From Science to Field
Banana Case Study – Guide Number 1

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

Jean-Michel Risède, CIRAD, France; Thierry Lescot, CIRAD, France; Juan Cabrera Cabrera, ICIA, Spain; Michel Guillon, IBMA, France; Kodjo Tomekpé, CARBAP, Cameroon; Gert H.J. Kema, WUR, The Netherlands; François Côte, CIRAD, France

Left from top: young tissue culture banana plants on a mulched soil; yellow pitfall traps with a pheromone attractant are set to control black weevils. Shade-tolerant *Impatiens* can be cropped under banana plants to avoid herbicide applications. Legumes such as *Neonotonia wightii* can be used as rotational or associated crops. © Jean-Michel Risède, CIRAD, France. Main photograph: immature banana fingers. © Régis Domergue, CIRAD, France.

endure
diversifying crop protection

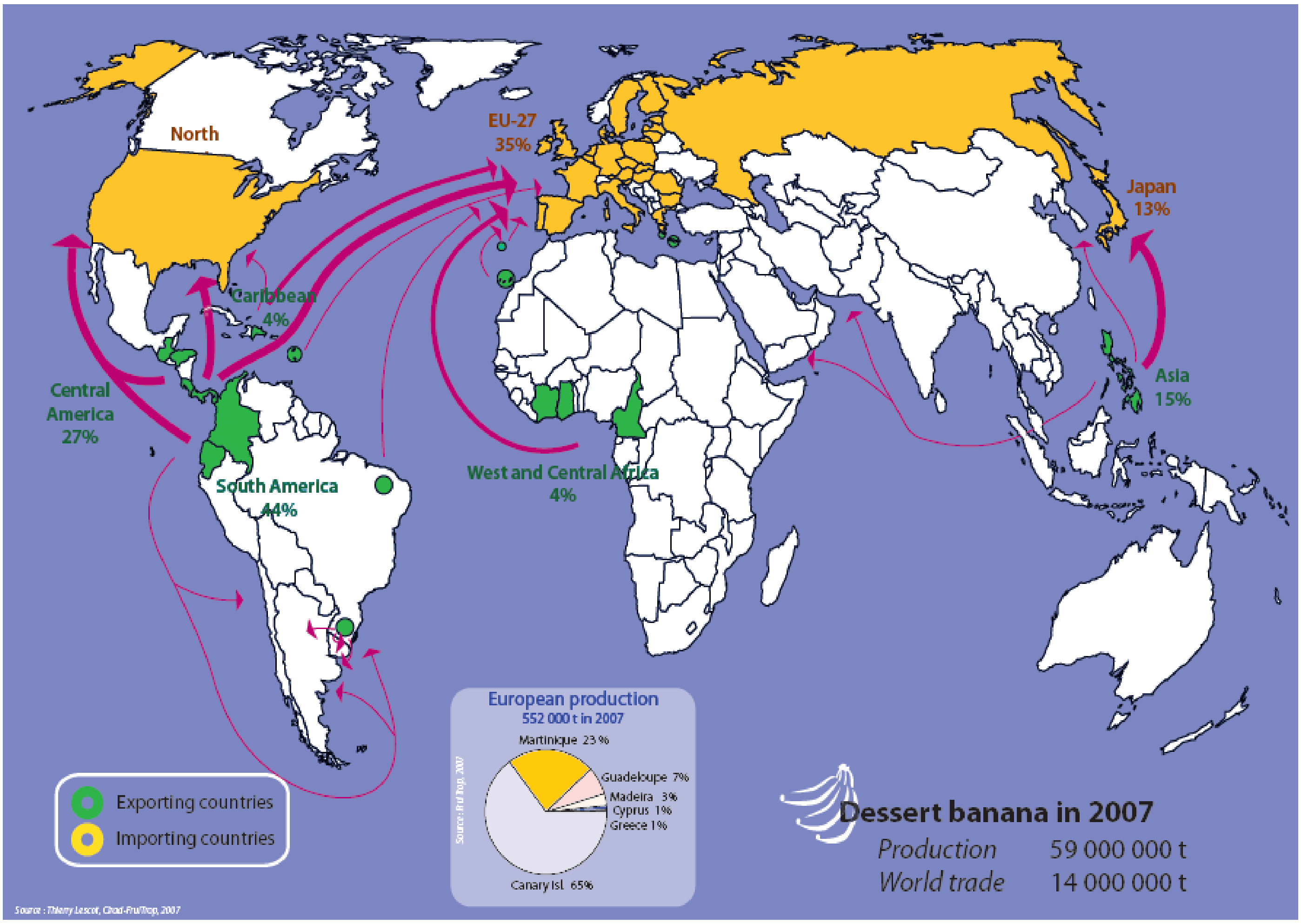
Food Quality and Safety
6TH FRAMEWORK
PROGRAMM

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

Bananas: Safer production of a major fruit crop

With a total production of about 105 million tonnes, bananas are one of the most popular fruit crops. Two main types of bananas are cropped: dessert bananas, among which the varietal subgroup Cavendish is the best known, and cooking bananas, largely plantains. In 2007, 59 million tonnes of dessert bananas were produced, among which 16.5m tonnes were shipped and traded. Europe is an active hub of the dessert banana trade, as it imports about one-third of the bananas traded worldwide while also producing bananas in some of its outermost regions such as the French West Indies (Guadeloupe, Martinique), the Canaries (Spain), Madeira (Portugal), Cyprus, and Greece (see figure 1).

Figure 1: Main dessert banana producing or importing sites throughout the world. © Denis Loeillet and Thierry Lescot, CIRAD, France



Various pathogens threaten the production of dessert bananas in tropical and sub-tropical environments. This situation is worsened by the poor genetic diversity in banana crops, and it also results from the pure stand cropping methods. Production has been ensured in these agrosystems by protecting, mainly by pesticides, the highly performing - but susceptible to a number of pests and diseases - Cavendish.

Public demand for safer food and, in this case, the safety of banana crops is increasing. It is a question of protecting the health of all stakeholders (field workers, workers in the packing stations, producers and consumers) by reducing exposure to pesticides both on the production sites and in the importing markets where the banana fruits are consumed. There is also an urgent need to alleviate the environmental injuries linked with excessive use of pesticides (pollution of soils, plants and waters).

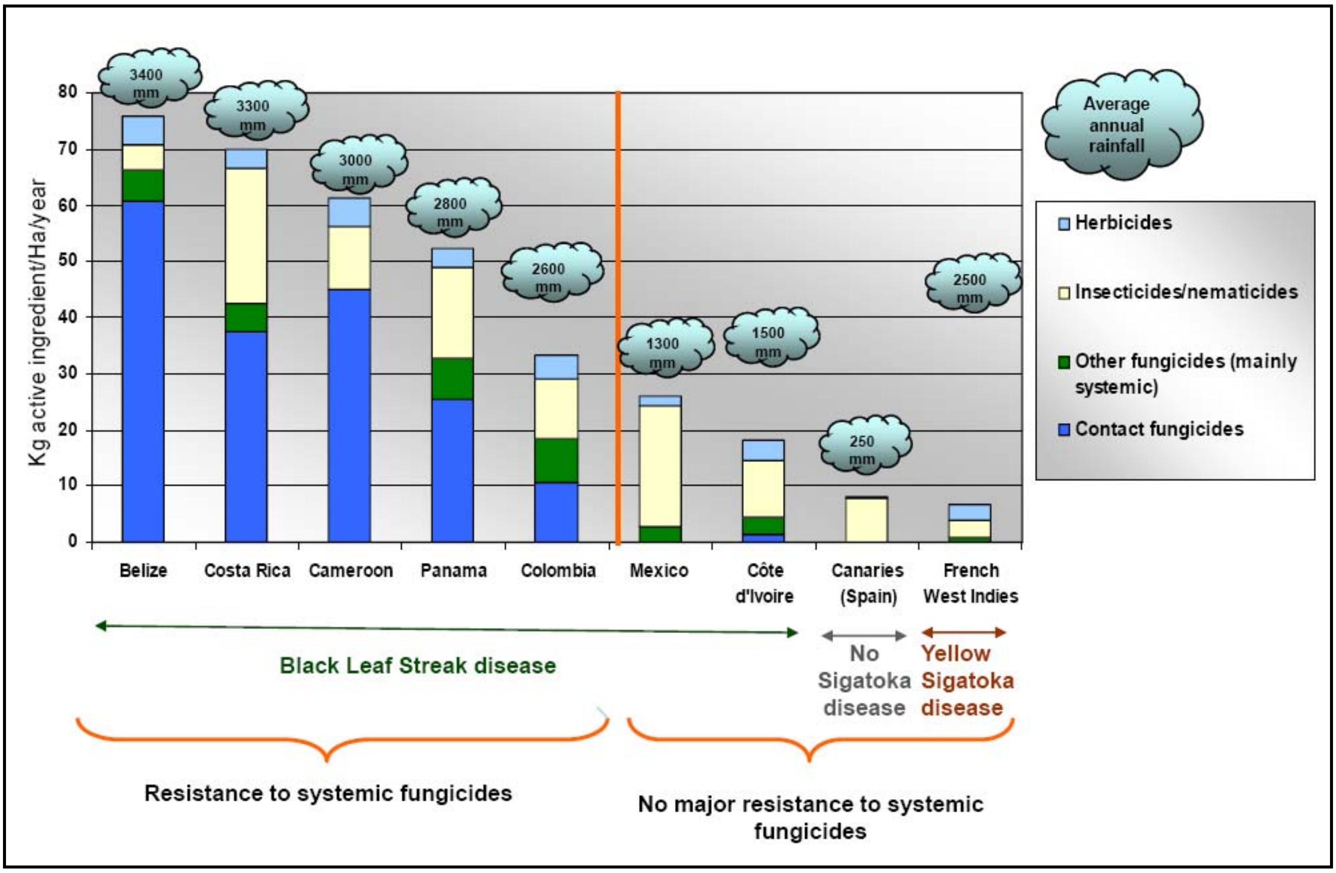
Lessons from an analysis of pesticide use in countries producing dessert banana

In 2006-2008, in the framework of the international project 'Pesticide Reduction Programme for Bananas (PRPB)', a global analysis of pesticide use in countries producing dessert banana was launched by four research and/or international development organisations: Bioversity International, CIRAD, the Catholic University of Leuven, and Wageningen University's Plant Research International. Data were collected with a questionnaire completed by grower associations, banana specialists in the countries and extension officers. As part of ENDURE's Banana Case Study, data were further analysed, and completed for Cameroon, the French West Indies (Guadeloupe and Martinique), and the Canary Islands (Spain).

Data analyses yielded four main lessons:

> The total quantity of pesticides used in dessert banana crops is generally linked with the level of annual rainfall (see Figure 2 below). The link is strong for fungicides, with a predominance for those that are sprayed to control the airborne *Mycosphaerella* foliar diseases.

Figure 2: Estimated total pesticide quantities used in dessert bananas in some countries, including European Community areas (2006-2007). © Thierry Lescot, CIRAD, France



> Fungicides, along with insecticides and nematicides applied to lessen the impact of soilborne pests, are the main pesticides on dessert banana crops (see Figure 2 above).

> In the higher rainfall areas, the repeated use of systemic fungicides (triazoles, strobilurines) resulted in resistance in *Mycosphaerella* populations. Field management of resistance is associated with a marked shift in fungicide use: contact fungicides (dithiocarbamates, chlorothalonil) are increasingly replacing systemic fungicides. Because they have a preventive rather than a curative effect, these contact fungicides are currently sprayed much more frequently and at higher doses than systemic fungicides, in particular to control the very aggressive Black Leaf Streak Disease (BLSD) caused by *Mycosphaerella fijiensis*.

\> In the production areas of the European Community, there is a markedly lower level of pesticide use on dessert bananas (see Figure 2), due to:

\> The absence of the foliar Black Leaf Streak Disease. In addition, a forecasting strategy contributes to reducing fungicide use for controlling the Yellow Sigatoka disease in the French West Indies.

\> The relevant efforts of producers, in particular during the last decade, to improve the control of black weevil and root-feeding nematodes by using alternative cropping methods.

\> The impact of European regulations on agrochemical use. In the European Community, current restrictions on pesticides strongly contribute to reducing their use in banana agrosystems. For example, no insecticide remains authorised, only one chemical nematicide is still used, and aircraft spraying to control Yellow Sigatoka will probably be prohibited in coming years. Elsewhere, legislative constraints and regulations on pesticide use in bananas vary widely due to the institutional and environmental policies of countries. They include aspects that impact producing countries (rules and restrictions on aerial spraying, timing and formulations for spraying, permitted toxicological and ecotoxicological profiles of active ingredients to be applied, local environmental protective measures) as well as importing countries (Maximum Residue Levels of fungicides in dessert bananas for the European market). Different trading requirements or specifications also exist on the international market, for example GlobalGAP, but legislation appears to be the critical force reducing pesticide use in European banana-producing countries. It hence drives the search for alternatives to pesticide use.

Legislation appears to drive reduced pesticide use in European banana-producing countries. EC citizens consumed an average of 10.7kg per head of bananas in 2007. © Thierry Lescot, CIRAD, France.

Landmarks for short and mid-term sustainable strategies to decrease pesticide use in bananas

Alternative and innovative solutions to decrease pesticide use in bananas are currently being developed by growers, researchers, and other stakeholders. Here we focus only on short and mid-term solutions, although long-term solutions exist, aiming at a better understanding of the banana agrosystem, along with an in-depth analysis of banana and pathogen genomes to unravel their relationships.

Short-term solutions are already being adopted in certain dessert banana-producing countries, but still at limited scales. They represent achievable alternatives to reduce pesticide inputs in banana agrosystems and need to be extended at larger scales.

Mid-term solutions bring together innovations designed for reaching integrated crop management of the concerned diseases. They include compatible and challenging solutions that are being tested in banana research programmes and are also based on prototypes of banana cropping systems that are evaluated by growers, extension officers and researchers. They include modelling as a relevant tool to achieve integration of innovative solutions.

Short and mid-term solutions are reviewed here for providing control of the four major types of banana diseases or pests: *Mycosphaerella* foliar diseases, the black weevil, plant-parasitic nematodes, and weeds. Reference is also made to the use of biocontrol agents and the requirements to sustain their development in the European Community (see page 7).

Control of *Mycosphaerella* foliar diseases

***Mycosphaerella* foliar diseases (mainly Black Leaf Streak Disease caused by *M. fijiensis*, and Yellow Sigatoka disease caused by *M. musicola*) severely alter the photosynthesizing leaf surface and induce premature ripening of fruits. These leaf spot diseases are usually controlled by aerial fungicide sprays. © Jean-Michel Risède, CIRAD, France.**

Short-term solutions

> Use forecasting strategies to reduce fungicide inputs based on disease incidence. This is possible mainly in regions with low disease pressure and no existing fungicide resistance, and in newly cropped areas.
> Promote prophylactic de-leafing of bananas in the field: this mechanical ablation of lesioned leaves bearing infectious conidia and ascospores restricts inoculum dispersal within and among plots.
> Allocate banana production without fungicide inputs to climatic zones that are unfavorable for Mycosphaerella, such as low rainfall regions. Banana should preferentially be organically produced in these regions.
> Use of biofungicides and natural organic products. Recent data indicate that some could favorably be combined with reduced doses of contact fungicides.

Mid-term solutions

> Complete integrated management of *Mycosphaerella* foliar diseases by growing dessert banana cultivars with resistance to *M. fijiensis* and/or *M. musicola*. Conventionally bred hybrids are currently under evaluation. GMOs could also be an alternative. In any case, disease-resistant banana cultivars should not be cropped in pure stands, but rather through spatial arrangements with other cultivars or other plant species, to reduce disease development and minimise chances to break down resistance to *Mycosphaerella*.

Control of the black weevil *Cosmopolites sordidus*

Here you can see a portion of banana corm heavily damaged by larval stages of Cosmopolites sordidus. Black weevil has long been controlled by polluting insecticide treatments, which are now banned. © Jean-Michel Risède, CIRAD, France.

Short-term solutions

> Mechanical destruction of contaminated rhizomes (with a machete, or a towed mechanical device).
> Use of pheromone-pitfall traps for monitoring populations and for mass-trapping within plots, at farm and landscape scale. Alternatively, bits of banana pseudostems (large pieces laid on soil, or pre-cut slices that are replaced in the mother pseudostem) can be used. Although less efficient than pheromone-pitfall traps, this technique is cheap and therefore of interest for smallholders.

Mid-term solutions

Short-term solutions contribute to an Integrated Pest Management strategy by implementing:
> Mass trapping with 'attract and kill systems'. These systems couple pheromones and entomopathogenic nematodes (*Steinernema carpocarpsae*) or fungi *Beauveria* spp.
> Bioprotection of banana root tissues with entomopathogenic fungi such as *Beauveria bassiana*, and/or non-pathogenic *Fusarium oxysporum*.
> Models to predict the dynamics and dispersal of the black weevil.
> Spatial arrangements within banana agrosystems to disrupt dispersal of the black weevil.

Control of plant-parasitic nematodes

In addition to alterations they cause in water and nutrient uptake, root-feeding nematodes induce a range of symptoms such as growth reduction and root breakage, resulting in toppling over of mature banana plants. Nematodes are controlled in many areas by two to four nematicide treatments per year. © Jean-Michel Risède, CIRAD, France.

Short-term solutions

> Start after crop rotation or fallow (see below), with new nematode-free plantlets derived from tissue culture. Small-holders can, alternatively, use *in vivo* mass multiplication techniques to sanitize planting material. However, this should be done in a collective process (grower association, nematological laboratory etc) to ensure dissemination of nematode-free plantlets.

> Sanitize plots from major banana parasitic nematodes, in particular *Radopholus similis*, by rotating banana crops with locally diagnosed non-host crops (such as pineapple, different cultivars of sugarcane, some forage grasses such as *Digitaria decumbens* or *Brachiaria humidicola*, some legumes such as *Neonotonia wightii, Macroptilium atropurpureum* or *Crotalaria* spp.), or by one/two year fallows. All volunteers (re-growing suckers) must be systematically removed.

> Systematically diagnose duration and effectiveness of soil sanitation against plant-parasitic nematodes with potted biotests using in vitro banana plants as traps.

> Surround nematode-sanitized banana plots (or banana field sectors) with 50-80cm deep ditches, to restrict *R. similis* dissemination by water run-off from contaminated plots.

Mid-term solutions

Short-term activities will support longer term integrated and more ecologically-based banana agrosystems by adopting:

> Deployment of above-ground diversity (plant diversity), to ensure ecological stability, including beneficial cover crops and nematode-resistant or tolerant banana cultivars.

> Modification strategies to improve the soil biota with target strains of micro-organisms (arbuscular my-corrhizal fungi, other fungal endophytes such as beneficial *Fusarium oxysporum* strains) and organic matter to strengthen plant and soil health.

> Models to predict nematode population dynamics in banana agrosystems and to assess and sort innovative cropping practices.

Weed control

Heavy weed pressure in a banana plot. Weeds can strongly compete with banana plants. Until now weeds have been generally controlled by frequent sprays of herbicides. © Jean-Michel Risède, CIRAD, France.

Short-term solutions

> Mechanical weeding with soil tillage devices such as spading machines or Rome plough *OR* mowers such as rotary engines for mechnisable lands, and hoeing or bush cutters for sloping lands.

> Set up new banana crops in mulches from a previous rotational crop, which will avoid or reduce pre/post emergence herbicide applications.

> Control weeds from heavily infected plots by a single herbicide application before planting the new banana crops.

> Cover inter-row space of banana plots by mulching with dead banana leaves or other organic residues (such as pieces of pseudo-stems) from harvest to cover the soil surface.

> Cropping other plants in the large inter-rows, such as the shade-tolerant *Impatiens* spp. (balsaminaceae), the perennial soybean *Neonotonia wightii*, or short-lived vegetable or cash crops (tomato, watermelon etc).

Mid-term solutions

Targeting Integrated Weed Management (IWM) in bananas by:

> Improved mechanical weeders adapted to new vegetation arrangements in banana plots.
> Effective low-dose herbicides, to help mulch installation before setting new banana crops.
> Planting annual cover crops that die naturally without herbicide applications, while being non-hosts to banana pathogens.
> Planting weed competitors (in space and in time) that still satisfy bananas by providing drainage, nutrients and beneficial organisms.

WHAT ARE THE REQUIREMENTS FOR PROMOTING THE DEVELOPMENT OF BIOCONTROL TECHNIQUES IN BANANA-PRODUCING AREAS OF THE EUROPEAN COMMUNITY?

Biocontrol methods exist for black weevil and pathogenic nematodes and to a lesser extent for post harvest fungal diseases. They still have to be developed against the main foliar disease of bananas, Black Leaf Streak Disease (BLSD).

Available biocontrol agents (BCA) belong to various classes of Plant Protection Products:

> Pheromones (agents modifying insect behavior): They are chemical but not biocidal.

> Microbials such as Entomopathogenic Fungi (EPF) for insect control.

> Macrobials such as Entomopathogenic Nematodes (EPN) for nematode control.

> Natural products such as Systemic Activated Products (SAR) for naturally induced resistance to pathogens.

To further promote the development of biocontrol techniques in European banana-producing areas, four conditions are required:

> Pest control: Pest or disease control must first be effective and validated. To control the black weevil, mass trapping with pheromone traps is effective, but also ‘attract and kill’ systems (coupling pheromone traps and EPN or EPF). Chemical insecticides are therefore no longer required in European banana production. Control of nematodes feeding on banana roots by pathogenic fungi is not yet satisfactory in areas that are highly infested, and additional work is required to improve efficacy. Control of BLSD is still under R&D as no SAR process has been found for Musa sp. As a consequence, organic bananas can therefore be grown only in areas where BLSD pressure is not high.

> Quality control of Biocontrol agents: In Europe, only standardised material can be registered (and then used). Production of BCA, their formulation and quality control are under strict legislation.

> Registration trials: Any biocontrol method has to be tested in multi-local field trials with officially approved protocols, and conducted by Good Laboratory Practices (GLP)/Good Field Practices (GFP) certified teams.

> Education of growers: As use of BCA requires ‘non-chemical’ specific usage rules, development of these new sustainable production systems needs technical training and support for growers, in order to make this technique workable and understandable.

Acknowledgements

Thanks to UGPBAN and ASPROCAN (the banana grower associations from, respectively, the French West Indies and the Canary Islands); Gérard Bertin Ngoh Newilah (CARBAP); Marc Dorel, Luc de Lapeyre de Bellaire and Denis Loeillet (CIRAD).

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

Summary

One of the most traded fruits in Europe and worldwide, dessert bananas have long been produced with a marked recourse to pesticides to control the various pathogens that threaten the crop. New ways are being developed to grow banana that rely less upon pesticides but rather upon agroecological measures and Integrated Pest Management strategies.

These operational solutions are continuously refined by researchers, growers and other stakeholders fully implied in ensuring more sustainable banana cropping systems, and further assuring human food and health.

This guide, the first of a series of five, starts by 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 bananas.

In particular these solutions are highlighted to alleviate fungicide, nematicide and insecticide use, which are the main pesticides used in dessert banana farming. Four following guides complete, or more specifically, exemplify the solutions recommended in this first guide.

For further information please contact:

Jean-Michel Risède, Banana Cropping System Research Unit,

CIRAD, France.

Telephone: (+590) 590 86 17 65

E-mail: jean-michel.risede@cirad.fr

About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

> Building a lasting crop protection research community

> Providing end-users with a broader range of short-term solutions

> Developing a holistic approach to sustainable pest management

> Taking stock of and informing plant protection policy changes.

Eighteen organisations in 10 European countries are committed to ENDURE for four years (2007-2010), with financial support from the European Commission's Sixth Framework Programme, priority 5: Food Quality and Security.

Website and ENDURE Information Centre:

www.endure-network.eu

This publication was funded by EU grant (Project number: 031499), under the Sixth Framework Programme, and is catalogued as Banana Case Study – Guide Number 1, published in January, 2010.