Integrated Pest Management (IPM) in Coffee Production

1. Integrated Pest Management:

1.1. Definition

The Integrated Pest Management (IPM) concept was developed not as a way of eradicating pests and diseases, but as *a method for their long-term management to minimize their impact and keep pest populations at an economically and environmentally acceptable level*.

IPM brings into play *all possible control methods, including pesticide use*.

1.2. Advantages and constraints

IPM sets out to minimize:

- Pest and disease damage;
- Risks of toxicity for people, goods and the environment by reducing pesticide use;
- The cost of crop protection measures.

IPM requires precise knowledge about the epidemiology of different pests and diseases, the development cycles of the organisms involved, and those of their natural enemies, along with environmental interactions and environmental conditions.

An IPM programme can only be considered if all the farmers in a given region effectively take part. Whilst chemical treatment might more or less totally control pests within a plot through pesticide persistence, the same cannot be said for other pest control methods. Indeed, primary inoculum foci in neighbouring fields where no IPM is practised are a substantial source of potential contamination.

By its very nature, IPM is a sophisticated method of pest and disease management requiring sound training for its users if it is to be efficient.

Although it is often presented as a relatively inexpensive method to apply, it is in fact as expensive as chemical control, at least for some control methods, or if all the research and development costs for its application are taken into account.

2. IPM methods and coffee growing:

Coffee IPM covers all the pests and diseases affecting coffee cultivation. However, particular attention is paid to controlling the coffee berry borer (CBB), an insect responsible for major yield losses and quality deterioration. Moreover, the presence of CBB–damaged beans seems to have an impact on ochratoxin A contamination *(see: 'Investigations of a possible correlation between OTA contamination and CBB infection' [.doc], found in the Support Documentation area of this Section)*.

Fig.1: CBB entry hole and chaff in ripe cherry (left), CBB entering cherry (centre), and CBB damaged coffee beans (right)[1]

Pesticide use should only be considered for CBB control when damage reaches very severe levels estimated at 15% or more. Chemical control is intended to drastically reduce CBB populations. In addition, chemical control should only be used to reduce infestation foci in a planting. Work undertaken for a thesis has revealed that CBB populations are aggregative and infestation develops from foci. This therefore means that regular monitoring is required in coffee plantations. Likewise, for proper chemical control, it is necessary to intervene very precisely in the CBB development cycle (3 months after flowering), with two insecticide applications one month apart.

2.1. Chemical control has been widely developed to control the main pests (CBB, *Antestia* or the variegated coffee bug, leaf-eating caterpillars, etc.) and the main diseases (coffee leaf rust, coffee berry disease).

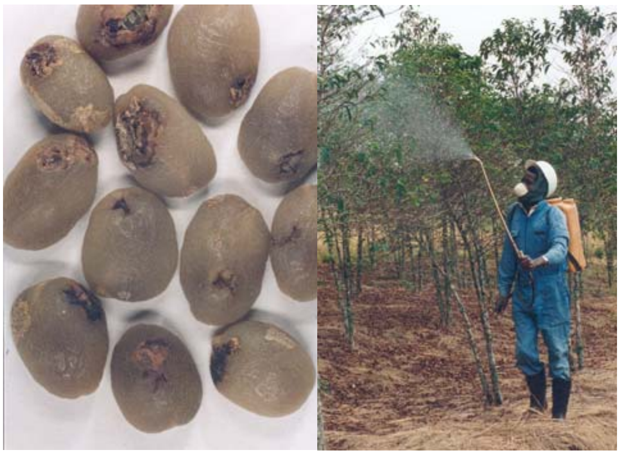

Fig.2: Damage by Antestia orbitalis (left) and spraying insecticide to control A. orbitalis (note protective equipment) (right)[2]

[1] Photos courtesy of John Frank, FAO Consultant (left and centre), and CIRAD (right).
[2] Photos courtesy of Bernard Bouyjou, Burundi.

However, there are still no truly effective control methods for some pests (trunk and branch borers, leaf miners, scale insects, etc.) or diseases (vascular wilt disease). Moreover, abusive pesticide use may have induced resistance (e.g. CBB resistance to endosulfan), or encouraged the development of scale insect populations when pesticides have killed their natural enemies. Nematode control by pesticides is not very effective, expensive and highly polluting.

2.2. Genetic control is the preferred method for disease control, it consists of identifying sources of genetic resistance within coffee tree collections established in different producing countries. Geneticists then cross cultivated varieties with resistant genotypes. This is how a certain number of varieties with resistance to coffee leaf rust and coffee berry disease have been created from Hibrido de Timor. A breeding programme against vascular wilt disease is currently under way. For pests, genetic control is more complex as it is difficult to reveal genetic resistance to pests. However, there is one case where genetic control is efficient: nematode control. Once *Coffea canephora* genotypes resistant (or only very slightly susceptible) to nematodes have been identified, they are used as rootstocks for *Coffea arabica*. Studies are under way in Brazil to control leaf miners using a coffee tree (*Coffea racemosa*) with resistance to the leaf miner as a source of resistance.

2.3. Biotechnology tools are a new way of controlling pests, involving the introduction of one or more genes encoding bio-insecticides or enzymes preventing pest development. Transgenic coffee trees with leaf miner resistance are currently being monitored in the field. A *Bacillus thuringiensis* gene encoding an insecticide protein effective against the leaf miner has been introduced into the coffee tree genome.

Genetic control of pests and diseases is a lengthy and expensive process requiring substantial human and financial resources for research. In addition, the resistance induced may be circumvented, as has already been seen on some leaf rust resistant cultivars. This goes to show that no control method used alone can provide a sure solution and just how important it is to combine different control methods to ensure the best possible protection.

Research is under way to identify *B.t.* genes encoding insecticides effective against CBB.

2.4. Biological control consists in using natural enemies of pests or fungi causing diseases.

Fig.3: Parasitoid on Antestia orbitalis eggs (left) and Beauvaria bassiana, an entomopathogenic fungus, (right) on coffee cherries, used in control of CBB[3]

a) Parasitoids: biological control using natural enemies of coffee pests consists of mass releases of parasitoids at a given moment in the corresponding pest cycle. Rearing of the pests and of their natural enemies has to be well mastered for such releases. The purpose is to act directly on pests by reducing infestation levels, with the hope of eventually increasing parasitoid populations. Controlling with parasitoids comes up against the fact that there is no guarantee that a natural enemy will easily become established in a country where it is not naturally present and also that a natural pest/parasitoid balance disturbed by mass releases tends to return to its initial level. Regular releases are therefore required as the years go by.

Three natural enemies from Africa have been studied for CBB control:

- *Cephalonomia stephanoderis*
- *Prorops nasuta*
- *Phymasticus coffea*

The first two are now well established in Latin America, and *P. coffea* (which, unusually, attacks the adult insect) was evaluated under a CFC/ICO project implemented by CABI *Commodities* (http://www.cabi-commodities.org [www]), which concluded in 2002. A mass-rearing process was developed with USDA and there is strong evidence that the wasp is now established in the field in Central and South America, with good levels of parasitism. Rearing and parasitoid production techniques have been mastered by numerous Latin American coffee producers.

In terms of CBB control, sanitation harvesting at the end of the season helps to reduce infestations and is therefore highly recommended. For example, in El Salvador where sanitation harvesting has been neglected due to relatively low coffee prices, there has been a resurgence of attack levels. The percentage of CBB-damaged beans has increased to more than 15 to 20% in a few years, whilst it was only 5 to 6% previously.

Sanitation harvesting consists of picking all remaining cherries off the trees and collecting all those fallen to the ground at the end of the season and destroying them. These cherries are very often infected and harbour CBB for the following season. Likewise, shading has been found to slightly reduce CBB infestation levels.

[3] Photos courtesy of John Frank, FAO Consultant (left), and Bernard Bouyjou, Burundi (right).

b) Using pathogens and biopesticides consists of spraying pathogenic bacterial, viral or fungal spore suspensions against pests and diseases. Pathogens against fungi causing coffee tree diseases are known, but their practical use has not been developed. *Bacillus thuringiensis*-based biopesticides are used against Lepidoptera, but unfortunately no strains that are highly active against CBB have yet been found.

2.5. Preventative measures

All preventive methods consist in creating an atmosphere that is not conducive to pest and disease development, or which limits their spread by reducing primary sources of infestation. They fall into two groups:

a) Agronomic and farm management practices:
These are very often the easiest methods for producers to implement. In the case of coffee leaf rust, whilst good shade management or well-managed fertilization do not prevent the disease, they do reduce its impact by promoting the regeneration of attacked plant parts. For leaf miners, total weeding tends to encourage outbreaks by destroying the habitat of their natural enemies.

b) Trapping:
This technique consists of diffusing attractants in coffee trees to attract pests into a trap. The attractants may be pheromones, or simple chemical substances.

Fig.4: CBB traps used in Brazil and Ecuador. On the left is the BROCAP ® designed by CIRAD – 36 of these per ha. can reduce CBB by up to 80%[4]

> In collaboration with various Central American countries, CIRAD has developed a trap into which CBB are attracted by a mixture of ethanol and methanol where they die. This method leads to catches of hundreds of thousands of insects in a few weeks. A low–investment installation consists of 18 traps per hectare containing flasks of attractant that need replacing every 2 months. Observations have shown that infestation levels can be reduced by over 80% and damage by more than 15%, in terms of green coffee weight.

[4] *Photos courtesy of Bernard Dufour (top right and left) and Daniel Duris (bottom right and centre), CIRAD.*

Recommendations for an adequate cultural control of coffee berry borer (from Cardenas 1996):

- Identify areas in the coffee plantation with the greatest infestation and designate them 'hot spots'
- Place a silverplate around hot spot trees, in order to gather the fruits from the ground after each harvesting
- Use bags with plastic coating, to avoid CBB re-entering the plantation
- Begin harvesting in coffee lots with the greatest infestation
- Harvest carefully - do not leave mature or over-ripe cherries on the tree and re-pass every 2 weeks to remove any such cherries
- Pulp immediately after harvesting
- Do to leave coffee cherries in the hopper unpulped as CBB could return to the coffee plantation
- Gather and heat treat floating beans from washing tank channels
- Place meshes in water-drains of washing tanks to catch insects
- Begin drying immediately after washing, if possible in silos
- Use traps to detect, monitoring and destroy populations of the insect