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Guide

Identification and Integrated PEST Management in Banana and Plantain Magdalena and Uraba Colombia

KEPCar AUGURA ASOCIACIÓN DE BANANEROS DE COLOMBIA

"REDUCTION OF PESTICIDE RUNOFF INTO THE CARIBBEAN SEA"

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Foreword

A fundamental objective of the Colombian Banana Growers Association (Asociación de Bananeros de Colombia – AUGURA) is to promote and implement projects that focus on enhancing sectoral productivity and competitiveness. For this, it has driven different programmes and research efforts in partnership with other entities to help growers improve their agricultural practices and to compete in the current markets.

Product quality presently includes the manner in which a given product has been produced; and such process must, among others, be aligned with national and international environmental regulations and environment-related market demands.

The partnership between the United Nations Environment Programme (UNEP) and the Asociación de Bananeros de Colombia, AUGURA resulted from the "Reduciendo el Escurrimiento de Plaguicidas al Mar Caribe"

(REPCar) project (Reducing Pesticide Runoff in the Caribbean Sea). Funded by the Global Environment Facility (GEF), the project is coordinated by the UNEP Regional Coordination Unit for the Caribbean, with the participation of Colombia, Costa Rica and Nicaragua.

Demonstration projects and training efforts headed by AUGURA within the REPCar Project framework seek to build awareness among growers on how their activities influence natural resource conservation, including marine ecosystems. These ecosystems are fundamental for tourism and fisheries activities in the region, thus contributing to the economy of coastal zones and the well-being of their inhabitants. Likewise, the Project seeks to provide tools for growers to strengthen their productive systems, increasing the competitiveness of the banana and plantain sector.

In this sense, AUGURA, with support of UNEP, is pleased to share the following educational materials:

-Compendium of Good Agricultural Practices for Banana in the Magdalena Region

-Compendium of Good Agricultural Practices for Plantain in the Urabá Region

-Integrated Pest Management for Banana and Plantain Crops

-Handbook for Pesticide Handling

We are sure these consultation materials will be helpful to growers, marketers, researchers and all stakeholders of this agro-industrial sector interested in implementing best practices to reduce the risk of pollution and foster safe food, as well as strengthen positions in international markets and sustainable development in the region.

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1. Introduction

Phytosanitary problems are present in regions of Colombia that produce banana and plantain for the export market. Depending on environmental or crop-related conditions, they affect plantations to a greater or lesser degree.

The most common problems found are associated with pests and diseases caused by fungi, bacteria, viruses and nematodes.

One solution to these problems is the adequate identification of their origin and various control methods: cultural, natural, biological and chemical.

It is important to note that integrated pest management is the base for sustainable crop production, harmonically uniting all existing control methods, considering environmental, social and technological variables, in order to guarantee future generations the existence and enjoyment of the resources currently exploited.

This document illustrates some of the phytosanitary problems that affect banana and plantain crops, aiming to publicize the causes, the current need for adequate control, and the main tools that can be used to achieve the goal of Integrated Management.

2. Insect pests in banana and plantain crops in Colombia

It is important to identify the different species that attack and defend these crops, their habits and management practices, to keep harmful populations below economic damage thresholds, using integrated management to affect the environment as little as possible. (Osorno, M and Mejía G)

2.1. Foliage insects

There is a group of Lepidoptera larvae (butterflies) that particularly attack these crops.

Banana plants can tolerate up to 20% defoliation. In seasons with high insect populations, larvae cause considerable damage to the leaf surface, a decrease in bunch size and weight, and a higher probability of fruit ripening during transportation and storage at destination. (Minambiente, SAC and AUGURA 2002, Ostmartk, 1989, Uniban 1998)

We will now describe each one of these pests, their life cycle, control methods and damage thresholds.

Banana leaf wooly worm

Scientific Name*: Ceramidia sp*

One of the main banana pests, no other host plant is currently known. Adult females are bluish black, with white spots on the abdomen. Eggs are laid on the reverse side of the leaves and

recently emerged larvae scrape the area in elongated and narrow bands. (Minambiente, SAC and Augura 2002, Uniban, 2001)

As the larva grows, the band size increases. Damage is perpendicular to the central vein, finally perforating the leaf. The chrysalis is surrounded by numerous larva hairs, which protect against environmental conditions and predators. Chrysalises are found mostly along the central vein on the underside of the leaf, on the shoot and occasionally on the bunch.

(Minambiente, SAC and AUGURA 2002, Uniban 2001)

Insect life cycle

5-6 days.
Figure 1. Ceramidia eggs

2

8 days
Figure 2. Ceramidia larva

Eggs:

These last some 5 or 6 days, and are laid individually or in groups of 2 or 3. Globe-shaped, these are clear green when recently laid and cream-colored when close to hatching.

Larva

Lasting 28 days, their body is covered with cream-yellow hairs and a brown head, measuring up to 3.5 cm. Initially they feed by scraping the leaf and finally perforating it.

8 – 9 days
Figure 3. Ceramidia chrysalis

Chrysalis

Brown in color, they last between 8 and 9 days, and are covered by larvae hairs. These hairs are whealing, and cause allergic reactions and skin irritation.

15 days
Figure 4. Ceramidia adult

Adults

Some daytime butterflies have a 4 cm wingspan, dark blue with metallic sheen. Their thorax and abdomen have silver glints.

✍ Cultural control

Management recommendations

- Perform adequate shoot and stem removal.

- Do not leave stumps when pruning leaves.
- Correct weed management, maintain soil cover.

Adults

Set up traps to catch adults, using agents like Oxyfluorfen (Goal). Install one monitoring trap for every 10 hectares, and record catches.

Figure 5. Trap for Ceramidia adults

Chrysalis

Perform adequate shoot removal to expose the chrysalis to natural control.

Figure 6. Shoot removal

Larvae

Evaluate larvae and development stage before applying biological control products for *Bacillus thuringiensis*.

Figures 7 and 8. Ceramidia adults and parasited larvae

Figure 9. *Adult Trichogramma* spp. (egg parasite)

Figure 10. *Brachymeria* sp. (Chrysalis parasite)

Figure 11. *Elachertus* sp. (Parasite on Ceramidia larva)

✍ Natural control

Existing natural controls like wasps and other parasites must be allowed to act on the management of this pest.

- *Telenomus spp* and *Trichogramma spp,* - egg parasites.
- *Elachertus* spp and *Apanteles* spp - larvae parasites.
- *Brachymeria spp* and *Spiochalsis spp* - chrysallis parasites.
- *Forcipomya spp* - larvae ectoparasytes.
- *Artichoris spp* - feed on eggs and small larvae.

✍ Damage level

Catching 10 moths in a trap is reason for alarm.

Banana green worm / Goat worm

Scientific name: *Opsiphanes spp*

This pest damages banana and plantain crops. Adults are butterflies and moths with sizes ranging from 8 to 10 cm. The forewings are dark brown, with a white or yellow band near the wingtip, and two small white spots. Hind wings are dark brown with reddish tones.

Male *Opsiphanes* show two hairy tufts, not so females. Spots on the ventral section resemble eyes. Adults spend the day on rejected fruit or rotting bunches feeding on their sugary substances, a behavior used in Uraba to set up traps with ripe bananas to attract and catch them. (Minambiente, SAC and AUGURA 2002, Uniban 1998)

Larvae look for dry places to form chrysalis, which are kidney-shaped and yellowish-green when recently formed, and turn light brown shortly before the butterfly emerges. They also show a small silver area on the sides, near the end of the body. (Minambiente, SAC and AUGURA 2002, Uniban 1998).

✍ Insect Lifecycle

Eggs:

They last for 8 days. In the field, eggs are laid individually on the shoots of psuedostem, initially light coloured and later displaying three reddish bands.

8 days
Figure 12. *Opsiphanes* spp eggs

27 – 28 days
Figure 13. *Opsiphanes* spp larva

Larvae:

Green, with small horns, they eat the leaf inwards from the edge. A single larva can eat up to 250 cm2 a day (half a notebook sheet).

12 days
Figure 14. *Opsiphanes* spp chrysalis

Chrysalis:

Green in color, they are found on the underside of the leaf and, in general, adults emerge after 12 days. In this stage the pest is susceptible to attacks by birds, parasites, bacteria and fungi.

Figure 15. Adult *Opsiphanes* spp.

Adults:

Brown butterflies; front wings with a cream colored band. They have daytime habits, and feed on ripe fruit or fruit leftovers.

✍ Cultural control

Management recommendations

- Chop fruit appropriately
- Mat stem by withdrawing spikes
- Prune rhizomes correctly
- Avoid leaving stumps after pruning
- Manage composters correctly

Chrysalis:

Collect without affecting existent natural control.

Figure 16. Manual collection of chrysalis

Larvae:

Evaluate before applying biological insecticide (use protection gear).

Figure 17. *Opsiphanes* larva

Adults:

- Use of traps with bait of banana or plantain.
- Application of biological insecticides such as *Bacillus thuringiensis*.
- Edible bait with insecticide.

Figure 18. Trap setup with bag and edible bait

✍ Natural control

For the management of this pest, allow the action of natural enemies:

- *Apanteles spp*, larva parasite

- *Brachymeria* spp, and *Spihalcis* spp, chrysalis parasites
- *Forcipomya*, larva parasite
- *Trichogramma* spp, egg parasite

Figure 19. *Trichogramma* parasiting

Figures 20 and 21. Chrysalis with *Brachymeria spp* parasite

Figure 22. Healthy egg

Figure 23. Egg with parasite

- **Damage level**

When 5 to 8 larvae appear in the middle third of the leaves, or when more than 20% of the leaf surface has been eaten.

Banana Saddle Worm

Scientific name*: Sibine spp*

- Several species.
- Order Lepidoptera, family Limacodidae.
- Few cases require control with biological insecticides.

This pest attacks plantain and banana crops. The back of the worm head is brown, and has a series of small thorns around the body, along with four macrothorns, all of which have stinging hairs. When the larva measures between 3 and 4 cm, a green stripe is visible on the back, with a brown spot in the middle, similar to a horseback saddle, hence its name. (Minambiente, SAC and AUGURA 2002, Uniban 1998, cited by Osorno, M,. and Mejia, G)

The blue-nosed saddle worm is smaller in size when compared to the above. It displays blue colors on the front end, light green on the hind end and abundant thorns with stinging hairs surrounding the body. Its larvae feed gregariously and begin damaging the leaf along the edges, until it is completely consumed. Perforations have regular edges. The saddle worm can eventually feed on tender banana. (Minambiente, SAC and AUGURA 2002, Uniban 1998, cited by Osorno, M,. and Mejía, G)

Management of these insects has also benefitted from the presence of natural enemies such as *Apanteles* spp, which attacks its larvae. (Minambiente, SAC and AUGURA 2002, Uniban 1998, cited by Osorno, M,. and Mejía, G)

✍ Life cycle

Larvae:

From the first instar onwards, larvae eat up to half of the limb thickness, grouped where the eggs were laid. Later they eat the whole limb, leaving only a few centimeters and the vein.

Figure 24. Saddle worm larvae

One larva can eat up to 400 cm^2 (one notebook sheet), which means that 45 to 50 larvae can eat a whole leaf.

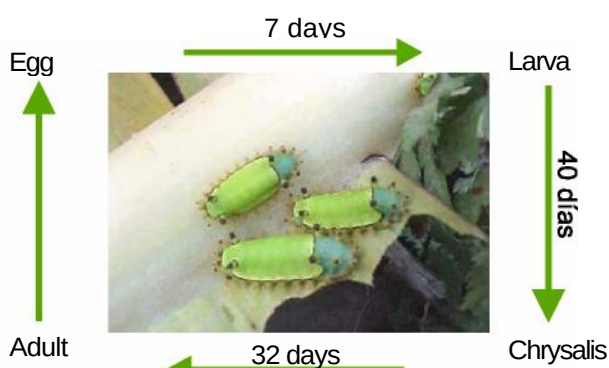

Figure 25. Life cycle of the saddle worm

✍ Natural control

This larva is attacked by a number of natural enemies, in many cases rendering other control practices unnecessary.

Figure 27. Saddle worm with a *Braconidae* parasite

Figure 26. *Apanteles* spp, larva parasite

Figure 28. *Braconidae* spp

Black goat / Owl butterfly

Scientific name: *Caligo sp*

Description

Large butterflies characterized by large eyespots on the ventral part of the hindwings. Larvae stay in groups, have longitudinal stripes and sometimes short thorns and bifurcated tails.

They are found exclusively in the tropics, living in forests and crop areas. Larvae feed on plants of the Musaceae and Heliconeaceae families. Adults feed on fermenting fruits and excrement.

Figure 29 and 30. *Caligo* sp. adults

Figure 29. *Caligo* sp. larva

They do not pose an economic threat because of numerous natural enemies.

Basket worm

Scientific name*: Oiketicus kyrbi Güildihg*

This pest is not a high economic loss in banana, but certainly is so for plantains because of occasional high populations.

Description

Adults:

Female

Similar in appearance to larvae, they have a small head, no antennae and an atrophic proboscis. They do not leave the basket, where they are fertilized by the male. Before copulating the female abdomen is full of ovules, enlarging it; but after oviposition its volume decreases up to one half, it leaves the basket and lets itself fall and die.

Male

Brown colored moth, with light and dark areas, small wings with 42 mm wingspan, body covered with scales, thick thorax and narrow abdomen. The average lifespan is 4.0 days for females and 3.0 for males.

During copulation, the male breaks the end of the female basket, using hook-like devices on its abdomen, and penetrates the genital opening extending its abdomen up to 7 cm.

Figure 31. Male basket worm

Eggs:

They have cylindrical shape, with rounded edges (0.34 x 0.53mm). At the beginning they are cream colored, later turn orange and finally darken when close to hatching. During oviposition, eggs are laid in the basket by the female before dying. Average incubation is from 27 to 47 days, with an almost 100% viability. A female can lay between 300 and 600 eggs.

Larvae:

Average duration of the larval period is 140 days for males and 151 days for females. Males and females have 8 and 9 development stages, respectively. At birth, larvae emerge from an opening on the lower end of the basket, they secrete a silk thread, and then spread assisted by the wind (foresia). As they move down any plant, they begin to scrape the epidermis of the leaves, using the remnants, stuck together with saliva, to form the basket. As the larva develops, it enlarges the basket with pieces of leaves, twigs and veins.

Chrysalis:

Female chrysalis has rounded ends, segmented appearance, and no external evidence of legs, antennae or other structures. Male chrysalis is pointed at the far end and curved towards the ventral area. Females are dark brown, while males are gray. Their average cycle is 36 to 40 days. (Campos *et al*. 1987)

Figure 32 and 33 Baskets constructed by the insect.

✍ Cultural control

Mechanical control by collecting baskets and pupas, placing them in cages to allow parasites to emerge, is a measure that aids in the management of this pest.

Performing adequate tasks such as shoot, stem and leaf pruning, fertilizing, irrigation and weed control not only helps to maintain a vigorous plantation, but also to eliminate this pest in its various stages (eggs, larvae, chrysalis).

✍ Biological control

Where populations of economic relevance are observed, or when a general infestation is detected, spray with *Bacillus thuringiensis* in doses from 350 to 400 g/hectare. The product must be used immediately after mixing, and the application must be done in the early morning. It is advisable to use motorized equipment to apply the product with a bonding agent at 2.5% volume over the whole surface.

Spider worm

Scientific name*: Phobetron* spp

It is occasionally present in plantain crops, in low populations and causes damage similar to the saddle worm. It eats the leaf from the edge towards the vein.

Figure 34. Spider worm

Larvae are flat with lateral extensions covered with hair, that look like spider legs, and when touched can cause allergies and stinging to sensitive people. The damage they cause is not of economic consideration.

Bud worm

Scientific name*: Spodoptera* sp

Occasionally present in banana plantations, these populations do not cause major economic damage. They eat the blade, generally attacking the flag leaf, and finally perforate it. Occasionally they attack the fruit by nibbling on the skin, thus affecting its quality.

Figure 35. Bud worm

Figure 36. Damage caused by the pest

2.2. Insects that attack the fruit

Colaspis

Scientific name: *Colaspis sp*

This is considered the main pest in areas producing plantain and banana for export. After emerging from the soil, adults fly directly to the fruit bunches, where they feed, scarring the surface and perforating the leaves. The insect nibbles along the strings and also through the flat surfaces of tender fingers. (Carmona, A, 2008)

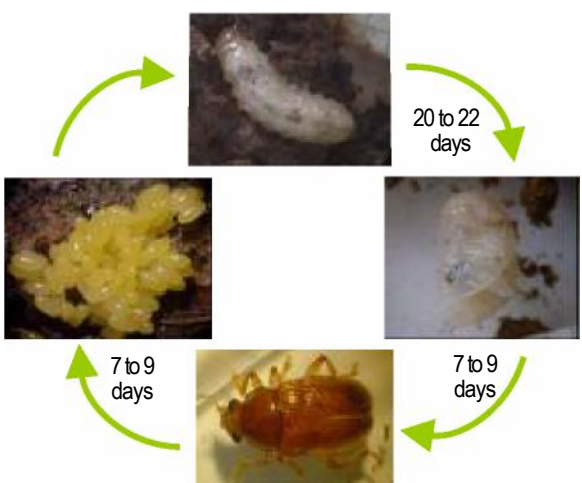

Figure 37. Life cycle

Adults:

Adults measure between 5 and 7 mm in length, and feed on the fruit skin. Females deposit the eggs on the ground, in moist conditions.

Figure 38. *Colaspis* adult

Larvae:

Larvae in the first stage are 1 mm, reaching up to 0.7 cm in length, grayish white, and found in the soil between 6 and 12 cm deep, feeding on grass roots.

Figure 39. *Colaspis* larva

Eggs:

Incubation lasts from 6 to 9 days; eggs are laid on the ground individually or in groups of 5 to 45 (López, 1978), at a depth of 0.5 to 1 cm, in small cavities, either pre-existent or dug up by the female.

Chrysalis:

The chrysalis is typical of coleoptera (beetles), with visible appendixes. Lopez (1978) states that the chrysalis stage takes place in the ground at a depth of 5 to 8 centimeters, for 7 to 10 days.

According to Salt (1928), once the chrysalis forms, it is completely white or cream colored, but marks appear every day. Therefore, pupa ages can be determined quickly depending on their color.

Damages:

Figure 42 . Damage on tender fruits **Figure 43.** Damage on 11 week old fruit

✍ Control measures:

- **Chemical:** Premature and pre-premature bagging using bags impregnated with Chlorpyrifos, preferably using three weekly rounds
- **Cultural control:** Weed control, mainly grass in ditches
- **Cultural control:** Using physical barriers like net bags and soil removal in outbreak areas, exposing immature insects to environmental conditions, predators and parasites
- **Mechanical control:** Using vacuum flasks to capture adults in the field
- **Biological control:** Soil application of *Beauveria bassiana* and *Metarhizium anisopliae* fungi has shown to be significantly effective to control this pest.

Black Soldier Fly

Scientific name: *Hermetia Illucens L.*

This pest has caused economic impacts on banana farms that inadequately manage rejected fruit, thus causing favorable growth conditions. (Minambiente, SAC and AUGURA 2002, Uniban 1998, cited by Osorno, M,. and Mejía, G)

Adults are shiny black, approximately 16 mm in length, and their legs have black and white. Females lay eggs in groups on rotting bananas, where they reach the chrysalis stage. Chrysalises have a segmented appearance and are brownish-gray.

(Minambiente, SAC and AUGURA 2002, Uniban 1998, cited by Osorno, M. and Mejía, G)

Figure 44. Black soldier fly

Damage:

Black blight on fingers in less than two weeks, which at the time of harvest, looks like alligator skin.

Figure 45. Black soldier fly larvae

Figure 46. Finger damage

Management recommendations:

- Chop up bunches accordingly
- Adequate management of composters
- Natural enemies

Cultural management includes crushing fallen plants and bunches beyond harvest age, and adding lime. Avoid rejected fruit and organic debris buildup, and bag bunches early using bags with holes of smaller diameter or bags treated with insecticide in periods of high insect populations.

Figure 47. "Writer spider"
Argiope argentata, black soldier fly predator

Mealy Bugs

Scientific name: *Pseudococcus elisae*

In Colombia, reports indicate that the following species have attacked *musaceae* plants such as plantain and banana:

Pseudococcus elisae
Pseudococcus jackbeardsleyi
Pseudococcus landoi
Pseudococcus longispinus
Pseudococcus peregrinabundus

Also called "mealy bugs," they comprise many species that cause considerable damage to the plant aerial portion and its roots. These insects are identified by the presence of glands that secrete a

Figure 48. Mealy bugs

whitish dusty or cottony wax. (OIRSA, 2000, cited by Osorno, M. and Mejía G)

Once the eggs hatch, nymphs stay in the capsules for a short time and then move about the plants. Nymphs extract the sap, damaging the plant because of the strong suction exerted on the tissues and the abundant production of sugary oozing that attracts ants and other insects and favours the development of fungi such as *Capnodium* spp or the Meliolaceae family, that cause black mildew. Growing colonies of this insect can deteriorate and cause cosmetic damage to fruit. (Osorno, M. and Mejia, G)

Figure 49. Insect – Insect relationship (mealybugs with ants)

Figure 50. Development of fungi on the fruit (black mildew)

Management recommendations:

During the rainy season, problems are sometimes even more severe on bunches covered with untreated bags.

- Premature bagging is recommended, using treated bags in areas with the highest presence of insects
- Adequate shoot pruning exposes the insect to rain and other organisms in plantations
- Since mealy bugs are generally transported by ants, fold the tie leaf to hinder access to the bunch
- Wash bunches with pressurized water to loosen mealy bugs from fingers, crowns and shoots
- Ensure adequate drainage maintenance
- Adequately control weeds in ditches and plantations, focusing on host plants. (pampas grass and powder puff)

The level of economic damage on banana and plantain has not yet been determined for this pest.

Caterpillar worm

Scientific name: *Ecphanteria* spp

Adults are white moths ranging in size from 4 to 6 cm. Females lay eggs in groups on the leaves and pseudo-stem. Larvae are reddish brown and eventually migrate to fruit bunches, where they feed and then move to the soil to form the chrysalis.

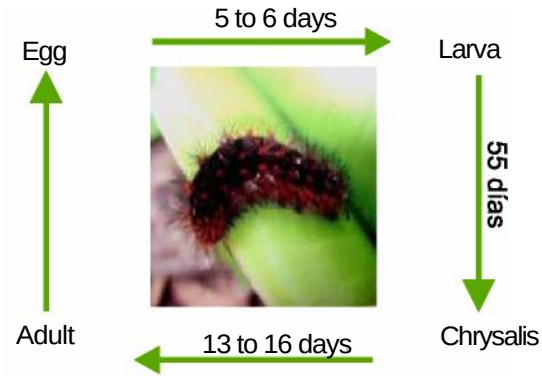

Figure 51. Life cycle

Smaller larvae affect the fruit most, eating the outer part of the skin and leaving streamer-shaped scars. Generally the damage is not of economic importance.

Figure 52. Damage on fruit

Management recommendations:

Since larvae prefer eating suckers and sprouts, they should be managed appropriately to prevent pest population increases.

Trigona Bee

Scientific name: *Trigona* spp

These dark-colored bees are attracted by the sugary nectars of banana and plantain flowers, eventually nibbling on the fruit and deteriorating its edges. Mechanical control of their nests contributes to manage the problem.

Figures 53 and 54. Trigona bee causing damage to fruit edges

Trips

Scientific name: *Frankiniela parvula*

These very small insects measure about 0.4 mm in length. Females are black, males are brown and nymphs are transparent. These insects feed on pollen, and place themselves inside the bracts, hiding in the tips of flowers. They lay their eggs on the surface, where nymphs go through their first development stage.

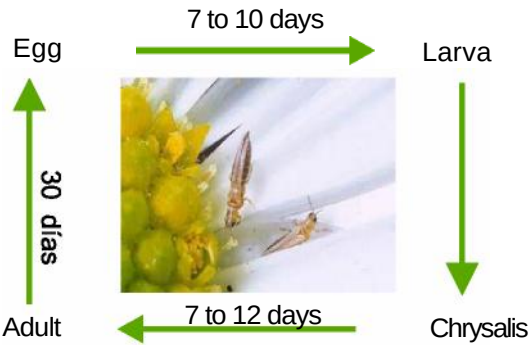

Figure 55. Life cycle

Damage

When eggs are laid on the fingers, bulging pustules form on the spot where oviposition took place, causing small dark brown spots.

A reddish spot is caused by pinching and egg placement on the skin, mainly as fingers rub against each other. A reddish color spreads all over the finger's surface and cracks form on the skin of more developed fruit.

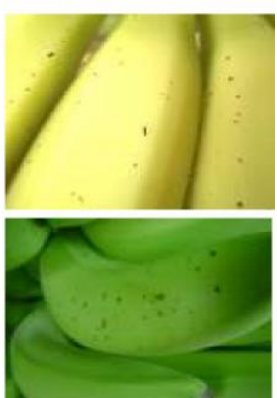

Figure 56. Damage on fruit

Control

No existing controls are efficient in presence of high insect populations. Consequently, the option is to eliminate all sources of pollen, either at bunch or plantation level. It is assumed that natural controls (fungi, viruses, bacteria and environmental conditions) keep populations in check. (Osorno, M. and Mejía, G)

Figure 57. Damage on flowers

2.3. Root insects

Banana root borer / weevil borer

Scientific name: *Cosmopolites sordidus*

One of the most important pests in banana and plantain farms in Colombia, these beetles measure 1.5 to 2 cm in length, and their head has a black and curved spike, and two large antennae. Their color ranges from dark brown in newborns to black when fully developed.

Figure 58. Adult banana weevil borer

Damage

The pest can attack any development stage of the plant. Larvae feed and develop inside the shoot, forming galleries or tunnels. The symptoms appear yellowing leaves, weakness, reduced bunch formation and development, or presence of defective bunches.

Figure 59. Banana weevil borer larva

Control

- Dispose of harvest debris and corms, since their decay attracts adult insects.
- Cut pseudo-stems of harvested plants into small pieces and scatter around the area to dry.
- Maintain plantation free of weeds and adequately fertilized. Monitor affected plants for eventual destruction.
- Use seedlings from healthy plantations.
- Establish traps with debris (stumps and pseudo-stems) to trap adult insects.
- Use microbial control with fungi such as *Beauveria bassiana* and *Matarhzium anisopliae*, which grow on larvae, chrysalis and adults. Commercial products based on these fungi are readily available.

Figure 60. Adult root borers with *Beauveria* parasite

Economic damage levels

Four to five insects per trap

Control

Scientific name: *Matamasius hemipterus*

A potential pest in plantain growing areas, these insects cause limited damage. Its presence is associated to plantations in poor conditions and potassium deficiency.

They can be found on plants with wounds, rotting tissues and harvest debris.

The insect itself cannot cause wounds on the stems, and instead exploits damage caused by other insects to enter the plant and build galleries inside the shoot.

Figure 61. Adult silky cane weevil

Damage

Leaves turn yellow and later dry out. A small, weak bunch is formed and ripens prematurely. Plants bend over due to the weight of bunches.

Figure 62. Silky cane weevil larva

Control

Do not damage the plant

Keep plantation free of weeds and fallen leaves

Adequately drain the plantation.

Beetle

Figure 63. March or April beetles

Scientific name: *Eutheola bidentata* and *Dyscynetus* spp

These insects appear with the arrival of the rainy season, and are commonly known as March or April beetles. They show up in new plantation areas, that were previously not in use or destined for pasture.

Larvae are locally called “chiza” or “mojojoy,” and feed on grass roots. When adults emerge from the soil in a recently planted area, they look for seedlings and perforate the pseudo-stem base to bore galleries, used for mating.

In countries that import plantain and banana, these insects are destined to quarantine. Although they do not directly or economically affect plantations or fruit, difficulties may arise and increase operational shipping costs.

Control

Destroy plants that are a source of food for the pest.

Plow the land before planting, to expose larvae and pupas to sunlight and predators.

Use light traps.

Nematodes

Scientific Names: *Radopholus similis; Helicotylenchus multicintus*

Nematode-related diseases play a relevant role in agriculture. *R. similis* is the most relevant nematode in banana and plantain farms in Colombia.

Figure 64. Nematode

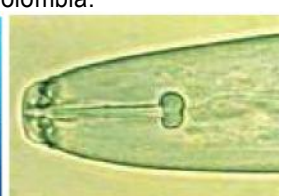

Figure 65. Nematode mouth structure

Damage

Root damage makes them turn blood red in color, and later purple or dark violet. As a consequence of the attack, there is root death and loss, resulting in a reduced capacity to transport water and nutrients. Limited anchoring causes high vulnerability to tipping, mostly in flowered plants, and a shorter production span.

Figure 66. Root damage caused by nematodes

Figure 67. Plant tipping caused by nematodes

Control

The main control lies in an adequate drain network, as well as correct corm management, which are the main vector of this problem. Addition of organic matter and mycorrhizae inoculation is also important.

Parasitic and predator nematodes species exist as well as predators that attack these harmful organisms.

2.4. Diseases

Black Sigatoka

Scientific name: *Mycosphaerella fijiensis*

This is considered the most disabling disease in banana and plantain farms in Colombia. It attacks leaves, and rapidly deteriorates fruit quality when left uncontrolled, as it causes early ripening.

In advanced stage

Damage

Initial damage is visible on the reverse side of the leaf, approximately 10 to 12 days after infection. Small red spots start growing parallel to the vein; the underside turns dark brown and almost black on the front side, finally coming together forming a large dark spot without further yellow parts. When inoculation is high a considerable portion of the tissue dries out.

Figure 69. Dead tissue on leaf (spots) caused by fungus

Figure 68. Plantain leaf with disease

In order to facilitate disease monitoring and information, its development has been subdivided in six stages. Severity is the parameter used to estimate the degree of disease attack, measuring the level of infection per leaf, plant, lot, farm and zone.

Development degrees of black Sigatoka

Grade 0: No symptoms

Grade 1: Less than 1% (up to 10 spots)

Grade 2: Less than 5% affected area

Grade 3: From 6 to 15%

Grade 4: From 16 to 33%

Grade 5: From 34 to 50%

Grade 6: More than 50% affected area

Figure 70. Degrees of infection

Cultural Control

Cultural management is aimed at reducing the sources of fungus inoculation, and managing conditions that may be unfavorable for the development of the disease.

Adequate ventilation is achieved through timely weed control, pruning, surgery, and correct management of surface water.

Phytosanitary management is an essential disease-control tool that many growers have implemented through integrated Sigatoka management (MIS).

Figure 71. Integrated pest management (IPM) of Sigatoka

Chemical Control

As the most widely used method today, it is achieved following the guidelines of the Action Committee against Fungicide Resistance (FRAC).

Numerous systemic fungicides and protectants are used to control this disease, as described on the following chart:

Commercial name	Active ingredient
Siganex SC (600g i.a/l)	Pyrimethanil
Opus SC (125g i.a/l)	Epoxiconazole
Volley 88 OL (880g i.a/l)	Fenpropimorph
Calixin 86 OL (860g i.a/l)	Tridemorph
Sico 250 EC (250g i.a/l)	Difenoconazole
Dithane F -MB (430g i.a/l)	Mancozeb
Impulse 800 EC (800g i.a/l)	Spiroxamine

Moko disease

This disease, commonly known as Moko or Maduraviche, is caused by *Ralstonia solanacearum* strain 2 bacteria.

Figure 72. Plantation affected by moko

Symptoms

Yellow circles form on central leaves, which are withered and yellowish, and the flag leaf dries out. Atrophic inflorescence and bunches, which also ripen prematurely. In the pseudostem the veins turn reddish, light or dark brown, and the corm displays red dots of vascular clusters with Moko oozing.

Figure 73. External symptoms on young plants

Figure 74. External symptoms on adult plants

Figure 75. External symptoms on bunches

Figure 76. External symptoms on inflorescences

Figure 77. Internal symptoms on suckers

Figure 78. Internal symptoms on pseudo-stems

Figure 79. Internal symptoms in stumps

Disease Dispersion Methods

The main and most frequent dispersion methods are related to several field activities and factors, such as:

- Lesions on plants in affected lots facilitate dispersion through work tools, which is considered the main vector in farms.
- Infected breeding materials moved to clean lots, and movement of animals among infected and clean areas.
- Late inspections that result in ripe bunches remaining in the field, and late or incorrect flower cutting, attracting disease-bearing insects.
- Water flowing through drainage ditches can spread infected materials from one area to another.

Figure 80. Shoots from infected lots spread the disease throughout the plantation

Disease Control

Control must be aimed at eradicating the disease instead of curing it. However, existing protective measures can limit its entry or dispersion in plantations, such as:

- Using healthy propagation material coming from disease free areas.
- Using tools exclusively to a given farm.
- Limiting the transit of animals and people not directly involved in the operation.
- Training all field workers in the detection and timely treatment of outbreaks.

Once an outbreak has been identified in the field, immediate eradication is required with systemic herbicides and integrated management during the quarantine. Treatment of outbreak areas could either eliminate or aggravate the disease, so it is advisable to not chop affected materials from the affected plants. Recommended controls dictate eliminating plants in the outbreak area with a 20% glyphosate solution of of the commercially formulated product of 480g/l. Thereafter, different strategies could be followed depending on the severity of each detected case:

- Eradication of plants in a 10-meter radius.
- Eradication of plants in a 5-meter radius.
- Eradication of the infected plant only.

In the first two cases, the infected plant is used as a centre point, from which a 5-10 meter radius is determined and healthy as well as infected plants are eliminated. All plants are injected with a glyphosate solution, applying 50 cc on adult plants in 5 different spots, following a spiral shape. The volume to treat young plants depends on their size.

An application of systemic herbicides is necessary to keep the area weed-free during the six-month quarantine, after which planting can resume.

Outbreak spots are inspected within 1 to 4 weeks, depending on the radius selected. If few plants were eliminated, inspection must be more frequent to ensure quick detection of suspected cases.

If only the infected plant was eliminated, all plants within a 10-meter radius must be inspected on a weekly basis, as there is a higher risk of infection.

In the event new cases are detected, the treatment radius is expanded to prevent further spreading.

After eradication, it is imperative to:

- Circle the outbreak point and note the treatment date.
- Do not cause unnecessary wounds to the plants during cultural tasks.
- Use foot rinse basins on trails, inside plantations and in places that may connect infected areas.
- Disinfect all tools used in the field.
- Tie flowered plants with double knot, never use needle.
- If applicable, suspend irrigation in outbreak areas.
- Adequately train and supervise operational staff.
- Respect the 6-month quarantine.

Appointing a single person to perform these tasks in infected lots is an effective way of keeping the disease under control.

Figures 81 to 85. Procedure to eradicate the banana and plantain plants affected by Moko disease

OTHER PHYTOSANITARY PROBLEMS IN BANANA AND PLANTAIN

Crown rot



Figures 86 to 88. Crown fungi

In the banana trade, crown rot is regarded the most important post harvest disease. It usually appears only on the crown, but when left untreated, it will also spread to the fingers.

This problem is caused by a series of fungi that affect fruit quality during the export process. Nowadays fungicides (Imazalil and Thiabendazole) are applied on the surface of recently cut crowns during fruit selection and packaging for control purposes. (Fernandez and Garcia 1991, cited by Osorno, M and Mejía, G. 2006)

In addition to numerous unidentified bacteria and viruses, more than 32 fungi species have been associated to this problem, among them: *Acremodium* spp*, Aspergillus* sp*, Botrioplodia theobromae, Cephalosporium* sp*, Ceratocystis paradoxa, Cladosporium herbaum, Clodosporium* sp*,* and *Colletotrichum musae*.

Fungi attack the cut surface of banana and plantain crowns. The crown tissue softens first and then spreads to the fruit peduncle.

All commercial banana varieties (AAA) are currently susceptible to this phytosanitary problem. (Fernández and Garcia 1991, cited by Osorno, M and Mejía, G. 2006)

Johnston Spot

Scientific name*: Pyricularia grisae*

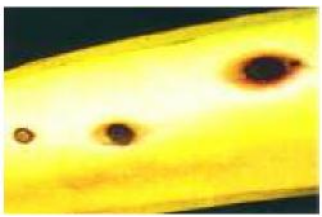

Figure 89. Johnston spot.

Round spots produce a reddish brown area around a recessed center, and a watery green spot can be detected on the outside. The center of the lesion does not crack and normally the pulp is not affected. Control consists of keeping plantation moisture in check. (Minambiente, SAC y AUGURA 2002, Uniban 1998)

Diamond

Scientific name*: Cercospora hayi,* followed by *Fusarium solani* and *Fusarium roseaum*

Figure 90. *Cercospora hayi* Diamond

Oval- or rhomboid-shaped lesions that can form on the finger. Infected cells cannot expand like healthy cells do, causing longitudinal cracks surrounded by a yellowish rim. With time, it turns black and grows to

approximately one inch in size, where the centre is the largest.

During its intermediate stage, the disease can be mistaken with a Johnston spot symptom. No specific control method existscurrently . (Minambiente, SAC and AUGURA 2002, Uniban 1998)

Mealy Bugs

Xanthomonas sp

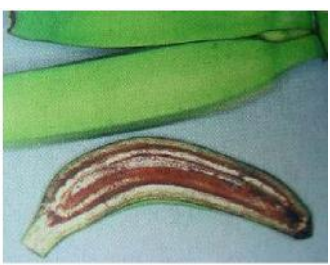

Figure 91. Fruit affected by *Xanthomonas*.

Mostly seen on fingers as a deformation of the tip (bottleneck), and/or smaller and thinner fingers when compared to those of healthy hands. The most severe symptom is pulp necrosis that can be seen when the finger is cut lengthwise.

One control method consists of removing flowers in the field to avoid the presence of inoculums in the finger. (Minambiente, SAC and AUGURA 2002, Uniban 1998)

Anthracnose

Scientific name: *Colletotrichum musae*

Figure 92. Fruit affected by anthracnose.

Cigar tip

Scientific name: *Trachysphaera fructigena, Verticillium sp, Stachylidium sp*

Figure 93. Fruit affected by cigar tip

Bunchy top banana virus

Scientific name: *Xanthomonas sp*

Figure 94. Symptom of disease on petiole

Figure 95. Dwarf plant affected by bunchy top

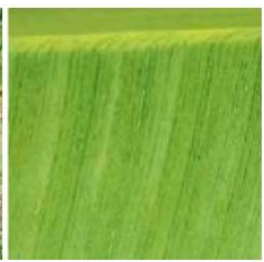

Figure 96. Stripes on the leaf

As the most significant viral disease for plantain and banana worldwide, this is transmitted locally and repeatedly by the banana aphid *Pentalonia nigronervosa*. It is borne by infected vegetative material, pup corms and seedlings (meristems). Since it is not present in the soil, tools are not likely disease vectors. Such a disease has not been reported in Colombia.

Symptoms

Affected plants show a variety of symptoms. In advanced stages they look like rosettes or bunches, with narrow, vertical leaves tapering in size, which gives them the bunchy top name. Leaf edges roll upwards and turn yellow. Usually, dark green stripes appear along smaller veins, and look like hooks as they get closer to the central vein.

Control

The virus can be most effectively controlled by eliminating sick plants, and using virus-free stock material. Infected production units should be eliminated completely, including corm and pups.

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4. Glossary

DEFOLIATION: falling of leaves, either from natural or artificial factors.

ECONOMIC DAMAGE LEVEL: amount of damage that justifies the cost of artificial control measures. The main goal of integrated pest management is to keep the population level below this threshold.

INOCULATION: introduction of a substance inside an organism.

LIMB: flat and visible part of plant, generally wide, crossed by veins and supported by petiole.

OVIPOSITION: action of egg lying by insects, arachnids, reptiles, birds, amphibians and other organisms.

PATHOGEN: any organism capable of causing a disease.

PSEUDOSTEM: false stem formed by densely rolled and superimposed leaf bases. Typical of the *Musa* genus.

PUPA: stage during which insect hides in a capsule for protection while juvenile organs are reabsorbed and the organism takes a completely different structure. Not all insects pass through the pupa stage.

TRAP CROPS: trap that attracts harmful insects and keeps them away from major crops. The use of these plants may reduce the damage on crops and the use of pesticides.

Table of Contents

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