Biotechnologies and coffee trees

Creating plants with resistance to insect pests

Leaf miners (Perileucoptera spp.) are insect pests in coffee plantations that mostly affect harvests in East Africa and Brazil. When very severe outbreaks occur, chemical control is essential for assuring protection. However, apart from its cost, such control always entails risks for human health, the environment, and the respect of biodiversity. Biotechnology tools offer an alternative: have the plant directly produce a protein capable of specifically limiting the development of Lepidoptera caterpillars.

Genetically modified coffee trees with resistance to leaf miners

Proteins of the bacterium Bacillus thuringiensis were chosen to create coffee trees with resistance to leaf miners. These insecticide proteins offer the advantage of being totally harmless for human health and are widely used in biological control. The natural gene cry1Ac of Bacillus thuringiensis, encoding a protein that is active against leaf miner caterpillars, was optimized for greater expression in plants. This gene was combined with marker genes and introduced into undifferentiated coffee tree cells using the bacterium Agrobacterium tumefaciens. Genetically modified plantlets of several Coffea genotypes — Arabica and Robusta — have thus been obtained by in vitro culture.

Molecular characterization of the plants was carried out so as only to keep those in which the gene had been successfully introduced. Their resistance to leaf miners was also tested in the laboratory, using young plants intentionally infested by these insects, and observing any gallery development in the leaves.

Plant assessment in the field, a well-controlled necessity

In order to check that the work undertaken in the laboratory was successful, and assess any impact these plants might have on the environment, CIRAD obtained authorization from the French biomolecular engineering commission (CGB) to set up a field trial. CGB authorized CIRAD to conduct this trial in French Guiana over five years (authorization No. B/FR/98.08.07), after which the plants will be destroyed. The appropriateness of the trial design, its security and environmental monitoring are thus guaranteed. The local plant protection service (SPV) is systematically controlling these trials.

A thousand in vitro plantlets were therefore introduced into French Guiana, under SPV supervision, and planted out in May 2000.
Research activities

Current research is focusing on the agro-nomic characteristics of coffee trees, and any impact the technique might have on the environment. The trials set up have five objectives:

- Check the true-to-type agronomic performance of genetically modified coffee trees compared to an unmodified control.
- Assess plant resistance to the South American leaf miner in the field.
- Assess the dissemination of gene cry1Ac by pollen: 21 micro-plots of "unselected" coffee trees have been planted specifically for this purpose at different distances from the site, to trap pollen from the coffee trees in the trial. By monitoring one of the marker genes, it will be possible to assess the dissemination of pollen in the environment.
- Carry out a field assessment of the impact of the plants on bee populations in the trial zone: hives have been installed near the site and in a control plot far away from the trial. These hives and their products (honey, royal jelly) are being monitored to compare their development.
- Assess any changes in the entomofauna: targeted counts are comparing the populations of insect populations living off coffee trees at the site, and those in a control plot set up around a hundred metres from the trial.

Prospects

The work carried out by CIRAD over the last ten years or so on biotechnologies applied to coffee trees, and the results of the trial currently under way, have led on to an integrated control strategy against coffee tree insect pests. Along with supervised chemical control, good cultural practices, biological control and trapping, the use of resistant plants obtained by genetic modification is a further tool in pest control. Based on the model developed with the leaf miner, work is under way to extend this control strategy to the coffee berry borer, and to the coffee stem borer.

However, this is a long-term strategy. The trial plants are being studied solely for research purposes. Large-scale dissemination of transgenic coffee trees cannot be considered for many years yet, since the validation stages remain to be completed, be it in terms of the genetic constructs tested, or of the impact of this technology on the agronomic performance of the plants, on the environment, and on the health safety of the coffees produced.

For further information

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