A booklet meant for farmers and other end-users. This booklet will sum up the alternative strategies and cropping practices yet developed or next coming in the major European banana-producing countries, in order to reduce pesticide use. Special attention will be given to innovative strategies that are compatible with Integrated Crop Protection.
Summary

This deliverable deals with the alternative and innovative strategies to reduce pesticides (and their non intentional effects) in banana production.

The first guide starts examining the lessons taught from an overall analysis of pesticide use in countries producing dessert banana, including representative European ones. Then, it goes through the main alternative or innovative solutions to reduce, in the short and mid-term, pesticide use in banana production. In particular these solutions are highlighted to alleviate fungicide, nematicide and insecticide use, which are the main pesticides used in dessert banana farming. The four following guides complete or more specifically exemplify the solutions recommended in the first guide.

Then, the second guide presents the alternatives that can be tentatively be used for a sustainable control of *Mycosphaerella* foliar diseases. They include i) short term solutions: implementing of forecasting strategies where they are feasible, or introduce fungicides with low negative environmental effects where the forecasting strategies are impeached by fungicide resistance; ii) mid-to-long term solution: developing and introducing resistant cultivars in the cropping system.

The third guide showcases the new integrated pest management strategies of the black weevil *Cosmopolites sordidus*. They include the implementation of prophylactic cropping practices and the use of pheromone-pitfall traps. It is emphasized that further refinement of this integrated pest management scheme in a longer term, will be strengthened by the use biocontrol agents (already under evaluation), and modeling tools developed to simulate the spatial organization of traps at the plot and landscape scales.

The fourth guide reviews the main steps of integrated crop management for the control of plant-parasitic nematodes in banana cropping systems in the French West Indies. This includes i) soil sanitation measures such as improved fallow to cleanse the soil of some nematode species, water isolation ditches to delay recontamination of fallows and already sanitized plots, along with the use of different non-host plants; ii) monitoring of soil sanitation before planting new banana crops; iii) use of healthy planting material, mainly tissue culture banana plants; iv) use of nematode tolerant banana varieties, and in the medium-term, nematode resistant varieties; and v) further integration of management strategies and the reintroduction of biodiversity to ensure sustainable control of nematodes.

The fifth guide deals with the combined use of cropping practices and sprayings with products alternative to conventional synthetic pesticides that are currently allowing canarian growers to successfully crop bananas under the standards of integrated or ecological production.

**Teams involved:** The teams involved in this deliverable are those in charge of the Banana Case Study i.e. CARBAP (Cameroon), CIRAD (France), IBMA (France, Europe) ICIA (Canary Islands, Spain) and WUR-PRI (the Netherlands). In addition, we also solicited some external partners as ASPROCAN (Asociación de Organizaciones de Productores de Plátanos de Canarias), ITBAN (Institut Technique de la Banane, France) and IRD (Institut de Recherche pour le Développement, France).

**Geographical areas covered:** All regions producing dessert bananas, with a focus the European ones.
Degree of validation and operability of findings: Findings labelled as “short-term” are already used at field. They are validated and operational but still at a limited scale. Findings designed as “mid-term” still required some additional years to be refined and extended.

To facilitate the dissemination of knowledge, this deliverable is formatted as a set of five guides that can be read independently one from the other. All five leaflets are available to public on the public web-site of ENDURE: http://www.endure-network.eu/endure_publications/endure_publications2

Guide N°1 - Challenging short and mid-term strategies to reduce pesticides in banana production
The fruit trees are an example of how to combine fruit trees with ornamental plants to create a visually appealing landscape.

The use of fruit trees in urban landscapes can help to improve air quality and provide a source of shade in hot weather. Fruit trees can also be used to create a sense of privacy and security in residential areas.

In addition to their aesthetic benefits, fruit trees can also provide a source of fresh fruit for residents. The selection of fruit trees for urban landscapes should be based on factors such as suitability for the local climate, soil conditions, and available space.

The use of fruit trees in urban landscapes can provide a range of benefits, including improved air quality, increased biodiversity, and increased community engagement. However, it is important to select the right type of fruit tree for the specific conditions of the urban environment.

Fruit trees can be a valuable addition to urban landscapes, but they require careful planning and maintenance to ensure their success. The selection of fruit trees for urban landscapes should be based on factors such as suitability for the local climate, soil conditions, and available space.

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Guide N°2 - Mycosphaerella foliar diseases of bana nas: towards an integrated protection

Mycosphaerella foliar diseases of bananas: towards an integrated protection

Liz de Lapeyre de Beaufort, CIRAD, France; Catherine Albaux, CIRAD, France; Jean Carlier, CIRAD, France; Jesús Ríos-Baquero, CIRAD, Cameroon; Dep. Po, Kaya, WUR, The Netherlands

Challenging short and mid-term strategies to reduce pesticides in bananas

Summary

Cotton leaf blight is one of the most devastating diseases affecting banana crops worldwide, causing significant yield losses and economic impact. Despite advancements in disease management strategies, the need for effective and sustainable control measures remains a priority. This guide aims to provide insights and practical strategies to reduce pesticide use in banana cultivation, focusing on short- and mid-term approaches.

1. Short-term strategies

   - Crop rotation and diversification: Implementing a diverse cropping system can help manage pest populations and reduce the need for chemical control. Selecting resistant cultivars is also crucial for long-term sustainability.

   - Biological control: Encouraging beneficial insects and natural predators can help suppress pest populations without relying on chemical pesticides. Release of parasitic wasps or predatory mites is a promising approach.

   - Integrated pest management (IPM): Combining various control methods, such as cultural practices, monitoring, and targeted chemical applications, can effectively manage pest populations while minimizing pesticide use.

2. Mid-term strategies

   - Genetic resistance: Developing banana cultivars with inherent resistance to key pests and diseases can significantly reduce the need for chemical control. Resistance breeding programs are crucial in managing emerging pests and diseases.

   - Pheromones and other attractants: These non-chemical methods can disrupt pest mating and population dynamics, leading to reduced pest pressure.

   - Crop management practices: Optimizing planting密度, irrigation, and fertilization practices can help enhance plant health and resilience against pests.

For further information please contact:

Jean-Michel Follet, Banana Crops Research Unit (DRU), CIRAD, Dray Blémy, 31610 Castanet-Tolosan, France.

Website and Information Centre:

www.endure-crops.eu

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A forecasting strategy for a rational chemical control

To ensure maximum benefit, traditional disease management strategies rely on explicit guidelines to avoid overapplication of pesticides. Even then, to ensure efficient management, a forecasting strategy is needed to measure the effectiveness of the control measures. This strategy is based on a method of determining the stages of infection in a plant community to determine the risk of disease development. The model is based on the concepts of disease development and the relationship between disease prevalence and infection rate. The model is based on the following assumptions:

- The plant community is divided into susceptible and resistant plants.
- The disease is transmitted by a vector, such as a pest or pathogen.
- The disease develops in stages, with each stage having a different level of susceptibility to control measures.
- The disease is controlled by the application of pesticides or other control measures.

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Guide N°3 - Integrated Pest Management of black weevil in banana cropping systems

Integrated Pest Management of black weevil in banana cropping systems

The black weevil (Cylas formicarius) is a major pest of bananas in many areas. It causes significant damage to banana plants, leading to reduced yields and economic losses. In this guide, we discuss the biology, life cycle, and management strategies for controlling the black weevil in banana cropping systems.

**Life Cycle and Biology**

- **Adult Stage**: Black weevils are active during the day and are attracted to the fruits of banana plants. They feed on the fruit, causing physical damage and facilitating the entry of other pests and diseases.
- **Larval Stage**: After feeding, the female weevil lays eggs in the soil near the base of the plant. The eggs hatch into larvae, which feed on the roots and lower part of the stem, causing wilting and death of the plant.
- **Pupal Stage**: The larvae eventually pupate in the soil, emerging as adult weevils after a few weeks.

**Management Strategies**

1. **Cultural Practices**: Maintain good sanitation and hygiene practices. Remove and destroy infected plants as soon as they are identified.
2. **Physical Controls**: Use physical barriers such as covers and nets to prevent access to banana plants.
3. **Chemical Controls**: Use insecticides as a last resort, but ensure proper application and rotation to avoid resistance development.
4. **Biological Controls**: Encourage natural predators and parasites of the black weevil to control the pest population.

**Conclusion**

Effective management of the black weevil in banana cropping systems requires a combination of cultural, physical, and biological controls. Regular monitoring and timely intervention are crucial to minimize losses and maintain healthy banana crops.

For further information, please contact your local agricultural extension officer or visit the ENDURE website for more detailed information.

ENDURE - Deliverable DR1.16
Guide N°4 - Integrated management of banana nematodes: Lessons from a case study in the French West Indies

Integrated management of banana nematodes: Lessons from a case study in the French West Indies

Jean-Michel Rheidt, CIRAD, France

Abstract: Lessons from a case study in the French West Indies

In the French West Indies, a case study was conducted to understand the impact of banana nematodes on banana production and to develop strategies for their management. The study focused on two banana production systems: one with high nematode pressure and the other with low nematode pressure. The results showed that nematodes had a significant impact on banana yield and quality. The study recommended the following strategies for nematode management:

1. Soil solarization: A practical and cost-effective method for controlling nematodes in the soil. Soil solarization involves covering the land with plastic sheets and heating it to high temperatures to kill the nematodes.

2. Crop rotation: Rotating banana crops with non-host crops can help reduce nematode populations. The study recommended rotating banana with other crops such as legumes or vegetables.

3. Chemical management: Chemical nematicides can be used to control nematodes, but their use should be limited due to environmental concerns. The study recommended using low-risk nematicides that have a low impact on the environment.

4. Biological control: Biological control agents such as nematophagous fungi and nematophagous nematodes can be used to control nematode populations. The study recommended using these agents in combination with other management strategies.

In conclusion, nematodes are a significant challenge for banana production in the French West Indies. Effective management strategies are needed to control nematode populations and improve banana yield and quality. The study provided practical recommendations for nematode management that can be applied in similar banana production systems.
Guide N°5 - Banana production under Integrated Pest Management and organic production criteria: the Canary Islands case study

Banana production under Integrated Pest Management and organic production criteria: the Canary Islands case study

Juan Carlos Calderón, JICA, Spacers Katelijne Herderink-Suárez, IICA, Spacers Angelita Peralta Colón, JICA, Spacers María del Carmen Soler Vega, IICA, Spacers Javier López Capelo, CORFA, CEDACO, CEDACO, CEDACO

Banana crops in the agricultural landscape of the Canary Islands. © Juan Carlos Calderón, JICA, Spain

Banana production in the Canary Islands. In the Canary Islands, banana production is part of the agricultural landscape. © Juan Carlos Calderón, JICA, Spain

In the Canary Islands, banana production is carried out mainly by beneficiaries. © Juan Carlos Calderón, JICA, Spain
Table: Widespread alternative cropping practices and control measures contributing to the reduction and elimination of extant pesticides in the Canary Islands

<table>
<thead>
<tr>
<th>Crappering method (if any)</th>
<th>Control measure</th>
<th>Reduction of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total eradication, regional</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Use of banana interplanted</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>New plantings (spraying during establishment)</td>
<td>All-in-one</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Soil solarization</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Removal of dead, broken</td>
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<td>Pesticides</td>
</tr>
<tr>
<td>Mulching</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Use of composted</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Spraying of other</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Use of broad-spectrum</td>
<td>All-in-one</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Bacterial control</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Spacing</td>
<td>None</td>
<td>Pesticides</td>
</tr>
<tr>
<td>Use of broad-spectrum</td>
<td>None</td>
<td>Pesticides</td>
</tr>
</tbody>
</table>

**From Team to Field**

**Banana Case Study: Guide Number 4**

ENDURE – Deliverable DR1.16

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