Progress in Insecticide Resistance Management of the Coffee Berry Borer *Hypothenemus hampei* (Ferrari) (Coleoptera : Scolytidae)

L.O. Brun[1] and D.M. Suckling[2]

[1]*ORSTOM B.P. A 5, Nouméa, New Caledonia*
[2]*DSIR Plant Protection, Private Bag, Christchurch, New Zealand*

Introduction

Insecticides are the most effective method of controlling coffee berry borer (CBB), a major cosmopolitan pest of coffee. Endosulfan is more widely used than the alternative organophosphate insecticides. It has lower environmental and human hazard, acting mainly by a strong vapour action against CBB inside coffee berries (Parkin *et al.*, 1992).

CBB arrived in New Caledonia in 1948 and rapidly became the major coffee pest. The area of coffee production in New Caledonia is small by world standards, being under 3000 ha, and comprising a small area of modern intensive production fields (350 ha), and a larger area grown under native forest canopy. The annual production is only 200–300 tonnes, due to the low productivity in traditional fields. However, coffee represents the only cash crop for the Melanesian farmers.

CBB is therefore a significant problem for farmers, since infestation levels can reach 90–100%. Infested coffee beans are down-graded in quality (Brun *et al.*, 1989), with a reduction in returns to farmers of 25% or more. The Coffee Board, a French government agency, provides financial assistance as part of a development programme for the local population. Assistance is provided in the form of grafted trees and fertiliser subsidies, as well as a CBB management programme which has been underway for nearly 20 years. Lindane was applied for control of CBB until 1975, and was then replaced with endosulfan, applied in January and February each year (Brun *et al.*, 1989). Treatments are applied using truck-mounted sprayers, all fields in production are sprayed from the roadside (Parkin *et al.*, 1992).

From 1985 to 1987, the Coffee Board of New Caledonia reported increasing problems in controlling CBB with the spray programme which had previously been successful for many years. Preliminary results indicated a very large difference in response to treatment between pest samples from different regions (Brun *et al.*, 1989). A major research effort was commenced, developing into a multidisciplinary team from several countries, under the acronym "SCOCA" or "scolyte du cafe", and based in Noumea. The aim of this research is to develop an insecticide resistance management programme for CBB, in the context of an integrated pest management approach.

Evaluation of the Proposed FAO Method

Concern that the difference in resistance levels between CBB samples could have been due in part to the method used, led to extensive tests of several methods. The Potter tower test method (Brun *et al.*, 1989) requires specialised facilities. An alternative method was thus developed, based around the vapour action of endosulfan (Brun *et al.*, 1990a), in the expectation that other laboratories might need resistance monitoring capabilities at some point. In this rapid, inexpensive and easy method, the insects are confined for six hours in a chamber above treated filter paper. They cannot contact the treated surface, due to a nylon gauze layer, which prevents beetles from burrowing into the filter paper. This method was also tried without the gauze, as a residue contact and vapour action method. Very little difference in response, either with or without the gauze, was found (Brun *et al.*, 1990a), which suggested that vapour action is the primary means of the dose reaching the insects.

The effects of temperature and time on the ability of the method to distinguish between resistant and susceptible phenotypes was investigated (Brun *et al.*, 1991). Tests were conducted at five temperatures, from 22–34°C, with hourly assessments from 2–10 hours. The chosen dose combination of 25°C, 400 ppm of endosulfan and six hours exposure, the $LC_{99.95}$ of susceptibles, was reliable at detecting the presence of lindane or endosulfan resistant insects in samples (Brun *et al.*, 1990b). No survivors were detected in samples from regions without reported field control problems (n = 4000 beetles).

A large scale survey was then commenced, in which samples were taken from the roadsides of over 200 fields from 15 regions of New Caledonia. The majority of samples were tested with both Potter tower and indirect exposure techniques, and treatment also included lindane. The precision of the two methods was similar for fields in

which resistance had been reported present. Resistance was present in 5 of the 15 regions surveyed, and was very widespread in two East Coast regions, with 97–100% of samples showing resistance (Brun *et al.*, 1990b).

Effect of Management History

Resistance was present in beetles at a significantly higher proportion of sunny fields compared to the traditional type of fields, and the frequency of resistant insects in samples from sunny fields was also higher (Brun *et al.*, 1990b). Resistance was also present at a small proportion of fields which had not been treated in the last year. Two of the fields with resistance present were known to have never been treated with insecticides. This finding lends strong support to our idea that the resistance was spread during the harvest season, as trucks loaded with berries moved between fields.

The possible impact of the technique of directional application of insecticides from the roadsides on the resistance frequency within fields was investigated. Samples were taken in transects away from roadsides. This work showed a clear trend of higher frequency of the resistant phenotype near the point of insecticide application, than on the other sides of fields some 50–100 m away (Brun & Suckling, 1992). The clines were particularly evident for sunny fields, and were unstable.

Use of endosulfan led to an increase in resistance in treated fields, while fenitrothion use led to a decrease in resistance after one year (Brun *et al.*, 1992). Examination of the data from four years of sampling shows that a switch to fenitrothion use accelerates the decline in endosulfan resistance frequency compared to that observed in untreated areas (Brun & Suckling, unpublished).

Field application techniques used in New Caledonia, and their potential to select for resistance were also investigated. Tracer dyes were used to determine the deposition characteristics of various sprayers under different conditions (Parkin *et al.*, 1992). Most of the deposition occurred within 10–20 m from the point of application, although wind was an important variable. Two types of bioassays showed that selection for resistance was greatest near the roadside, decreasing with distance across fields (Parkin *et al.*, 1992). Filter paper packets indicated the mortality which could be expected of free-living beetles, and infested coffee berries indicated the mortality of beetles inside berries. In these bioassays, we compared susceptible and resistant CBB strains, and found that a significant difference in mortality was still evident between strains, as far as 80 m away from the roadside. This difference in mortality relates to the selection pressure for resistance, since mortality of susceptibles increases the frequency of resistant beetles.

The higher frequency of endosulfan resistance in sunny fields, compared to shady fields is attributable to the higher temperatures during January and February when spray applications are made. Measurements of air temperature inside the canopy made with a data logger were an average of 3°C cooler than in sunny fields, which amounts to a 20% change in the LC_{50} ofsusceptibles (Brun *et al.*, 1991). Warmer temperatures therefore would lead to a higher kill of susceptible beetles, and enhanced selection for resistance.

Studies on the inheritance and population genetics of resistance are underway. The resistance appears to be due to a single incompletely recessive gene, but further analysis of backcross data is needed. Insects have now been successfully reared on artificial diet for many generations (Brun *et al.*, 1992).

The parasitoid *Cephalonomia stephanoderis* was introduced to New Caledonia in 1989, but it is not yet clear whether the insect has established. Further introductions may take place in future.

A preliminary investigation of the host plant volatiles used by CBB females to locate ripe berries has been completed (Giordanengo *et al.*, 1992), and it is clear that a kairomone effect is present. Further work is underway to determine the exact nature of these compounds, which we hope to be able to report in future.

Acknowledgements

We would like to thank the Coffee Board of New Caledonia (ADRAF-Opération Café) for their support in this project and the French Embassy (Wellington) for financial assistance for DMS. We are also grateful to V. Gaudichon and C. Marcillaud who provided technical assistance for this work, and to P. Wigley for discussion and advice for developing an artificial diet essential for the genetic studies.

References

Brun, L.O., Marcillaud, C., Gaudichon, V. & Suckling, D.M. (1989) Endosulfan resistance in Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera : Scolytidae) in New Caledonia. *Journal of Economic Entomology* **82**: 1311–1316.

Brun, L.O., Marcillaud, C. & Gaudichon, V. (1990a) Provisional method for detecting endosulfan resistance in the Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera : Scolytidae). F.A.O. *Plant Protection Bulletin* **37**: 125–129.

Brun, L.O., Marcillaud, C., Gaudichon, V. & Suckling, D.M. (1990b) Monitoring Endosulfan Resistance in Coffee Berry Borer, *Hypothenemus hampei* (Coleoptera : Scolytidae) in New Caledonia. *Bulletin of Entomological Research* **80**: 129–135.

Brun, L.O., Marcillaud, C., Gaudichon, V. & Suckling, D.M. (1991) Evaluation of a rapid bioassay for diagnosing endosulfan resistance in coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera : Scolytidae). *Tropical Pest Management* **37**: 221–223.

Brun, L.O. & Suckling, D.M. (1992) Field selection for endosulfan resistance in the coffee berry borer *Hypothenemus hampei* Ferrari (Coleoptera : Scolytidae) in New Caledonia. *Journal of Economic Entomology* (In press).

Brun, L.O., Gaudichon, V. & Wigley, P. (1992) An artificial diet for continous rearing of the coffee berry borer *Hypothenemus hampei* (Ferrari) (Coleoptera : Scolytidae). *Insect Science & Its Application* (submitted).

Giordanengo, P., Brun, L.O., & Frérot, B. (1992) Evidence for allelochemical attraction of the coffee berry borer *Hypothenemus hampei* by coffee berries. *Journal of Chemical Ecology* (submitted).

Parkin, C.S., Brun, L.O., & Suckling, D.M. (1992) Spray deposition in relation to endosulfan resistance in the coffee berry borer (*Hypothenemus hampei*) (Coleoptera : Scolytidae) in New Caledonia. *Crop Protection* (In press).

Pest Control & Sustainable Agriculture

Editors
S.A. Corey D.J. Dall W.M. Milne
Division of Entomology, Canberra

CSIRO
AUSTRALIA