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> Insect pest control in agriculture

Changing scale: from field to landscape

François-Régis GOEBEL

Over the last 20 years, insect pest pressure on agriculture has been increasing. This growing pressure is explained by the expansion of monocropping and the intensification of farming practices, which are altering landscapes and reducing biodiversity. It is reinforced by climate change, which causes tropical insects to migrate to temperate zones and modifies insect biology.

Controlling this growing pressure while reducing or ending pesticide application implies no longer acting solely at field level, but also at landscape level. This scale change makes it possible to use biodiversity to regulate pests, and also to coordinate stakeholder practices, as shown by attempts to control sugarcane and cotton plant pests.

However, it requires detailed knowledge of the interactions between pest populations and their natural enemies, and also between landscape components, biodiversity and human activities, which opens up new avenues for transdisciplinary research.

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Through *Perspective,* CIRAD provides the opportunity to explore new avenues for discussion and action based on research, without presenting an institutional position.

Increasing pressure

For the last 20 years, insect pest pressure on agriculture has been increasing. This growing pressure is explained primarily by the deforestation and clearing of vast stretches of land in order to use them for industrial monocultures to meet demand for agricultural food and energy products. These practices alter and standardise landscapes, reduce biodiversity and damage certain ecosystem services, such as pollination by bees. Insect pests and their natural enemies (predators, parasitoids, etc.) are responding to the destruction of their biotopes by migrating to other biotopes, or even colonising new territories. Biological balances are being disrupted.

This growing pressure is also a result of the intensification of farming practices. The large companies, sometimes aided by research and development institutes, recommend technical packages: systematic pesticide application (insecticides, herbicides, fungicides, etc.); and the use of fertilisers and improved varieties, whether genetically modified or not. These recommendations are altering the way in which ecosystems function. Pesticide resistance is emerging, and some pests can no longer be controlled. In Africa, for example, where cotton crops have long been treated with insecticides, the cotton bollworm has become resistant to pyrethroids, and sap-sucking insects (aphids, whiteflies) to organophosphates. In the United States, India and China, this bollworm has also become resistant to the toxins produced by genetically modified varieties developed to fight them, and pests considered as secondary have become a major concern. The impact of inputs is magnified by the fact that recommendations are not always respected. For example, overuse of nitrogen fertilisers, which are commonly employed to increase yields of rice, maize and sugarcane crops, results in more frequent infestations.

> Monocropping and the intensification of farming practices increase pest pressure

Moreover, systematic insecticide application has resulted in the reduction or even disappearance of traditional local knowledge, which had nevertheless proved effective. In West Africa, farmers used to manually top cotton plants which, in reaction, sent chemical messages to prevent egg-laying by female *Helicoverpa armigera*, *Diparopsis watersi* and *Earias* bollworm. Although topping could be put back into practice further to conclusive tests in Mali, other knowledge is no longer used, even though it could be valuable. One example of this is sugarcane detrashing, which was once common practice in Java (Indonesia): by detrashing leaves well before harvesting, it eliminates the entry points through which pests bore into stalks.

Other farming practices increase insect pressure, such as the removal of natural plants or burning. Removing natural plants around fields deprives natural enemies of food, creating an imbalance that is detrimental to the natural control of pest populations. Burning, on the other hand, is still carried out in sugarcane fields, in Sudan and South Africa for example, in order to facilitate harvesting and to provide refineries with clean cane without leaves; but this destroys the useful natural enemies and does not eliminate moth borers, which develop inside the stalks. Likewise, the burning of cotton stalks and branches, which is still common in Africa, does not destroy pests, which take refuge in plant waste that falls to the ground.

In addition to these harmful practices, climate change is causing insects to migrate from tropical zones to temperate zones, which increases pest pressure in destination countries. Thus, the number of tropical insects that have migrated to Europe is growing steadily – 1 500 species have arrived there in the last 20 years: *Paysandisia archon*, a butterfly native to Argentina, which is decimating palm trees in the south of France; *Cacyreus marshalli*, a butterfly native to South Africa, which is destroying geraniums; and Asian hornets and ladybirds, which are supplanting European species, etc. Furthermore, climate change is altering the life cycles of insects in their countries of origin, resulting in more frequent and more virulent outbreaks.

> The landscape level makes it possible to take advantage of biodiversity and to coordinate stakeholders

In this context, what can be done to control pests? For a long time, systematic insecticide application at field level was favoured. Although insecticides have now been called into question due to their adverse effects on human health and the environment, fields or farms remain the level at which most action is conducted. However, from the perspective of agroecological control, this level is no longer sufficient. Indeed, insects are mobile: they are born in one habitat, and go on to colonise others; their habitat is not therefore limited to the field or the farm, but extends beyond the agricultural area. In addition, the field has limited biodiversity, and does not provide the opportunity of exploiting the attractive or repellent effects of plants on specific insects, or of stimulating the control of pest populations by natural enemies. Farmers in Java (Indonesia) are aware of this: they conserve natural plants and shrubs (grasses, Malvaceae, Euphorbiaceae, fig trees, etc.) around their fields (rice, maize, sugarcane, vegetables, sunflowers), since this natural vegetation attracts a variety of insects. Finally, the field level is insufficient as it only involves the farmer concerned, whereas effective control requires coordination of stakeholders at different levels.

Essential biodiversity

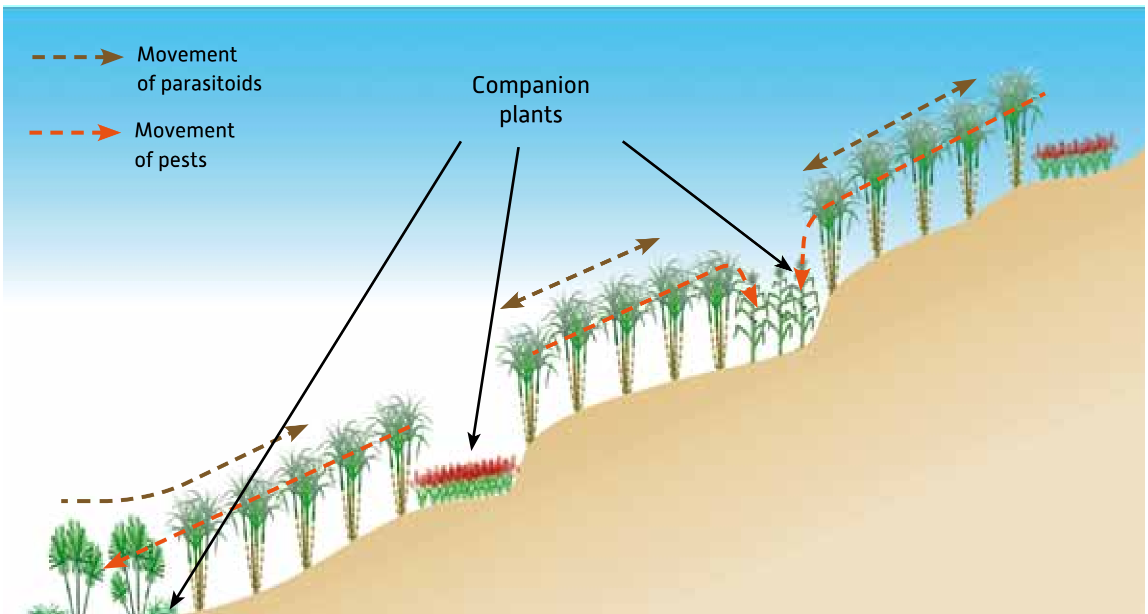
> **Developing landscapes to maximise the use of companion plants**

It is therefore necessary to plan and carry out pest control on a broader scale than that of the field: the landscape, in other words a spatial extent, whether natural or modified by humans, which presents a visual or functional identity. At this level, it is possible to take advantage of the biodiversity present in the landscape components: natural vegetation, cultivated plants, trees, forest corridors, pastures, watercourses, etc. At this level, it is also possible to coordinate the actions of farmers and other stakeholders (State services, development agencies, etc.), or even to develop the landscapes in order to maximise the use of companion plants, which attract or repel crop pests and their natural enemies.

> **Being agroecological in nature, crop protection will be in the hands of a transdisciplinary team**

Research conducted in Australia and South Africa (see box p. 4) demonstrates the importance of this level. In Australia, the cane beetle, *Dermolepida albohirtum*, causes damage in fields bordering forests with fig, palm, eucalyptus and acacia trees. After developing on sugarcane at the larval stage, the adult beetles live and reproduce in these trees, before infesting the fields again. Since these beetles migrate no further than 200 m from their original habitat, it will only be necessary to take action in fields at this distance from the forest. Recognising the importance of this finding, farmers in Queensland, who had been concerned only with their own fields, decided to meet at regular intervals, and to associate industries and public agricultural and environmental services. They now share information on the ecology of this pest and the damage it causes, and coordinate their practices. They decided, for example, to prioritise fields close to high risk areas in order to avoid the multiplication of outbreaks. This collective process has been of benefit to all the farmers, who have made savings on insecticide treatments, and has reduced the risk of pollution in watercourses flowing towards the nearby barrier reef. It has also led to discussions on the plant species to be grown or avoided around sugarcane plantations in order to reduce risks of infestation: palm and fig trees have thus been replaced by less attractive species, such as mango trees.

In South Africa, the sugarcane borer *Eldana saccharina* invaded sugarcane monocultures when this crop was introduced in the last century. Only the use of insecticides and resistant varieties succeeded in limiting the damage caused by this pest. Biological control was problematic, as the parasitoids of the sugarcane borer did not "follow" it when it colonised sugarcane from *Cyperus papyrus* (Cyperacae) and wild grasses. Research has identified the companion plants to use or introduce around fields in order to stimulate the natural control of the sugarcane borer: wild plants such as *Cyperus*, *Erianthus*, *Pennisetum* or *Desmodium*, and cultivated plants such as maize or sorghum, which attract parasitoids, and trap or repel pests (Fig. 1).



Pest control requires knowledge of interactions within the agro-ecosystem between insects and their natural enemies (parasitoids, pathogens, predators, etc.), and also between host plants and the natural vegetation in which insects live.

Figure 1: Taking into account landscape components and companion plants for biological control of *Eldana saccharina*, a sugarcane pest in South Africa.

Source: adapted from Conlong D., Rutherford S., 2010. South African Sugar Research Institute.

A few words about…

François-Régis GOEBEL, has a PhD in the field of applied entomology (Paul Sabatier University, Toulouse). He specialises in plant protection and integrated pest management. He has been with CIRAD since 1988, and has conducted the majority of his research on sugarcane while posted in Réunion, South Africa and Australia, and during assignments in Indonesia and several African countries. He is currently based in Montpellier in the Annual Cropping Systems research unit (http://ur-sca.cirad.fr/) as a deputy director of this unit.

francois-regis.goebel @cirad.fr

As shown by this research, developing systems to minimise infestations and to encourage natural pest enemies implies taking into account the interactions between insects and all the components of the landscape: natural vegetation, its location, its characteristics; the fields, their size and the plants grown there; fallow land; corridors; and of course the strategies adopted by farmers and other stakeholders. Knowledge of these elements is therefore essential.

Organising transdisciplinarity

Research must be carried out in tropical countries, where many pests originate, on the biology of insects and on their regulation mechanisms, in order to ensure more effective control in countries of origin and destination alike.

This research focuses first and foremost on insects and plants. For example, by identifying the chemical messages (volatile compounds) released by plants when they are attacked, or by specifying the services provided by plants, it will be possible to identify the plants to be grown in and around cultivated fields with the aim of attracting or repelling insect pests or their natural enemies. Research also focuses on ecological processes both within and beyond agrosystems, in order to rethink farming practices and their intensification, to characterise and promote ecosystem services, and also to use local knowledge. Finally, it deals with stakeholder strategies with a view to ensuring the coordination necessary for effective crop protection.

Being agroecological in nature, crop protection will no longer be in the hands of entomologists or agronomists, but in those of a transdisciplinary team. Such an approach is complex and implies building bridges between disciplines: entomology – insect biology, spatial ecology, ecology of insect communities, chemical ecology –; botany; agronomy; human and social sciences; modelling, spatial information (GIS, remote sensing), and information technology, etc. It is also crucial to associate stakeholders from the research planning stages. <

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This research has led to several publications, including:

Goebel F.-R., Sallam N., Samson P., Chandler K., 2010. Quantifying spatial movement of the greyback cane beetle in sugarcane landscape: data available and research needs. *Proceedings of the Australian Society of Sugar Cane Technologists* 32: 71-83

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42, rue Scheffer
75116 Paris . FRANCE

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Email: perspective@cirad.fr

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