From Science to Field
Banana Case Study – Guide Number 4

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

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Association of bananas with the perennial legume *Neonotonia wightii*. © Jean-Michel Risède, CIRAD, France.

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Plant toppling caused by burrowing nematodes in the French West Indies. © Jean-Michel Risède, CIRAD, France.

Plant-parasitic nematodes are tiny worms that live mainly in soil and roots. In the case of banana plants, the most damaging species spend most of their life cycle in root and corm tissues. Their mouth cavity contains a hollow stylet with which they puncture the cell and remove the contents. Plurispecific communities of millions of individuals can develop in corm and root tissues of which they alter the physical and functional integrity. Nematode proliferation can disrupt nutrient and water uptake, delay growth and cause banana plants to topple over. In the French West Indies, toppling over is the main damage caused by nematodes.

As in many other banana-producing regions around the world, 10 years ago in the French West Indies methods for the control of nematodes in export bananas relied on the use of synthetic carbamate and organophosphate nematicides. For the most part classified as toxic or highly toxic, in recent years many of these products have gradually been banned. Alternative integrated plant-parasitic nematode management has consequently been developed in banana cropping systems in the French West Indies with the support of different stakeholders (growers, researchers, extension officers etc).

Soil sanitation is a key step in preventing the build-up of the burrowing nematode *Radopholus similis*

Female of the burrowing nematode *Radopholus similis*. © Jean-Michel Risède, CIRAD, France.

The main banana parasitic nematodes do not develop a resting stage for long-term persistence in soils. Consequently, in most cases soil prophylaxis is efficient in slowing down their population dynamics, especially in the case of the worldwide endoparasitic species *Radopholus similis*. In the French West Indies, recommendations for soil sanitation against nematodes are usually based on a twofold strategy:

Improved fallow to cleanse the soil of *R. similis*: This type of fallow relies on the destruction of nematode-infested banana plots by injecting a reduced quantity of herbicide into the pseudostems. When the plot is replanted after using this technique, only 10-15% of plants are reinfested after 9-12 months as oppose to 75-80% with mechanical destruction. It is essential to systematically remove - by hand or mechanically - all spontaneously re-growing suckers ('volunteer plants') as they can host and multiply residual nematode populations. If necessary, the ground should also be weeded by hoeing or mechanically to prevent the growth of host weeds for *R. similis*. Species belonging to several families including Poaceae, Euphorbiaceae, and above all Solanaceae and Urticaceae, can harbour *R. similis* populations.

Water isolation ditches to delay the recontamination of fallows and plots that have already been sanitized: Run-off water from nematode-infested banana plots can disseminate *R. similis* and re-contaminate sanitized plots. As a consequence, fallows being sanitized and plots that are already sanitized must be protected against incoming water from nematode-infested plots. Digging 50-80cm deep ditches around plots efficiently prevents the dispersion of *R. similis*. In this way, re-infestation of banana fields by parasitic nematodes can be reduced and delayed by more than three years.

Non-host crops also contribute to soil sanitation and prophylaxis against nematodes

A way to complete soil sanitation and prophylaxis against plant parasitic nematodes in banana agrosystems is planting nematode-resistant plants as rotational or associated crops. Such cropping practices are most effective against the burrowing *R. similis*, but less effective against the lesion nematode *Pratylenchus coffeae*, which has a wider ecological niche.

Above: **Pasture rotation with Pangola grass (*Digitaria decumbens*); grass is being mowed. © Jean-Michel Risède, CIRAD, France.**

Various types of plants can be used as rotational crops thanks to their non-host status for *R. similis*:

> Cash crops including certain varieties of sugarcane and pineapple.

> Pasture grasses such as Pangola grass (*Digitaria decumbens*), creeping signal grass (*Brachiaria humidicola*) and Guinea grass (*Panicum maximum*); and also legume grasses such as perennial soybean (*Neonotonia wightii*), Stylo grass (*Stylosanthes hamata*), and Siratro (*Macroptilium atropurpureum*).

> Other cover crops such as *Crotalaria* species.

Cover crops that are not hosts for *R. similis* can also be associated with banana to favour below-ground biodiversity in banana cropping systems and to promote more beneficial soil biota. Two crop associations are currently being developed in the French West Indies:

> Banana-*Impatiens* association: *Impatiens* spp. are shade-tolerant Balsaminaceae that do not compete with banana. This type of association is being developed in the highlands of Guadeloupe. In addition to being unsuitable for build up of *R. similis* populations, *Impatiens* species may lessen or even avoid herbicide applications.

> Banana-perennial soybean association: perennial soybean (*Neonotonia wightii*) is a legume with a strong tap root that penetrates vertically into the deep soil layers, while banana roots grow horizontally in the shallower soil layers. As a consequence, the two plants do not

Above: *Crotalaria* species are promising annual legumes that are not only resistant to *R. similis* but can also be used to sustain soil fertility. © Jean-Michel Risède, CIRAD, France.

compete. In addition to avoiding the need for herbicides in banana plots, perennial soybean provides a key ecosystemic service, i.e. fixing and supplying nitrogen for plant productivity.

Left: Shade-tolerant *Impatiens* do not compete with banana and are being tested in the highlands of Guadeloupe. In addition to being unsuitable for the build up of *R. similis* populations, *Impatiens* species may lessen or even avoid herbicide applications. © Jean-Michel Risède, CIRAD, France.

Monitoring soil sanitation before banana planting is essential

Potted biotests to monitor the progress of cleansing the soil of *R. similis* in commercial banana plots can be performed by a nematology laboratory. Such biotests are a decision tool that should be used to monitor the effectiveness of a soil sanitation process before planting a new plot. The basic principle is to trap and multiply residual nematode populations present in soil samples of the plot to be diagnosed using *in-vitro* micro-propagated plants of a nematode-susceptible banana variety. After two months, banana plants are uprooted and their root system analysed to estimate the percentage of nematode-infested plants.

Healthy planting material must be used when planting new banana crops

As a basic precept, it is essential to increase the value of as yet uninfested soils or already sanitized soils, by planting healthy material. It is a fact that banana corms have long been the major source of nematode dissemination throughout fields, countries and continents. Today, tissue culture banana plants represent an opportunity to use clean planting material. Even so, such material must be periodically checked for the presence of nematodes. The water used in weaning and hardening nurseries of tissue culture banana plants must also be checked for nematode contamination. Nematodes can be spread by river water and introduced into nurseries by pumping and it may thus be necessary to equip pumping material with 5µm sieves to prevent contamination of irrigation water.

Five-week-old tissue culture banana plants under weaning conditions. © Jean-Michel Risède, CIRAD, France.

Nematode tolerant or resistant varieties: a promising complementary solution

Banana hybrids under field conditions.
© Jean-Michel Risède, CIRAD, France.

Although Cavendish bananas are susceptible to both *R. similis* and *P. coffeae* species, they exhibit different levels of susceptibility to these nematodes. These differences can be exploited if producers of tissue culture plants single out the less susceptible Cavendish lines, as it was the case for the MA13 line, a Cavendish selection obtained by CIRAD and Vitropic S.A. In addition, the selection of banana hybrids that are resistant to nematodes is a promising medium-term solution that has already been launched by the CIRAD breeding programme, and is currently being further developed in the framework of the '*Plan Banane Durable*' (Sustainable Banana Plan), a new participatory project bringing together researchers, growers and other stakeholders dealing with pesticide reduction. Conventionally bred, such banana hybrids have the key advantage of displaying strong partial resistance to both Black Leaf Streak Disease and Yellow Sigatoka Disease, the most damaging airborne diseases of banana. These hybrids are currently being released for joint evaluation by growers and researchers. Some are showing promising resistance to *R. similis*.

Integration of management and reintroduction of biodiversity: a further step towards sustainable control of nematodes

The stricter regulations on the use of chemical nematicides alongside the combination and then the adoption of the prophylactic measures and monitoring procedures described above has led to reductions of up to 60% of nematicide inputs in banana cropping systems. To enable disruption of the spatial, temporal and genetic homogeneity characterising banana plant covers, and to create new below-ground biological balances that reduce the abundance and mitigate the effects of nematodes parasitic to bananas, a major step will be the complete integration of current nematode management techniques, and the re-introduction of biodiversity in banana agrosystems, to ensure a variety of ecological services that sustainably support soil and plant health.

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Summary

Plant-parasitic nematodes are tiny worms that live in soils and roots; in the case of banana plants, they spend most of their life cycle in root and corm tissues. Their proliferation mainly disrupts nutrient and water uptake, delays growth, and may cause the banana plants to topple over. Until recently, most methods for the control of banana nematodes relied on the use of chemical nematicides, many of which are gradually being banned in Europe. This guide reviews the main steps of alternative integrated plant-parasitic nematode management in banana cropping systems in the French West Indies. This includes i) soil sanitation measures such as improved fallow to cleanse the soil of the burrowing nematode *Radopholus similis*, water isolation ditches to delay recontamination of fallows and already sanitized plots, along with the use of non-host plants including cash crops, pasture grasses, and legumes; 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.

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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.

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