FARMER'S SERVICE BULLETIN

Banana Crops

Guarany

tradition and technology

FARMER'S SERVICE BULLETIN

BANANA CROPS

ÍNDEX

Introduction

Bananas (genus Musa spp.) originally came from Asia and have spreadall over the world. Today it is the fruit most produced worldwide, with approximately 102 million tonnes being produced in 2011 (source: FAO, 2012).

There are about 50 species of Musa known worldwide; some are inedible.

Among the edible group of bananas, the most commercially grown varieties mainly come from the Musa acuminata species and Musa balbisiana, from which various combinations of the genome have developed, giving their origin to the banana, as we know it today.

Some 130 countries produce this crop, and Brazil is the 5th largest producer (6.9% of the total), following Ecuador (7.8%), Philippines (8.9%), China (9.3%) and India (28.1%) (FAO, 2012).

In recognition of the importance of this crop in many countries, we have prepared this Farmer's Service Bulletin with useful and practical information on theeffective control of pests, diseases and weeds based on our experience in developing equipment and accessories for the phytosanitary treatment of the banana.

Here, producers can find a complete range of products and the best technical solutions for every situation in order to optimize the results from their plantations.

In thisFSB, which is prepared by our technical experts, key points are addressed such as major symptoms, damage, conditions conduciveto problems that occur, the right timing for control and the best solutions, such as Guarany equipment.

We hope that this bulletin becomes a pocket guide, and a very useful day-to-day reference for the producer to maintain a healthy and productive plantation, ensuring the best results.

You can count on Guarany, a company that invests in continuous improvement for better spraying results. The company's products are certified and recognized for their quality and technological innovation and are now available in over 60 countries.

Note: Phytosanitary problems (diseases and pests) and methods to control them described in this bulletin are directed mainly at the triploid banana in the AAA genomic group, Cavendish subgroup (made up of Dwarf Cavendish, Lacatan, Williams and Grand Naine crops), which together represents most of the sales worldwide.

However, for the other groups/crops that are susceptible to the same pests and diseases reported in this bulletin, such as the prata, the applebananas and other crops - in the AAB group - which also have significant commercial importance, the same methods of control are applied.

2.WEED CONTROL

2.1 CONTROL PERIODS

According to the crop phase:

• Banana plantation - the first 5 months of planting:

The crop in this phase is very sensitive to competition from weeds, requiring monthly controls to achieve faster growth and higher banana production;

• Banana formation- 5 months after planting:

Upon entering this phase, the crop becomes less sensitive to competition from weeds, but the control should not be overlooked, because some weeds provide shelter and a food source for organisms that transmit disease and pests, e.g. bacteria Ralstoniasolanacearum specie 2, which causes Moko disease, the Sordidus Cosmopolitesbeetle (Common name banana root borer) and even nematodes (for example: Radopholus similis).

According to the season/time of year:

• Rain

The highest incidence of weeds and growth is during the rainy season; thus, you should be more attentive to the control during this period, even in well-formed banana plantations ("mature plants").

• IMPORTANT NOTES BEFORE APPLICATIONS

1. Identify the species of weed to be controlled (historical area data);

2. Select the ideal herbicide:

- Pre-emergent = strength depends on soil texture;
- Post-emergence = strength depends on weed growth stage;
- Selective herbicides - to control narrow leaf or broadleaf (concots/dicots) invasions;
- Non-selective herbicide - for general weed control.

Contact the pesticide manufacturers and/or a suitable qualified and legally responsible technician in order to choose the correct chemical.

2.2 GUARANY SOLUTIONS FOR WEED CONTROL

1.Sprays:

- Knapsack Sprayer SP - 20 and 16 litre;
- Knapsack Sprayer SP - 12 litre;
- Flat Jet impact spray nozzle (deflector);

Accessories:

- Horizontal Rear Boom, with 4 or 6 spray jets placed 50 cm apart (Figure 1a and 1b);
- Flow Rate Regulators (CF Gate Valve® - Figure 2), for pressures of 1 BAR (yellow) 1.5 BAR (red), 2 BAR (blue) and 3 BAR (red);
- Flow Rate regulator - with stopcock and pressure gauge (Figure 3);
- Spray Control Shield - Figure 4a and 4b

Figure 1a

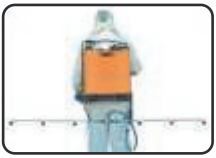


Figure 1b

Figure 2

Figure 3

Figure 4a

Figure 4b

- All Guarany Knapsack Sprayers can be used for weed control and we recommend using the Horizontal Rear Boom accessory to improve performance and increase the yield and efficiency of the operation. This boom can be adapted to work in front of or behind the operator;
- Guarany SP symmetrical knapsack manual sprayers are supplied with a flat jet impact spray nozzle (deflector), ideal for non-selective herbicide applications, since they allow a good coverage of weeds with low product drift;
- Apart from these, Guarany also recommends using CF Gate Valve®flow rate regulators (Figure 2) or the Guarany flow regulator (Figure 3) for optimal control of flow/pressure and hence less interference with the variation of volume applied and droplet size;
- The use of the Spray Control Shield (Figures 4a and 4b) is also recommended for use withflat jet impact spray nozzles (commonly called 'range' nozzles) to apply non-selective herbicides, for better protection of "young" bananas from possible drift.

3. CONTROL OF PRINCIPLE DISEASES IN BANANA CROPS

3.1 YELLOW SIGATOKA and BLACK SIGATOKA

Characteristics	YELLOW SIGATOKA	BLACK SIGATOKA
Causal agent of the disease	Fungus ***Musicola*** *Mycosphaerella* ***(Leach)*** - sexual form of the fungus, or *Pseudocercospora musae (Zimm)* - asexual form	Fungus ***Mycosphaerella*** *fijiensis* ***(Morelet***) - sexual form of the fungus, or *Fijiensis Paracercospora (Morelet)* Deighton - asexual form.
Other common names for the disease	Cercospora leaf spot of banana, poor leaves, leaf spot and leaf blight.	Black *leaf streak* or *black streak*, when it was first discovered (1963).
Specifications	Known since 1902 on the island of Java, Southeast Asia. First reports of significant damage in 1913, in the Sigatoka Valley, Fiji.	This is the most destructive disease in all banana-producing areas worldwide. Attacking more crops than yellow sigatoka.

IMPORTANT: tthese are the two main banana crop diseases, since most of the world trade of this fruit is concentrated on a single group of cultivars *(Musa acuminata*, AAA, Cavendish subgroup), which is highly susceptible!

SYMPTOMS OF YELLOW SIGATOKA

Symptoms can be seen on the upper surface of the leaves and are defined by six development stages (I to VI - see Figure 5), which characterizes the development of the disease on the plant:

- Early stages of the disease (I and II) = can be seen above the 2nd up to the 4th leaf from the 'cigar leaf' (zero leaf) ; these are all small light green spots (up to 1mm), which develop into yellow traces (up to 3mm) on the top edge of the leaves.

- Stage III = traces widen (forming streaks) with brown edges and rust-coloured centres.

- Stage IV, V and VI = the streaks become elongated brown patches, then are replaced by black (with yellow outlines) and the plant material in the centre of the lesion completely dies. Patches reach from 12mm to 15mm long by 2mm to 5mm wide and can be seen on the 4th and/or 5th formed leaf.

[1]Note: The cigar leaf or zero leaf stage is when the leaf has not opened. The leaves are counted from the youngest to the oldest.

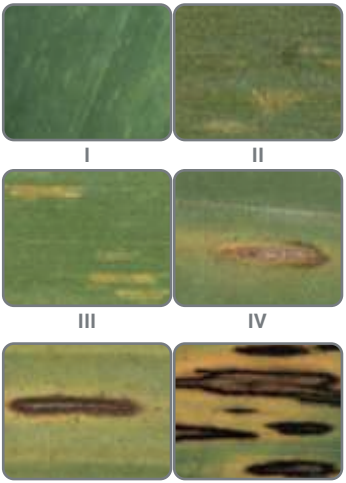


Figure 5. Phases of development of yellow sigatoka on banana leaves

SYMPTOMS OF BLACK SIGATOKA

Black Sigatoka is similar to yellow sigatoka where fungal infection occurs in the young leaves of the plant and symptoms evolve in 6 stages (I to VI - see Figure 6) but the symptoms of black sigatoka are first seen in a different location, on the underside of the leaves. In addition, the disease may be seen even in young plants (seedlings), whereas yellow Sigatoka is more restricted to mature plants.

- Early stages of the disease (I and II) = With the aid of a magnifying glass(10X to 20x magnification), small white or yellow marks may be seen on the 1st and 2nd leaves after the cigar leaf (zero), with brown spots coming together to make lesions (2 to 3mm lines) between leaf veins;
- Stages III = Lines join together, becoming larger and darker lesions, which can be seen by the naked eye on the 3rd and/or 4th leaf;
- Stage IV, V and VI = Black spots are formed which can be seen on the upper surface of the leaves, these patches become depressed in the centre and sometimes are surrounded by a yellow halo; finally the centre of the lesion is completely necrotic ("fully burned"), in very dark grey, with several black spots being visible (the reproductive structures of the fungus).

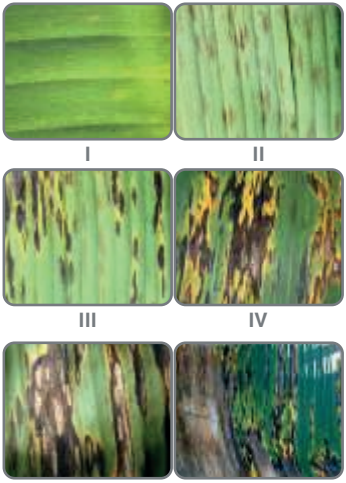


Figure 6. Phases of development of black sigatoka on banana leaves

TIPS TO DIFFERENTIATE YELLOW SIGATOKA AND BLACK SIGATOKA IN THE FIELD

What/where to look for?	YELLOW SIGATOKA	BLACK SIGATOKA
Initial Symptoms	Clear streaks	Brown streaks
Location of initial symptoms	Upper surface of young leaves	The underside of new leaves
Yellow halo around the lesions	Commonly occurs	Does not always appear
Lesions joining up	Occurs in the later stages of lesion	Usually occurs in the early stages - the streak stage
Shape of lesions	Mostly elliptical with contours	Most irregular with ill-defined contours

DAMAGE

YELLOW SIGATOKA	BLACK SIGATOKA
Leaf area reduced = reduced photosynthesis = decrease in production (average decrease is 50%).	Large and quick reduction in leaf area = photosynthesis = large drop in production, 50% to 100% reduction compared to ideal conditions.
In advanced stages of the disease, lesions merge and the leaves die, with a consequent reduction in the number of bunches and fruit size and uneven amount of fruit ripening.	Even in the early stages of the disease, a large number of lesions are formed which join up and cause premature death of leaf tissue, with a consequent reduction in the number of bunches and fruit size and uneven ripening of fruits.

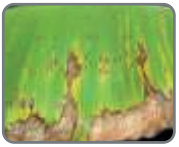


Figure 7a. Typical damage of yellow sigatoka

Figure 7b. Leaf with severe yellow sigatoka damage

Figure 8a. Typical damage of black sigatoka

Figure 8b. Plant heavily damaged by Black Sigatoka

FAVORABLE CONDITIONS FOR THE DISEASE

YELLOW SIGATOKA	BLACK SIGATOKA
Optimum temperature between 21 and 25°C	Temperatures higher than 21°C with an optimum range between 25 and 28°C.
Prolonged wet leaves and high relative humidity, after rainy periods in the year	Prolonged wet leaves and high relative humidity
Specifications: In general, temperatures below 15°C and above 35°C result in a considerable decline in the rate of infection and disease development, even with appropriate conditions of moisture.	**Specifications:** In general, temperatures below 20°C result in a considerable decline in the rate of infection of the pathogen. Above 30°C, the severity of the disease is reduced. However, above 80% humidity, the fungus even develops at temperatures above 35°C.

CHEMICAL CONTROL

TIMING

To apply chemical control at the right time, favourable weather conditions for the disease must be monitored - as described above. In some countries, the major producing regions are located in different climatic zones, so the most favourable time for the disease varies by region. The important thing is to be aware of the rainy periods with higher temperatures which cause sigatokas to develop faster in the field.

There are also forecasting systems (or biological pre-advice) used to set the correct time to start chemical control.

They are based on periodic assessment of disease severity in young leaves and in plant development by weekly bulletin announcements. These systems are widely used in Central American countries such as Costa Rica and in some regions of Brazil. **Contact a legally qualified and/or professional research institute in your producing region to find out further information on this.**

SPRAYS

Spraying is the chemical control method used worldwide to combat these two diseases.
The following information, related to the target (location) area and the type of application, as well as the chemicals most commonly used, can also be applied to the management of the two diseases. The main difference between controlling the two sigatokas is that since the Black one is more aggressive, it generally requires more spraying.

IMPORTANT: The fungi usually start infection when the leaves are at the 'cigar leaf' stage (curled) or when newly opened. Therefore, they are the main places that should be sprayed to contain the spread of disease.

CHEMICALS USED

- Protective fungicides (contact or preventive), copper-based products, such as copper oxychlorides, copper hydroxides and copper oxide;
- Systemic fungicides: the triazole chemical group, used alone or in mixed (formulations) with strobilurine
- Mineral oils for spraying: are commonly used in mixtures with the fungicides mentioned here, however, you should be careful not to spray the fruit clusters because these oils can cause phytotoxicity or plant tissue damage!

LEAVE IN BOLD

IMPORTANT: Only buy government registered pesticides to use on banana crops and apply the correct dosage complying with the intervals of application recommended through legally qualified professionals and product manufacturers.

3.2 GUARANY SOLUTIONS FOR CONTROLLING THE DISEASE

1. Foliar sprays using **11 litre and 18-litre** Knapsack Power Mist Blowers.

When using the Guarany mist blower to control sigatoka (yellow and black), it is important to target the fungi in the areas where the infection starts, i.e. the youngest leaves, which are at the top of the plant. So, the chemical should be sprayed above the level of the leaves with the mist blower nozzle in the vertical position (Figure 9), walking between the lines of plants moving the discharge tube slightly from left to right so that the product can be deposited on the youngest leaves and does not affect the bunches of fruit.

Figure 9. The correct spray position to control sigatoka with the Guarany Mist Blower.

11-litre and 18-litre Knapsack Power Mist Blower: provide these benefits: greater comfort when used on an incline, high performance TK 65 Kawasaki engine (high power) and excellent droplet penetration into the crop. The equipment has an **atomizer nozzle (Figure 10a):** 5-flow rate options (200, 750, 1500, 2000 and 2500 ml/min) and a diffuser to increase the diameter of the droplet jet (Figure 10b).

a b

Figure 10. (a) Mist blower nozzle in use (b) colour-coded flow rate regulators (200-2500 ml/min from left to right) and diffuser (black).

3.3 CASE STUDY: GUARANY EXPERIENCE IN CONTROLLING BLACK SIGATOKA IN BANANAS IN THE DOMINICAN REPUBLIC

Considering the importance of banana plantations in the Dominican Republic, which represents 3.9% of the Gross Domestic Product (GDP), the impact of the Black Sigatoka disease can cause serious economic losses to farmers.

In 2009, the disease had reached alarming levels of destruction across the country's producing area, with over a 40% reduction in banana production for export.

This fact led to an increase in aerial spraying, which did not manage to control the disease and later manual spraying with power misters and hydraulic pressure nozzles, creating environmental contamination, phytotoxicity problems (burning leaves and fruit), health problems and so reducing the farmer's profits.

In this context, the company FERQUIDO (Fertilizantes Químicos Dominicanos), a partner of GUARANY,prepared a series of measuresthat reduced the damage from Sigatoka, increased productivity and also resulted in new technologies.

General Objectives of the work

To assess and compare the traditional method of ground application (hydraulic pressure nozzle) to using the Guarany Power Mist Blower (pneumatic nozzle) in relation to:

- Application efficiency and effectiveness in disease control;
- Number of applications/year;
- Phytotoxic effects in the plantation.

Spraying was done in plantations cultivating varieties of Williams and Grand Naine (in Spanish 'Grane enano'), both from the genomic group AAA, subgroup Cavendish grown at a spacing of 2m x 2m; and using 2 applications with the same product and strength (Peptiram for organic bananas, Flonex and Orang oil).

After the necessary equipment adjustments and calibrations in testing areas, the following set treatments were applied:

- **Guarany Knapsack power mist blower:** 1500 ml/min tip, Volume Median Diameter (VMD) of 85 micron droplets and application volume of 69 L/ha;

- **Power knapsack sprayer [2]:**
·application volume of 125 L/ha

The differences between the equipment according to the above criteria were measured by the following assessments:

- Average density of droplets (droplets/cm^2) on water sensitive paper, on 9 leaves on the plant;

- Index of disease severity over time following applications - scale based on the system of prior notice of the disease and the number of healthy leaves sprouted weekly during a period of approximately two months after the chemical treatment began;

[2]Power knapsack sprayer with nozzle with hydraulic pressure: droplet size (VMD) not published in the manufacturer's catalogue.

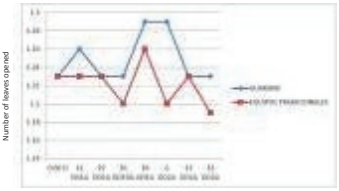
•Analysis of visual symptoms from phytotoxicity on leaves;

•Number of hectares (ha) treated per hour of work.

•Average density of droplets (droplets/cm^2) :
The water sensitive paper was placed on the underside of leaves. It was noted that the number of droplets obtained with the Power knapsack sprayer was always below the droplet density patterns recommended in the literature relative to fungicides for the control of sigatoka (60 to 80 droplets/cm^2):on the other hand, the recommendations were reached using the Guarany Mist Blower.

• Index of disease severity:
It was found that with Guarany equipment the disease severity was always lower, which highlights the importance of obtaining adequate droplet coverage on the leaves of the plant.

•Number of healthy leaves opening up per week:
Based on assessing the number of healthy leaves opening (able to photosynthesize) during a 6-7 day period for 2 months from the start of chemical treatment, it was found that the Guarany Mist Blower provided a greater number of leaves opening up, which consequently results in a better rate of photosynthesis and may result in higher production.

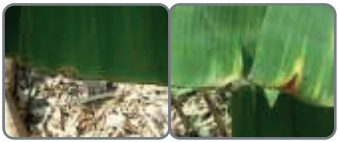


•Analysis of visual symptoms from phytotoxicity on leaves:
As seen in Figure 11 below, it is possible to see that the agrochemical spray applied, containing a mixture of fungicide + oil, resulted in a minimal (not significant) phytotoxicity when sprayed with Guarany equipment. However in applications with Power Knapsack Sprayers, there is a marked phytotoxicity at the edges of the leaves, indicating that the droplet size and volume applied using this equipment promotes a flow of mixture that is harmful to the plant.

GUARANY Mist Blower:

a b

Power Knapsack Sprayer (PKS):



c d

Figure 11

•Number of hectares treated per hour of work:

Applications showed more operational efficiency for Guarany equipment than the Power Knapsack Sprayer (Figure 12 below), due to: a) the reach provided a wider application range, b) droplet size spectrum resulted in greater coverage of droplets on the leaves c) less solution was used on a given area.

In the field, this can be translated into less equipment needed and less labour employed per treated area.

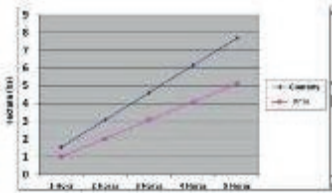


Figure 12

4. CONTROLLING THE PRINCIPAL PESTS

4.1 BANANA ROOT BORER

Scientific name: *Cosmopolites sordidus* (Germ. 1824) .

The Banana Root Borer, considered a major pest for banana plantations, is a Coleoptera beetle, in the group ofCurculionidae (Figure 13), and can be found in several production areas throughout the world and has high potential for causing damage. This insect attacks all cultivars, but with different intensities.

Figure 13. Adult beetle – It is approximately 11 mm long by 4 mm wide and is black

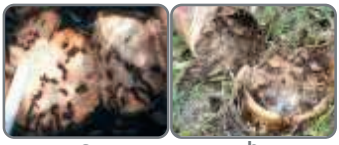
The adults are active at night, but is rarely found during the daytime, they remain "hidden" in the light, in clumps of the plant and between the sheaths of leaves. It mainly lays its eggs inside the sheath of the leaves near the crown of the rhizome, which then produes larvae (Figure 14).

Figure 14. Larva = can measure up to 12 mm long by 5 mm wide

DAMAGE

The larvae feed and build tunnels inside the rhizome (Figure 15) and the bottom of the pseudo stem.
Thus, the leaves dry out resulting in a large reduction in the weight of fruit. Tunnels formed make the plants fragile and susceptible to falling over as well as allowing diseases to start.

A reduction of 20% to 50% in production is common throughout infested areas.



a b

Figure 15. (a) Banana rhizome with tunnels formed by larvae C. Sordidus and (b) plants falling over as a result of a larvae attack.

CONDITIONS CONDUCIVE FOR THE PEST

Humid environments and soils favour the survival of the beetle and oviposition.

CHEMICAL CONTROL
TIMING

In this FSB, we approach pest control when the banana plantation is being formed (when planted) and during production, not in the treatment of

1. Banana plantation under formation - planting: Apply the chemical in the hole dug to plant the banana.

2. Banana production:
By monitoring the number of insects in the area by using a trap:
The most traditional and cheapest traps are made using the plant itself (which have produced fruit less than 15 days ago), and can be done in two ways:

- The "tile" type: pieces of pseudo-stem cut longitudinally, which should be placed next to the corm, with the cut face pressed against the ground - Figure 16a;

- The "cheese" type –pseudo-stem pieces of 5 to 10 cm transversely cut at an angle, as shown in Figure 16b below.

a b

Figure 16. Different types of traps used to catch and find *Sorditus Cosmopolites* beetle population levels in the banana trees:(a) the "tile" trap (b) the "cheese" trap..

Numbers of traps spread per hectare = 20-50.
The beetles (adults) in the traps should be counted after being placed there for seven days. Traps should be replaced after two weeks.

The maximum number of beetles per trap needed to justify starting chemical control varies between regions, countries, etc. cultivars planted for example, in the State of São Paulo (Brazil), the number can vary between 2-5 insects/trap/month. **It is important that farmers contact legally qualified and/or professional research institutes in its producing region for such guidance on these numbers.**

For recommendations on the chemical leaflet/label: Each product has its own specific strength (per hole or trap) and amount of applications needed. Read the agrochemical label and information leaflet for legally registered agrochemicals in your country for the control of this banana pest.

CHEMICAL PRODUCTS USED
The granular systemic nematicide insecticides of carbamate and organophosphate chemical groups are most used.

4.2 GUARANY SOLUTIONS FOR PEST CONTROL

1. The application of granular systemic insecticides by using a Manual Granular dispenser:

This equipment can be used both for injecting granules into a hole during planting and for plants already in production in the field. It is completely safe for the operator and the environment while efficiently mixing the chemical with the soil.
For production plantations, apply the granulate between 30 and 50 cm in front of plants that are going to fruit, as shown in Figure 17.

a b

Figure 17. Manual Granular Applicator (MGA) - Applies doses of 1.5 to 12g, in up to 5cm depth of soil.

2. Application of granular systemic insecticides with the Knapsack Granular Applicator:

The Guarany Knapsack Granular Applicator enables quick surface applications using a 'joystick' in front of the operator. It is easy to adjust and operate and applies with a pull of the trigger a wide range of dosages (from about 8g to 285g).

The tank design and command functionality allows the full, quick and accurate flow of granules, working under conditions laid down in the equipment manual, positioned as shown in Figure 18b below.

The equipment is used to apply granulated agrochemicals at the base of the plant before coming into fruit (Figure 18c, d) for the product to be absorbed by the banana plant roots and rhizomes. The smaller markings controlling the dosage (No. 0.5 and 1) allows low dosages to be applied that are commonly used with these types of pellets.

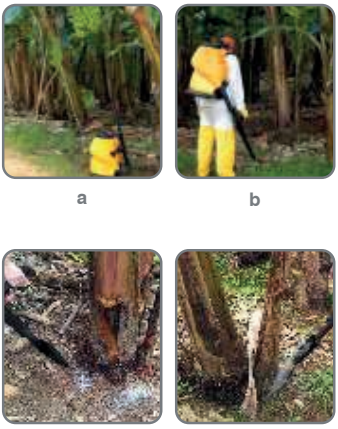


Figure 18. Knapsack Granular Applicator – Applies doses ranging from 8 to 285g; in images (c, d) adjusted to apply granular nematicide in a dosage of 10g per trigger pull.

4.3 THRIPS

Thrips are very small insects: between 1.0 mm and 1.4 mm (mature).
They lay their eggs in fruit and their life cycle (egg to adult), in general, ranges from 13 to 30 days, depending on the species and conditions (climate and food).
They live in unopened flowers (bracts protected by the banana "heart"), in young flowers and in the fruit.

Banana Rust Thrips- scientific name of the genus: *Chaetanaphothrips spp.*; *Caliothrips* spp. and *Typhactothrips spp*. Their young (larvae) move slowly, are light in colour while adults are fast, and are dark (Figure 19).

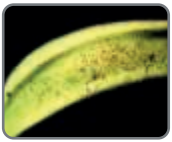
Figure 19. Adult banana rust thrips

Fruit Flower Thrips- scientific name of the genus: *Frankliniella spp.*

Banded Greenhouse Thrips- scientific genus name: Hercinothrips spp.
Both larvae and adults (Figure 20) are brownish.
The larvae are often in groups of 10 to 20 on a fruit.

Figure 20. Adult Banded Greenhouse Thrips

DAMAGE

Banana Rust Thrips	Fruit Flower Thrips	Banded Greenhouse Thrips
Banana skins are reddish brown (rust) showing the reaction to egg laying female and larvae and adults feeding. In general, it does not affect the edible part, but cannot be exported. Large infestations can crack the skin, causing more damage (Figure 21a).	Brown warts on the banana skins (Figure 21b), from the plant's reaction to the female laying eggs. It does not affect the edible part, but commercially devalues the product.	Banana skins with silver bands at the beginning, which then turn brown (Figure 21c). Generally, it does not affect the edible part, but commercially devalues the product. In young fruit, it severely attacks the fruit, cracking the skin.
		
Figure 21a	Figure 21b	Figure 21c

SUITABLE CONDITIONS FOR THE PEST

Presence of inflorescence/flowers and fruit on the plant;
Hot and humid periods = favourable feeding and thrip reproduction.

CHEMICAL CONTROL

TIMING

In the early stages of fruit formation and development, as shown in Figure 22.

CHEMICAL PRODUCTS USED

Usually products from organophosphate and neonicotinoid chemical groups.

4.4 GUARANY SOLUTIONS FOR PEST CONTROL

1. Knapsack Sprayers with lance extension:

Allows a directed spray.

Spraying all flowers/inflorescence and all forming fruit is recommended.
Apply 2-3 times while that particular fruit is in the development stage, see Figure 22 below.

Stage 1

Stage 2

Figure 22. e the Guarany sprayer with discharge extension to control thrips in banana.

Figure 23. Lance extensions are available in lengths of 0.5 m, 0.9 m and 1.2 m.

5.CONTROLLING MAJOR BANANA NEMATODES

Nematodes attacking the banana roots and rhizomes are the second most serious disease problems in this crop after the black sigatoka, especially for the Cavendish variety.

There are many species that parasitize the banana crop, but we stress the importance of treating the following: *Radopholus similis* (Figure 24) and the genus *Meloidogyne spp*.

Nematodes that attack banana crops can only be seen through a microscope. Thus, they can only be detected by observing symptoms in the plant roots and shoots or by laboratory analysis of roots and/or soil from the area planted.

5.1 Burrowing Nematode *(Radopholus similis)*

Figure 24. Nematode Radopholus similisseen under a microscopic

SYMPTOMS and DAMAGE

Necrotic roots or roots containing darkened dead parts (Figure 25a) and/or cracks (Figure 25b).

Dead roots causing plants to fall (Figure 26) from wind gusts or under the weight of the bunches of fruit. Dead roots reduce the plant's absorption capacity (water and nutrients) and result in loss of physical support.

When attacking new plants, the nematode prevents normal plant growth, producing symptoms called dwarfism and consequently prevents fruit from forming.

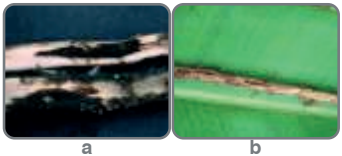


Figure 25. Attack Symptoms *Radopholus similis*: (a) root necrosis and (b) root cracks

Figure 26. Fallen banana plant infested by *Radopholus similis*

In soil highly infested with these nematodes, production losses can reach 100% in Cavendish bananas.

Note: Damage/lesions caused by nematodes of the genus *Pratylenchus spp*. are similar to *Radopholus similis*;however, to a lesser extent and intensity.

5.2 ROOT KNOT NEMATODES *(Meloidogyne spp.)*

Within this genus *Meloidogyne incognita* (Figure 23) andMeloidogyne javanica stand out as those nematodes affecting banana species.

Figure 27. The nematode *Meloidogyne* incognita as seen under the microscope

SYMPTOMS AND DAMAGE

This nematode generally causes less obvious and severe damage and than *R. similis*.

Main symptom
Thickening / deformation of the roots; known as root 'knots' (Figure 28).

Symptoms in high infestations
rotting roots/root necrosis, reduction in the number, size and weight of the fruit and also a delay in maturing.

Figure 28. Characteristic symptoms of a Meloidogyne spp. attack in banana roots

SUITABLE CONDITIONS FOR NEMATODES

Radopholus similis
This species is already widespread in all tropical and subtropical regions where bananas are grown. However, the following conditions favour reproduction and infestation:

- Cavendish Bananas ('Dwarf Cavendish', 'Lacatan' and 'Williams');
- Moist soils;
- High temperatures (25-30°C)

Meloidogyne spp

The species that are highlighted,Meloidogyneincognita and Javanica,are widespread worldwide and can occur together with the Radopholus similis nematode. However, adverse conditions for Radopholussimilis favour this nematode, as follows:

- More arid climates - soils with lower moisture;
- Mild temperatures - below 25°C and even below 20°C.

CHEMICAL CONTROL

In general, control times, chemicals and application techniques described below, apply to all nematodes reported in this FSB.

WHEN TO APPLY and WHICH PRODUCTS TO USE

Systemic granular insecticides (carbamate or organophosphate chemical groups) are applied normally in infested areas at intervals ranging from 4 to 6 months.

5.3 GUARANY SOLUTIONS FOR CONTROLLING NEMATODES

1. The application of granular systemic insecticides by using a Manual Granular Dispenser:

This equipment can be used both for injecting into the hole during planting as well as to treat plants already in production in the field. It is completely safe for the operator and the environment while efficiently mixing the chemical with the soil.
For production plantations, apply the granulate between 30 and 50 cm in front of plants that will fruit, as shown in Figure 29.

Figure 29 Manual Granular Applicator (MGA) - Applies doses of 1.5 to 12g, in up to 5cm depth in the soil.

2. Application of granular systemic insecticides using the Knapsack Granular Applicator:

The Guarany applicator allows surface applications.
The tank design and command functionality allows the full, quick and accurate flow of granules, when used in accordance with the equipment manual, as shown in Figure 30b.

Applies granulated agrochemicals at the base of plants about to fruit (Figure 30c; d) for the product to be absorbed by the banana plant roots and rhizomes. The smaller dosage control markings (0.5 and 1) allow low dosages to be applied that are commonly used with these types of pellets.

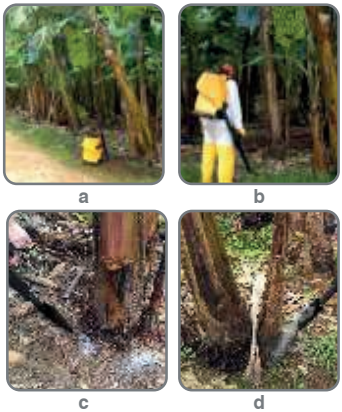


Figure 30. Knapsack Granular Applicator (KGA) – Applies doses ranging from 8 to 285g; in images (c, d) adjusted to apply granular nematicide in a dosage of 10g per trigger pull.

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Code: 10849.04.00 - Ver. 01 – February/2015

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