THE USE OF VEHICLE-MOUNTED AIR-BLAST SPRAYERS FOR THE CONTROL OF COFFEE BERRY BORER IN NEW CALEDONIA

C.S. PARKIN

Silsoe College, Cranfield Institute of Technology, Silsoe, Bedford, MK45 4DT, United Kingdom

L.O. BRUN, V. GAUDICHON, C. MARCILLAUD

Insitut Français de Recherche Scientifique pour le Developpment en Coopération (ORSTOM), BP A5, Nouméa, New Caledonia

ABSTRACT

Spray deposit patterns from two vehicle-mounted air-blast sprayers operating from field boundaries have been measured using surface fluorimetry. Deposits were measured in open plantations and traditional shaded plantations. In all cases, most of the spray was deposited near to the point of application. Large variations of deposit between leaves were measured with coefficients of variation up to 150%. Since this method of application is at present, for logistic and economic reasons, the only suitable method, it is recommended that it should be optimised. The design of the air-jet and the characteristics of the spray nozzle appear to be influential.

INTRODUCTION

Coffee is an important crop of the Melanesian farmers in New Caledonia, and Hypothenemus hampei (Ferrari), known as the Coffee Berry Borer (CBB), is the only insect pest requiring chemical control. For these reasons, the chemical control of CBB is undertaken by the government agency, Agence de Dèveloppment Rural et d'Amènagement Foncier (ADRAF). Spraying is usually carried out during the months of January and February using vehicle-mounted air-blast sprayers operating from field boundaries, usually the roadsides.

The standard treatment for CBB control is a 0.7 % solution of endosulfan AI (Thiodan 35 EC, Hoechst AG, Germany) in water. After failures of CBB control in 1986 and 1987, resistance to endosulfan was discovered (Brun et al 1989) in some areas of the main coffee growing area on the East coast. This resistance was found to be unevenly distributed across the fields (Brun et al 1990) and to be greatest near the point of application. Thus, a direct link was sought between the distribution of CBB resistance to endosulfan, and spray deposition. This link was established recently by Parkin et al (1990).

In this paper we present details of the spray deposit patterns achieved by the vehicle-mounted air-blast sprayers and discuss methods by which improvements in deposit pattern might be made.

METHODS AND MATERIALS

Spray equipment

Two models of vehicle-mounted air-blast sprayer are in use in New Caledonia. For small areas of open plantation, a BSE Mk IV (Germany) mounted on a light truck is used. However, the majority of the coffee, which is grown in traditional shaded plantations, is sprayed by a large air-blast sprayer, the BSE Super Bangui, which is mounted on a heavy truck.

The BSE Mk IV consists of a petrol engine driven centrifugal fan which generates an air jet of 1.5 m^3 m^{-1} with a nominal outlet velocity of 113 m s^{-1}. The direction of the outlet is control by hand by the operator but the normal operating mode is to project the air-blast horizontally from an emission height of 2.5 m. The air outlet is surrounded by a ring of six 2.5 mm diameter hollow-cone nozzles. At the 20 bar normal operating pressure they deliver 94 ml sec^{-1} per nozzle. This gives an application rate for the sprayer of 174 l ha^{-1} assuming a 25 m swath and a typical forward speed of 3 km hr^{-1}.

The BSE Super Bangui consists of a large centrifugal fan, driven by a diesel-engine. The outlet is capable of being directed in both the vertical and horizontal planes by the operator via a crown wheel and pinion gear set. The typical emission height of the air jet is 3.3 m. The fan generates an airflow of 7.8 m^3 s^{-1} at a nominal velocity of 125 m s^{-1}. The outlet from the fan is surrounded by a ring of six 2 mm orifice hollow-cone nozzles. Each nozzle emits 79 ml s^{-1} at 20 bar pressure. This gives the sprayer an application rate of 125 l ha^{-1} at a forward speed of 3 km hr^{-1}.

Deposit analysis

The spray deposition patterns achieved by the sprayers were measured using a surface fluorimeter (Parkin and Uk 1983). This technique was chosen since it was capable of operation in the field with the minimum of laboratory facilities and was capable of measuring large numbers of samples rapidly (Cowell et al 1988a). It would have been preferable, since the biological target is the coffee berries, if the measurements could have been made directly on the berries. Unfortunately, at the time of spray application the berries of the coffee (*Coffea caneophora var. robusta*) varied widely in diameter and a suitable modification to the surface fluorimeter was not feasible. Thus, it was decided that the measurements would be made on the leaves nearest to the berry growing points.

The tracer used was the pigment Lunar Yellow (Swada Ltd., London). This was specially formulated by Shell Research Ltd., (Sittingbourne, Kent) as a 25 % m/v SC. It was applied at the rate of 4 litres product per 100 litres of water. The tracer formulation required no special agitation in use. Suitable optical filters were fitted to the surface fluorimeter to optimise its performance for Lunar Yellow. The fluorimeter was calibrated by applying known concentrations of Lunar Yellow onto coffee leaf surfaces using a Potter Tower (Potter 1952). Linear correlations were achieved between mass deposited per unit area and fluorimeter reading for both leaf surfaces (Adaxial r^2 = 0.992 28 DF and Abaxial r^2 = 0.989 28 DF). This enabled the results to be expressed qualitatively. Cowell et al (1988b) achieved similar correlations using doses applied by a pipette. As is normal practise with such measurements, allowance was made in the measurements for the background fluorescence of both surfaces.

Because a large amount of data was anticipated from the results, data from the surface fluorimeter were stored automatically onto a Campbell 21x data logger (Campbell Scientific, Nottingham). This enabled the data to be downloaded onto a lap-top computer and saved on disc. Analysis of the data was carried out using software developed at Silsoe College and a standard spreadsheet.

Experimental Sites

The experimental fields were situated at La Foa on the West Coast and at Ponérihouen on the East Coast. In the work reported here three fields were used. The first (Field 1) was at La Foa and was typical of a mature but open plantation. The tree height was around 2.5 m and the tree spacing 3 x 2 m. The second field (Field 2) was also an open and mature plantation, but it was located at Ponérihouen on the East coast. The trees were also 2.5 m high but the spacing was 3 x 2.5 m. The third field (Field 3) was also situated at Ponérihouen but it was typical of a traditional shaded plantation. The tree spacing was variable but around 5 m and the height around 2.5 m. The tree shape was also more umbraculiform and the leaves larger than the open plantations.

Other Measurements

Temperature and humidity were monitored by whirling arm hygrometer (Casella Ltd, Bedford) and wind speed by a hand-held vane anemometer (Airflow Developments, Aylesbury).

Spray Experiments

A summary of the spray experiments is given in Table 1. The first two experiments compared the large and small vehicle mounted sprayers in similar plantation types, whilst the second and third experiments compared the deposit patterns achieved by the large sprayer in the traditional and open plantations.

Sampling Protocol

In the experiments in open mature plantations, 10 leaves were sampled from around the trees at each of three levels. On each leaf three measurements were taken of each surface. In the experiment in the shaded traditional plantation, 20 leaves were taken at each sample level since it was assumed that the variation in deposit would be greater. Also, because of the shape of the trees, only two sample levels were identified in this experiment. In the experiment at La Foa and the first experiment at Ponérihouen, measurements from two transects were taken, but since the results from both of the transects were similar, only one from each experiment is reported.

Table 1 Summary of the spray deposition field experiments

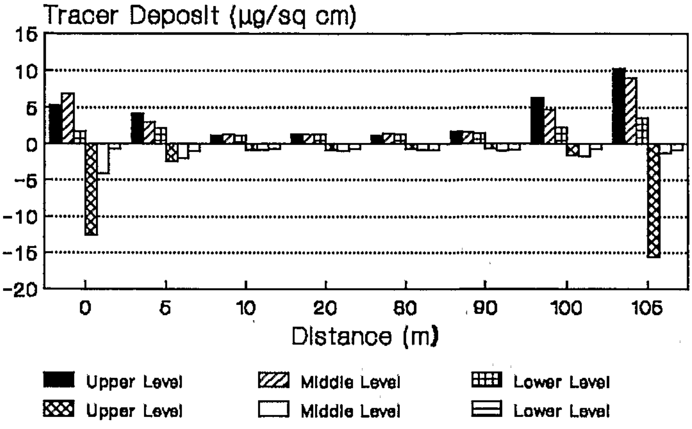
Description	Location	Temp. °C	Humidity %	Wind(a) m s^{-1}
Small Sprayer Mature Open Plantation	La Foa (Field 1)	31	55	-1.5 (b) +1.25
Large Sprayer Mature Open Plantation	Ponérihouen (Field 2)	29	78	+1.86
Large Sprayer Mature Shaded Plantation	Ponérihouen (Field 3)	29	78	Calm

(a) Wind component in direction of spraying
(b) Plot sprayed both with and against wind from each field edge

RESULTS

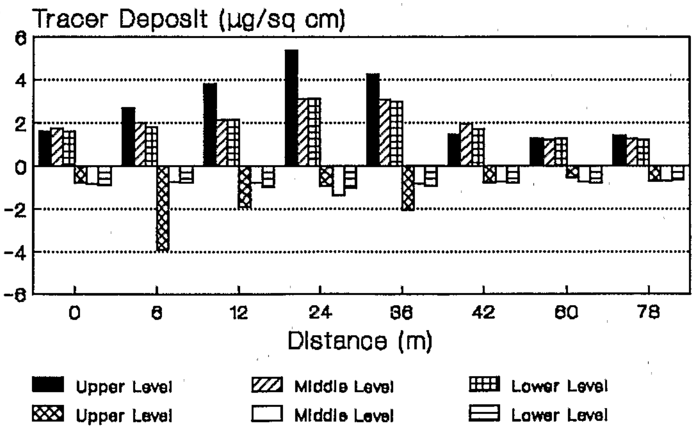
The spray deposit results are shown on Figs. 1-3. The deposits on the abaxial surfaces are represented as negative values to provide a simple comparison between surfaces. Figs. 4-6 show the corresponding Coefficients of Variation (CoV) for the mean deposit between leaves. This provides a simple description of the variability of spray deposit at each sample location.

Fig 1 Deposit profiles BSE Super IV
Open mature plantation



Positive adaxial, Negative abaxial

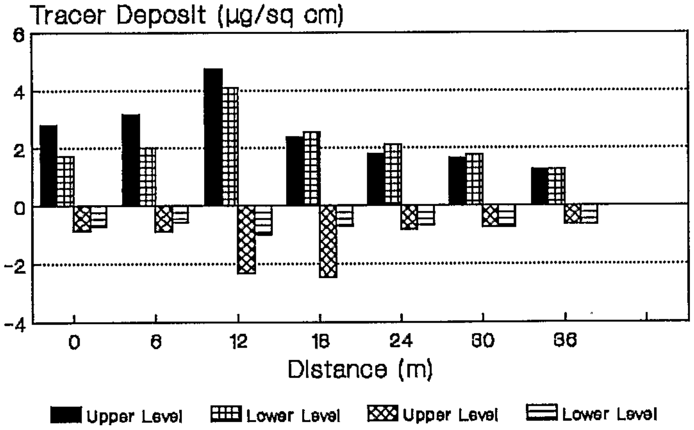
Fig 2 Deposit profiles BSE Super Bangui
Open mature plantation



Positive adaxial, Negative abaxial

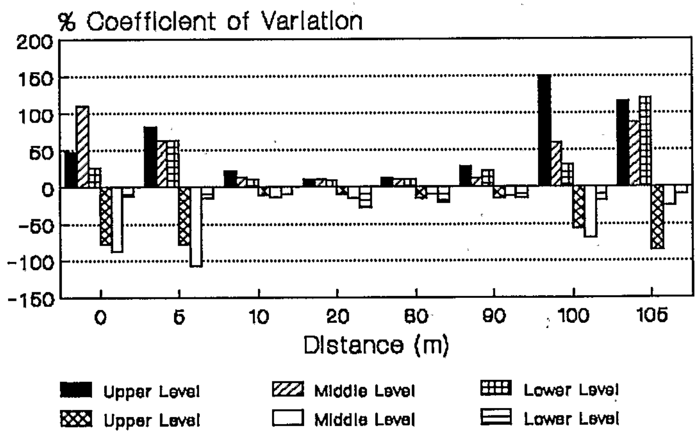
With both surfaces there is a detection limit for the surface fluorimeter measurements. This was 1.2 $\mu g/cm^2$ for the adaxial surface and 0.75 $\mu g/cm^2$ for the abaxial. When measurements reach the limit of detection, the variability is reduced to that of the instrument, plus that of the natural background fluorescence of the leaves. It can be seen that for adaxial leaves the CoV for background deposits are around 10% and for abaxial leaves around 15%. Since tests have shown that the basic variability of the instrument is 2%, it is clear that the majority of this variation is in the natural fluorescence of the leaves.

Fig 3 Deposit profiles BSE Super Bangui
Traditional shaded plantation



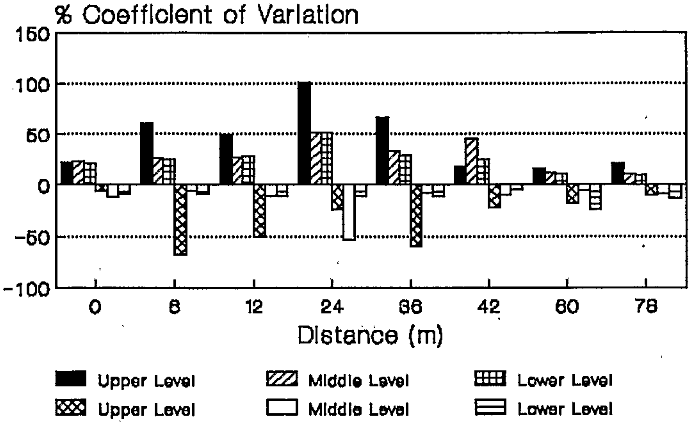
Positive adaxial, Negative abaxial

Fig 4 Deposit variation BSE Super IV
Open mature plantation



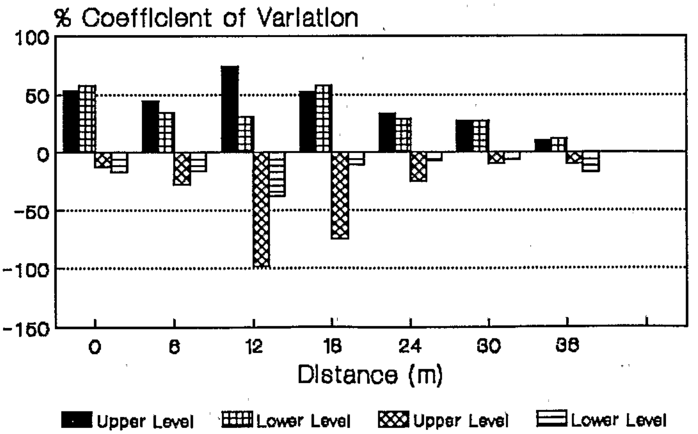
Positive adaxial, Negative abaxial

Fig 5 Deposit variation BSE Super Bangul
Open mature plantation



Positive adaxial, Negative abaxial

Fig 6 Deposit variation BSE Super Bangul
Traditional shaded plantation



Positive adaxial, Negative abaxial

It should be noted that the spray application in Fig. 1 and Fig. 4 was the result of an application against the wind (from position 0 m) and with the wind (from position 105 m). The lack of spray penetration beyond 10 m from the point of application is clear. The large variation in spray deposits is also apparent with CoV up to 150 %. The clear link between deposit level and variation can also be seen.

The spray deposit and CoV patterns with the larger sprayer in an open plantation are shown on Figs. 2 and 5. Here variability was less than with the smaller sprayer and the projection of the spray across the field greater. A significant level of spray deposit was found up 20 m (Parkin et al 1990), but it is clear that improvements in spray deposition profiles are required.

Alternative application techniques, such as by motorised knapsack sprayer, have been considered but this form of application has serious disadvantages, particularly in traditional shaded plantations. In these areas the underlying ground is very uneven, making application by individuals difficult. Also the increased resources and organisation required for application by individuals would significantly increase the cost of control. It is therefore likely that, for the near future, application will be made from the roadside.

FUTURE WORK

The current application technique must, therefore, be improved. The most simple improvement would be if access to the fields was improved so that applications could be made from each end of the fields. This would, of course, require suitable meteorological conditions, but since at present applications are only carried out in light winds in the early morning, this would not create a problem. Improvements in sprayer performance could be made by optimising the air-jet characteristics and the drop size produced by the nozzles. Experiments investigating the use of air-jets of varying velocities and volumes are required. Work on this aspect is currently being carried out at Silsoe College using Computational Fluid Dynamics (CFD) techniques to predict the behaviour of the turbulent air-jets and to assist with the planning of field experiments.

It would be an advantage if the surface fluorimeter was adapted for spherical surfaces thus making it suitable for use on crops where a small fruit is the spray target. Direct comparison experiments would then be possible between Gas Liquid Chromatography measurements and surface fluorescence on, for example, Coffea arabica.

CONCLUSIONS

Measurements of spray deposits on leaves, from sprays applied by vehicle-mounted air-blast sprayers operating from roadsides, have been made using a surface fluorimeter. These measurements have shown that most of the spray is deposited close to the point of application, particularly with a small sprayer mounted on a light truck. Since the current system of application is unlikely, for logistical and economic reasons to be replaced, it is vital that it should be optimised.

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