas
* hoja más joven con necrosis (HMJN)
* hoja más joven enferma (HMJE)

La precipitación fue tomada por medio de un pluviómetro y medido por día.

1.4.2 resultados y discusion

Se presenta los resultados detallados en Anexo B.

El porcentaje de hojas infectadas fue calculado dividiendo hojas infectadas con total de hojas por planta. Resulta que el porcentaje sube mucho (Fig. 1.11), pero el tiempo es demasiado breve para decir si hay una relación con la precipitación (Fig. 1.12). El porcentaje hojas infectadas es el porcentaje de todos las hojas con una infección desde solamente algunas estrías hasta mucho necrosis.



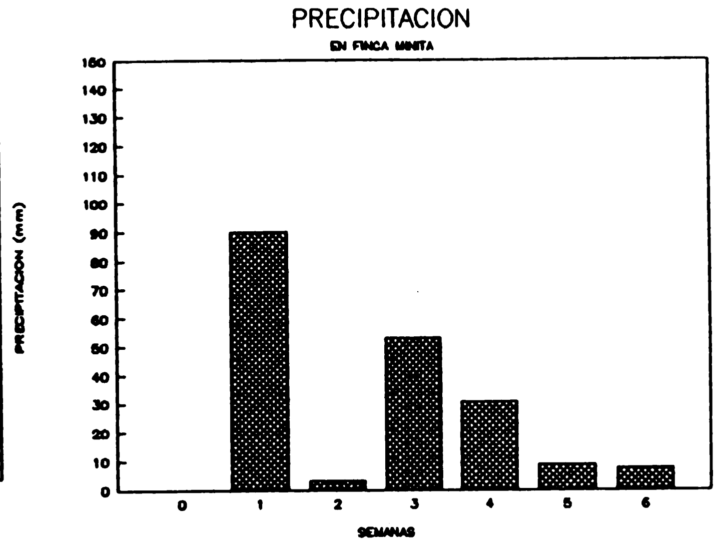
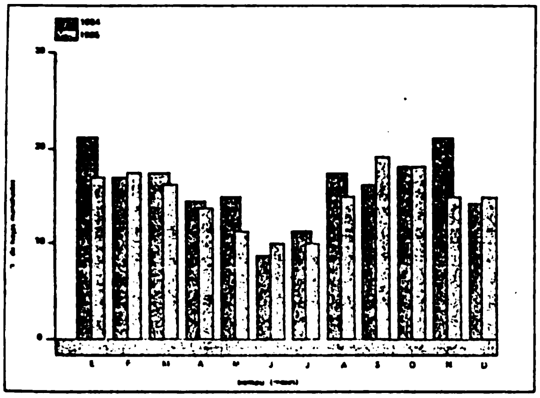


Fig. 1.11 y 1.12 % hojas infectadas y precipitación a un finca de plátano a la Zona Atlántica de Costa Rica coleccionado entre medio octubre y fin de noviembre 1992

La investigacion de CORBANA en banáno (Romero y Cubero, 1987) resulta que existe una relación entre la severidad de Sigatoka negra y la precipitación. El porcentaje de hojas infectadas es más bajo que en plátano, porque hay más aplicaciones de fungicidas. También presenta solamente el porcentaje de hojas manchadas; las hojas con estrías no se usa. Los figures 1.13 y 1.14 muestran que desde marzo hasta julio la enfermedad se baja y desde agosto hasta febrero se sube. Entonces en periodos con mucho lluvia la enfermedad es menos y en periodos con poco lluvia la enfermedad es mayor. Es mejor aplicar fungicidas después una periodo con mucho lluvia.



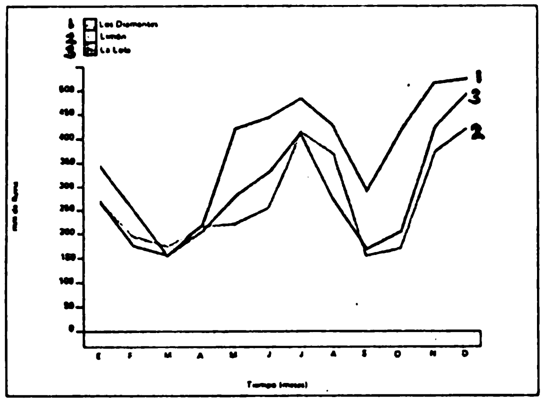


Fig. 1.13 y 1.14 Porcentaje de hojas infectadas con manchas coleccionado durante 1984 y 1985 a 16 fincas de banáno a la Zona Atlántica y valores mensuales de precipitación pluvial en tres localidades del Atlántico de Costa Rica (promedios de registros de más de 30 años).

2 LA EXTRACION DE NUTRIENTES DEL SUELO

2.1 introducción

Para ver la cantidad de nutrientes extraidos del suelo por las frutas de plátano, hemos investigado los porcentajes de fruta para el mercado (exportación, local), para el autoconsumo y rechazo. En la periodo de medio setiembre hasta el fin de octubre los datos fue coleccionados de algunas fincas de plátano en la Zona Atlántica.

2.2 resultados y conclusión

Los resultados de la investigación se presenta en los cuadros 2.1 y 2.2. Las consecuencias para la retiración de nutrientos se presenta en los cuadros 2.3 y 2.4.

Cuadro 2.1 Peso y numeró de dedos por rácimo de plátano observado durante cosechas entre medio setiembre y fin de octubre 1992 a 6 fincas a la Zona Atlántica de Costa Rica

finca	rácimos examinado	kilos/rácimo			dedos/rácimo			peso promedio/ dedo (gr)	rácimos/caja	dedos/caja
		min	max	pro	min	max	pro			
Salazar (3333 plantas/ha)	17	8.0	14.0	10.5	22	39	28.5	317[1)]	2.5	72[2)]
Salaza (1800 plantas/ha)	35	7.0	16.0	10.3	22	37	29.6	299	2.6	76
Baltasar	18	7.0	14.0	8.8	19	39	25.9	281	3.1	81
Nuñez	25	7.0	13.0	10.4	21	37	28.2	316	2.6	72
O.Villegas	25	5.0	11.0	7.7	19	34	24.8	250	3.7	91
C.Villegas	20	5.0	15.0	9.4	19	37	29.2	271	2.9	84
J.Villegas	14	6.0	10.0	7.9	21	34	26.9	238	3.6	95
promedio	22	6.4	13.3	9.3	20	37	27.6	282	3.0	82

nota: 1) en realidad peso promedio/dedo para exportación es más alto. El valor arriba es la promedio de todos los dedos, inclusivo los rechazado para exportación

2) en realidad dedos/caja (caja=22.72 kg) es menor, porque el valor arriba es basado en el valor peso promedio por dedo, el cual es menor que en realidad (nota 1)

Cuadro 2.2 Destino de plátano cosechado entre medio setiembre y fin de octubre 1992 a 3 fincas a la Zona Atlántica de Costa Rica

finca	rácimos	exportación		mercado local		autoconsumo		rechazado	
		kg	%	kg	%	kg	%	kg	%
Salazar (3333 plantas/ha)	154	1196	85.9	138	9.9	17	1.2	42	3.0
Salazar (1800 plantas/ha)	150	812	63.0	391	30.3	35	2.7	53	4.0
Nuñez	58	409	81.5	93	18.5	0	0	0	0
C.Villegas	188	1306	87.9	45	3.0	0	0	134	9.1
Promedio	138	931	79.6	157	15.4	13	1.0	45	4.0

Resulta que el porcentaje de plátano para exportación es casi 80 %. El porcentaje total que es retirado del campo es 96 % porque solamente 4 % es rechazado totalmente y dejado al campo. Esto quiere decir que con un cosecha de promedio 14000 kg de frutas por año por ha, 13500 kg de frutas son extiraidos del campo. Cuántos este es en cantidades de nutrientes presenta en cuadro 2.3.

Cuadro 2.3 Extración de nutrientes (kg) por plátano por ha por año

kg plátano	nutrientes N	nutrientes P	nutrientes K
1000	3.9 - 6.3	0.43 - 0.66	20.6 - 34.2
13500	52.7 - 85.1	5.8 - 8.9	278 - 463

Fuente: Du Montcel, 1987
Nota: no se dispone de datos sobre Curraré; las cifras arriba son de un cultivar muy parecido

Algunas agricultores llevan los pinzotes al campo después la cosecha, otros los dejan cerca de la empacadora. El contenido de nutrientes de la pinzote presenta a cuadro 2.4. Resulta que la cantidad de potassium (K) es bastante alto y tal vez cuando tiene suficiente tiempo vale la pena llevar los pinzotes al campo.

Generalmente resulta que la cantidad de K extraido del campo es alto. Entonces después nitrógeno, potassium también tiene que aplicado.

Cuadro 2.4 Contenido de nutrientes del pinzote

	nutrientes N	P	K	
pinzote (1.5 kg)	26.3	1.2	74.6	gr
1800 pinzote/ha	47.3	2.2	134.3	kg

Fuente: Sattler, 1990

ANEXO A Resultados de la investigación de Sigatoka negra a 10 fincas de plátano en la Zona Atlántica de Costa Rica

Spencer fecha	H/P	HMJE	HMJN	% hojas en grado 0	1	2	3	4	5	6	total	P.P.I.
11-9	10.2	7.5	-	0.64	0.10	0.14	0.07	0.05	0.00	0.00	1.00	0.79
24-9	10.1	7.5	8.7	0.64	0.13	0.16	0.04	0.02	0.02	0.01	1.02	0.74
8-10	10.5	6.9	8.3	0.56	0.15	0.19	0.06	0.05	0.00	0.00	1.01	0.89
22-10	10.8	7.2	8.0	0.57	0.10	0.20	0.08	0.04	0.01	0.00	1.00	0.94
05-11	10.5	7.1	8.5	0.59	0.13	0.20	0.08	0.01	0.01	0.00	1.02	0.81
19-11	10.7	6.5	8.0	0.52	0.16	0.24	0.09	0.00	0.00	0.00	1.01	0.91
promedio	10.5	7.1	8.3	0.59	0.13	0.19	0.07	0.03	0.01	0.00	1.01	0.85

Foster fecha	H/P	HMJE	HMJN	% hojas en grado 0	1	2	3	4	5	6	total	P.P.I.
11-9	8.5	5.8	-	0.56	0.02	0.10	0.08	0.08	0.09	0.08	1.01	1.69
24-9	8.7	4.7	5.0	0.44	0.04	0.28	0.06	0.07	0.05	0.08	1.02	1.75
8-10	7.9	4.8	5.5	0.47	0.11	0.17	0.16	0.09	0.01	0.00	1.01	1.34
22-10	8.5	4.6	5.3	0.42	0.08	0.17	0.12	0.13	0.04	0.04	1.00	1.72
05-11	9.1	4.4	5.3	0.38	0.10	0.23	0.14	0.08	0.04	0.04	1.01	1.74
19-11	9.7	4.3	5.0	0.34	0.07	0.29	0.10	0.09	0.08	0.04	1.01	1.93
promedio	8.7	4.8	5.2	0.44	0.07	0.21	0.11	0.09	0.05	0.05	1.01	1.70

Ricketts fecha	H/P	HMJE	HMJN	% hojas en grado 0	1	2	3	4	5	6	total	P.P.I.
11-9	6.9	4.2	-	0.46	0.02	0.19	0.18	0.08	0.03	0.06	1.02	1.74
24-9	7.6	4.2	4.6	0.42	0.05	0.14	0.06	0.10	0.09	0.14	1.00	2.19
8-10	7.0	3.7	4.8	0.39	0.13	0.19	0.12	0.08	0.08	0.02	1.01	1.70
22-10	7.6	4.0	4.4	0.39	0.05	0.23	0.09	0.07	0.11	0.07	1.01	2.00
05-11	7.7	3.5	4.2	0.32	0.09	0.25	0.10	0.08	0.07	0.09	1.00	2.05
19-11	7.6	2.8	3.4	0.23	0.08	0.30	0.14	0.09	0.07	0.10	1.01	2.41
promedio	7.4	3.7	4.3	0.37	0.07	0.22	0.12	0.08	0.08	0.08	1.01	2.02

Alberto fecha	H/P	HMJE	HMJN	% hojas en grado 0	1	2	3	4	5	6	total	P.P.I.
11-9	10.1	5.6	-	0.46	0.06	0.18	0.09	0.11	0.03	0.07	1.00	1.70
24-9	9.1	4.4	4.9	0.38	0.08	0.23	0.17	0.07	0.03	0.04	1.00	1.71
8-10	8.9	4.0	5.2	0.34	0.13	0.19	0.13	0.11	0.08	0.05	1.03	1.96
22-10	6.7	3.8	4.6	0.42	0.11	0.30	0.12	0.05	0.00	0.00	1.00	1.28
05-11	camino cerrado											
19-11	8.3	3.8	4.6	0.34	0.09	0.27	0.12	0.14	0.03	0.02	1.01	1.78
promedio	8.6	4.3	4.8	0.39	0.09	0.23	0.13	0.10	0.03	0.04	1.01	1.69

				% hojas en grado								
Salazar	H/P	HMJE	HMJN	0	1	2	3	4	5	6	total	P.F.I.
fecha												
11-9	10.0	6.2	-	0.52	0.10	0.21	0.13	0.04	0.01	0.00	1.01	1.11
24-9	10.9	5.8	6.2	0.46	0.02	0.21	0.13	0.10	0.06	0.03	1.01	1.70
8-10	10.1	5.1	6.1	0.41	0.10	0.18	0.13	0.05	0.09	0.06	1.01	1.77
22-10	10.0	5.1	6.4	0.41	0.15	0.18	0.14	0.06	0.07	0.01	1.02	1.54
05-11	9.6	4.8	5.6	0.39	0.09	0.32	0.09	0.08	0.03	0.01	1.01	1.49
19-11	9.3	3.7	4.4	0.28	0.12	0.35	0.14	0.07	0.03	0.02	1.01	1.80
promedio	10.0	5.1	5.7	0.41	0.10	0.24	0.13	0.07	0.05	0.02	1.01	1.57
promedio de suelos arenosos	9.0	5.0	5.7	0.44	0.09	0.22	0.11	0.07	0.04	0.04	1.01	1.55

				% hojas en grado								
VillegasJ	H/P	HMJE	HMJN	0	1	2	3	4	5	6	total	P.F.I.
fecha												
18-9	9.6	4.5	5.5	0.37	0.11	0.21	0.13	0.11	0.06	0.03	1.02	1.80
1-10	9.5	4.9	5.6	0.41	0.09	0.22	0.10	0.10	0.06	0.03	1.01	1.71
14-10	9.3	4.3	5.4	0.35	0.13	0.17	0.14	0.10	0.07	0.04	1.00	1.86
29-10	9.4	4.7	6.2	0.39	0.13	0.14	0.14	0.10	0.04	0.07	1.01	1.85
12-11	9.3	4.1	5.7	0.33	0.17	0.17	0.13	0.08	0.07	0.06	1.01	1.92
26-11	8.8	4.1	5.1	0.32	0.14	0.29	0.09	0.08	0.07	0.02	1.01	1.76
promedio	9.3	4.4	5.6	0.36	0.13	0.20	0.12	0.10	0.06	0.04	1.01	1.81

				% hojas en grado								
VillegasC	H/P	HMJE	HMJN	0	1	2	3	4	5	6	total	P.F.I.
fecha												
18-9	9.5	4.5	5.4	0.37	0.12	0.28	0.15	0.06	0.03	0.00	1.01	1.51
1-10	9.1	4.8	5.4	0.41	0.07	0.22	0.19	0.08	0.03	0.00	1.00	1.56
14-10	10.1	5.2	6.3	0.41	0.11	0.10	0.13	0.12	0.10	0.04	1.01	1.68
29-10	8.9	5.3	6.4	0.48	0.14	0.19	0.05	0.10	0.03	0.02	1.01	1.32
12-11	8.5	4.3	6.2	0.38	0.24	0.23	0.08	0.06	0.02	0.00	1.01	1.27
26-11	8.4	3.5	4.7	0.29	0.16	0.33	0.11	0.06	0.05	0.02	1.02	1.71
promedio	9.1	4.6	5.7	0.39	0.14	0.23	0.12	0.08	0.04	0.01	1.01	1.54

				% hojas en grado								
VillegasO	H/P	HMJE	HMJN	0	1	2	3	4	5	6	total	P.F.I.
fecha												
18-9	10.4	4.0	5.3	0.27	0.14	0.27	0.15	0.08	0.08	0.03	1.02	1.55
1-10	10.6	5.2	5.9	0.39	0.07	0.12	0.11	0.15	0.09	0.08	1.01	2.12
14-10	10.2	4.3	5.9	0.32	0.14	0.15	0.09	0.11	0.09	0.09	0.99	2.15
29-10	9.3	5.3	6.4	0.47	0.12	0.23	0.04	0.10	0.04	0.02	1.02	1.39
12-11	10.1	4.9	6.3	0.39	0.15	0.21	0.08	0.05	0.07	0.05	1.01	1.70
26-11	9.7	4.3	5.5	0.34	0.13	0.29	0.11	0.06	0.03	0.04	1.00	1.65
promedio	10.1	4.7	5.9	0.36	0.13	0.21	0.10	0.09	0.07	0.05	1.01	1.83

Adelina	H/P	HMJE	HMJN	% hojas en grado 0	1	2	3	4	5	6	total	P.P.I.
fecha												
18-9	10.4	5.3	6.9	0.42	0.16	0.20	0.10	0.08	0.05	0.01	1.01	1.46
1-10	9.6	4.8	6.3	0.39	0.19	0.24	0.15	0.03	0.01	0.00	1.01	1.26
14-10	9.6	4.7	6.0	0.38	0.16	0.38	0.06	0.02	0.01	0.00	1.01	1.21
29-10	10.2	5.2	6.5	0.41	0.14	0.30	0.12	0.03	0.01	0.00	1.01	1.26
12-11	9.2	5.3	6.5	0.46	0.14	0.33	0.07	0.01	0.00	0.00	1.01	1.32
26-11	9.8	4.9	6.8	0.39	0.20	0.24	0.12	0.03	0.02	0.00	1.00	1.25
promedio	9.8	5.0	6.5	0.41	0.17	0.28	0.10	0.03	0.02	0.00	1.01	1.[illegible]5

Nuñez	H/P	HMJE	HMJN	% hojas en grado 0	1	2	3	4	5	6	total	P.P.I.
fecha												
18-9	8.9	4.0	5.5	0.36	0.18	0.18	0.09	0.05	0.09	0.06	1.01	1.80
1-10	8.9	4.5	5.1	0.39	0.08	0.26	0.13	0.05	0.03	0.06	1.00	1.69
14-10	9.1	4.7	5.6	0.42	0.10	0.23	0.15	0.07	0.04	0.01	1.02	1.52
29-10	9.3	5.0	6.1	0.44	0.12	0.22	0.11	0.07	0.03	0.02	1.01	1.43
12-11	8.9	4.3	5.8	0.37	0.18	0.19	0.13	0.04	0.06	0.05	1.02	1.66
26-11	8.3	3.4	4.6	0.28	0.16	0.34	0.12	0.06	0.03	0.01	1.00	1.63
promedio	8.9	4.3	5.5	0.38	0.14	0.24	0.12	0.06	0.05	0.04	1.01	1.62
promedio de suelos arcillosos	9.4	4.6	5.8	0.38	0.14	0.23	0.11	0.07	0.05	0.03	1.01	1.61

Promedios por semana de los observaciones para los dos tipos de suelos en la Zona Atlantica de Costa Rica desde 11-9 hasta 26-11 1992

semana	H/P arena	H/P arcillo	HMJN arena	HMJN arcillo	% infectada arena	% infectada arcillo	PPI arena	PPI arcillo
1	9.1				0.47		1.41	
2		9.8		5.7		0.64		1.71
3	9.3		5.9		0.53		1.62	
4		9.5		5.7		0.60		1.67
5	8.9		6.0		0.57		1.53	
6		9.7		5.8		0.62		1.72
7	8.7		5.7		0.56		1.50	
8		9.4		6.3		0.56		1.45
9	9.2		5.9		0.58		1.53	
10		9.2		6.1		0.61		1.51
11	9.1		5.1		0.66		1.77	
12		9.0		5.3		0.68		1.60

ANEXO B

INVESTIGACION DE SIGATOKA NEGRA Y LA RELACION CON LA PRECIPITACION
FINCA LA MINITA 2
AGRICULTOR: JUAN VINCENTE SALAZAR MORA

GRUPO 1
FECHA DE SIEMBRA: 25-7-92 (BOLSAS REBROTE)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	6.6	2.0	30.3%		5.6	
22-10-92	7.6	3.2	42.1%	130.6	5.4	6.3
29-10-92	8.2	5.0	61.0%	151.0	4.7	6.6
05-11-92	9.4	5.4	57.4%	165.0	5.0	5.9
12-11-92	9.6	5.4	56.3%	180.0	5.2	5.2
19-11-92	10.4	7.0	67.3%	190.8	4.4	7.0
26-11-92	9.2	6.2	67.4%	196.0	4.0	6.6

GRUPO 2
FECHA DE SIEMBRA: 25-8-92 (SEMILLA DIRECTA)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	5.8	1.8	31.0%		5.0	
22-10-92	6.8	2.4	35.3%	78.6	5.4	6.2
29-10-92	8.0	4.8	60.0%	87.4	4.2	7.2
05-11-92	9.0	4.6	51.1%	92.0	5.4	7.6
12-11-92	9.2	4.8	52.2%	94.0	5.8	7.0
19-11-92	9.6	7.4	77.1%	99.6	3.2	6.8
26-11-92	10.0	7.8	78.0%	104.0	5.2	7.2

GRUPO 3
FECHA DE SIEMBRA: 15-9-92 (BOLSAS REBROTE)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	4.8	1.6	33.3%		4.2	
22-10-92	6.4	1.8	28.1%	36.8	3.6	5.8
29-10-92	7.6	3.2	42.1%	40.6	5.4	7.4
05-11-92	9.0	4.2	46.7%	55.0	5.6	6.0
12-11-92	8.0	2.8	35.0%	61.6	5.2	6.0
19-11-92	8.6	5.8	67.4%	68.4	5.0	6.8
26-11-92	8.8	5.6	63.6%	76.6	4.2	7.8

GRUPO 4
FECHA DE SIEMBRA: 15-6-92 (SEMILLA DIRECTA)

FECHA	HOJAS/PLANTA (PROMEDIO)	HOJAS INFECTADA (PROMEDIO)	% HOJAS INFECTADA (PROMEDIO)	ALTURA (CM) (PROMEDIO)	HMJE (PROMEDIO)	HMJN (PROMEDIO)
15-10-92	5.2	2.0	38.5%		4.2	
22-10-92	6.8	3.0	44.1%	123.4	4.4	6.0
29-10-92	7.4	4.4	59.5%	133.0	4.0	5.8
05-11-92	8.4	4.4	52.4%	141.6	5.4	6.2
12-11-92	9.2	5.0	54.3%	150.8	5.2	6.4
19-11-92	9.6	5.2	54.2%	159.0	5.8	6.4
26-11-92	8.8	5.4	61.4%	166.0	4.4	6.6