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CHAPTER 15

Agroecological pest control and landscape organization in the French West Indies

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Integrated pest and disease control, in particular through bioregulation processes, is the basis for direct services to reduce pesticide use for the benefit of farmers and society. Its effectiveness is the result of the integration of these processes through practices whose application ranges from the level of the individual plant to that of the territory, in the broadest sense. This requires complex forms of collaboration between farmers, the various actors of the sectors concerned, and those involved in the territory's management. Banana plantations in the French West Indies are the target of a number of air- and soil-borne pests which exhibit highly contrasted dispersal traits. Since the late 1990s, producers, driven by societal demand, have made fundamental changes to their technical itineraries to reduce pesticide use. New practices have been adopted in the island territories of Guadeloupe and Martinique as a result of improved knowledge of epidemiological and bioregulatory processes, and an integrated organization of the sector and of territorial management. The control of pests that affect bananas is characterized by farmiug practices that are often applied in plots, but whose effectiveness depends on their generalization at the farm or landscape level. We illustrate here how this integration of levels has enabled the optimized control of the banana weevil *Cosmopolites sordidus*, of plant parasitic nematodes, in particular *Radopholus similis*, and black sigatoka *Mycosphaerella fijiensis*.

CONTROL OF THE BANANA WEEVIL

The control of the banana weevil *Cosmopolites sordidus* is an archetype that highlights the fact that pest control can be truly effective only through a thorough understanding of the epidemiological mechanisms involved, followed by an implementation of pest management practices on a large scale. This pest, whose larva burrows tunnels into banana corms, causing them to fall or limiting the plant's ability to take up nutrient and water, has a relatively low mobility and fertility. Since the 1990s, pitfall traps have been used with an aggregation pheromone attractant (Rhino *et al.*, 2010). One such attractant, Sordidin (Budenberg *et al.*, 1993), lures individuals of both sexes within a radius of about ten meters. Radio-tracking of the movement of individual insects (Vinatier *et al.*, 2010), based on range, coverage and pheromone traps, have helped identify conditions that enhance the effectiveness of these traps, and thus propose improvements. Spatially explicit individual-centred models have subsequently been used to understand how to optimize the organization of habitats and traps (Vinatier *et al.*, 2012). Simulations have shown that pheromone traps are most effective at the interface of cultivated and fallow plots. They have also demonstrated the importance of trapping at the farm level. This new knowledge has been assimilated by over 80% of the farmers, thus cutting down on the amount of insecticides used to combat this pest. These practices have also led to the creation of rural enterprises that offer pest trapping services. Furthermore, this structuring of actors has helped in disseminating optimized practices. Like many agroecological practices, the trapping of the banana weevil is effective only if it is carried out at the level of the territory, and over a sufficiently long period of time (Duyck *et al.*, 2012).

Control of plant parasitic nematodes

The control of plant parasitic nematodes in banana is a successful example of the implementation of pest control at several spatial levels and of institutional support. The plant parasitic nematode, *R. similis*, leads to root necrosis which causes banana trees to fall. From a biophysical point of view, the control strategy developed in the French West Indies was based on introducing fallowing – with a fallow or rotation period free of plants that host *R. similis* – using nematode-free planting material grown through *in vitro* culture, and by preventing or limiting any contamination of sanitized plots by appropriately channelling water flows that are likely to transport nematodes from contaminated plots. In fact, given that *R. similis* has dissemination capacities reduced to only a few metres, the risk of passive transportation via runoff requires the adoption of supra-plot approaches to prevent its spread. The strategy is based on an accurate understanding of the relationships between plants and nematodes (Quénéhervé, 2008) and between nematodes and their environment. It has required a rethinking of the organization of farms. The temporary conversion of a portion of each farm into a non-productive area has necessitated changes in the organization of farm labour, but fallow-based systems have proved to be economically and ecologically more efficient after a transition period (Blazy *et al.*, 2009), leading to a greater durability of banana plantations. Finally, management of water flows at the farm and territory levels has often been improved to minimize the contamination risk (Chabrier and Quénéhervé, 2008). The adoption of these innovations was facilitated by European aid to purchase healthy plants derived from *in vitro* culture. Applied at a territorial level, this strategy led to a 96% reduction in the use of nematicides over about 20 years.

Control of the causal agent of black sigatoka

Efforts to control the causal agent of black sigatoka *Mycosphaerella fijiensis* in banana highlight the need to work at a territorial scale. Indeed, the spores of this fungus possess a dispersal capacity of more than a kilometre in the case of ascospores (Rieux *et al.*, 2014). This disease not only drastically reduces the leaf area of bananas but also reduces the shelf life of fruits, which is unacceptable for an export crop (Castelan *et al.*, 2013). The efforts to control this disease in the French West Indies has to be seen in the light of the pathogen's recent arrival (2010 in Martinique and 2012 in Guadeloupe), and in the context of increasingly restrictive regulations: a ban on aerial fungicide applications and a limited number of approved pest control products. These dual biotic and regulatory constraints have forced farmers to rethink their control strategies at multiple levels: plant, plot, farm and territory. At the plant level, regular leaf-stripping was recommended to limit fungal growth and its effects on fruit quality, since leaf necroses are a source of spores. At the farm level, this practice required a reorganization of labour. Finally, at the territorial level, the ban on aerial spraying led to a cessation of generalized and centralized application with prior notification, as treatments became ground-based and were carried out by individual farmers. In fact, there has been observed a very strong heterogeneity in the use of fungicides in a same bioclimatic zone, which greatly increases the risk of the appearance of strains that are resistant to fungicides. Furthermore, the high dispersal capacities of ascospores can promote the spread of resistant strains from one plantation to another, irrespective of the practices of individual farmers. This threat, which could, in the very short-term, affect control strategies for this disease, is compelling farmer organizations to rethink the model of the collective management of the disease at the scale of the entire agricultural territory.

Outlook

To control the three main pests of banana in the French West Indies, it is necessary to simultaneously adopt a set of methods at several spatial and organizational levels. Societal, biotic and regulatory changes have forced significant modifications in control strategies. This triple experience shows that the control of pests requires a good knowledge of their biology (dispersion, bioregulation process) and an appropriate multi-actor organization. Given the trend of increasing biodiversity in agroecosystems (already achieved by the introduction of service plants in more than 10% of the area under banana cultivation), this diversity will involve managing the seed distribution chains as well as those of plants suitable for integration into agrosystems. In addition, services provided by diversified agrosystems, such as biodiversity conservation, will need to be evaluated. This type of strategy requires an integrated and biodiversified organization of the territory to meet the demauds of civil society (reducing pollution at the source, maintaining agricultural employment, conserving or even improving landscapes) while improving farm sustainability.

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