LABORATORY AND FIELD DEVELOPMENT OF A CDA SPRAYING SYSTEM FOR CONTROL OF COFFEE LEAF RUST (*HEMILEIA VASTATRIX*): AN OVERVIEW

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ABSTRACT

A CDA spraying system for control of *Hemileia vastatrix* has been developed for use in Colombia. *In vitro* work showed that 30 drops of copper oxychloride per cm^2 abaxial leaf surface prevented infection. Concentration and droplet size were unimportant. *In vivo* work showed that the air-assisted CDA sprayer was superior to conventional spraying in terms of leaf infection and damage to coffee cherries.

INTRODUCTION

Copper oxychloride has been used for many years as a conventional treatment for control coffee leaf rust, (*Hemileia vastatrix*) in Colombian coffee (Fernandez *et al*, 1986). There was a need to reduce the volumes of fungicide applied and work was started in 1990 to develop a spinning disc CDA system that could provide disease control equal to that obtained by the conventional hydraulic nozzle system chosen by the Colombian Coffee Growers Federation (FNCC). *In vitro* tests were undertaken in the UK and Colombia followed *in vivo* tests in Colombia. The contract required the programme to be completed within two years which meant that results of the *in vitro* studies had to be translated quickly into cost effective field treatment. This paper describes the programme and its outcome.

FUNGICIDE FORMULATION

Wettable powders (WP) and suspension concentrates (SC) of copper oxychloride suitable for spinning-disc application and commercially available in UK were used for *in vivo* studies.

LABORATORY BIOASSAYS

The effect of copper on spore germination

The activity of copper fungicide was examined by measuring the germination of rust spores immersed for 18 hours in various aqueous concentrations of copper oxychloride. These *in vitro* experiments demonstrated (Table 1) that copper oxychloride is prevents germination of rust spores at about 1 ppm.

TABLE 1. Percentage germination of spores of *Hemileia vastatrix* immersed in aqueous concentrations of copper oxychloride.

copper concentration (ppm)	germination (%)
0.00	41
0.01	41
0.12	8
0.19	9
0.35	0.6
1.92	0.0
15.3	0.3
81	0.0

Identification of the characteristics required for a residual deposit of copper oxychloride for protection of coffee leaves

Laboratory bioassay (Waller *et al*, 1988) was used to assess the relative importance of copper concentration, droplet size and droplet density, the three major factors involved in determining the nature of the fungicide deposit. Leaves were sprayed using a spinning disc sprayer. Different concentrations of the suspension concentrate formulation were used. Neither copper concentration nor droplet size made a significant contribution to explaining the variation in percentage germination. Droplet density had a significant effect on spore germination, *i.e.* logit(germination) = $-1.25 - 0.047(\text{drops/cm}^2)$ with standard errors of $\pm$ 0.33 for the intercept and $\pm$ 0.0011 for the slope ($p < 0.002$ for both parameters). For droplet densities higher than 30 drops/cm^2, there is a 0.9 probability that germination will be less than 10%; the probability decreases as the cover falls below this value. These results suggests that, even at the lowest concentration and smallest drop size tested, raindrops could contact the copper oxychloride deposits and dissolve sufficient copper to inhibit germination, so long as there is adequate cover on the underside of leaves.

Assays were also undertaken to assess the extent of rust infection. Different densities of uniform droplets containing copper oxychloride were applied to detached coffee leaves. After the deposit had dried, the leaves were inoculated with a

suspension of rust spores and kept at constant temperature for 21 days under a regime of humidity which simulated typical field conditions. The underside leaves were then assessed for the number and size of lesions. The lowest droplet densities applied (11 drops/cm^2) were sufficient to reduce substantially the extent of lesion development under laboratory conditions. However, complete prevention of infection was only observed for drop densities above 30 drops/cm^2.

These *in vitro* studies emphasise the importance of droplet density in inhibiting spore germination and subsequent development of rust lesions, but do not take into account the possible effects of persistence and/or redistribution of the copper following spraying (Rayner, 1962), which are best examined under field conditions. If copper can be deposited on the undersides of the leaves, however, resistance to rain washing should be improved.

DEFINITION OF THE SPRAYING MACHINERY.

From the beginning, it was agreed that the spray system would be based on a machine producing droplets by means of a spinning disc so that the droplet size could be controlled and a narrow droplet spectrum obtained. It was also decided that the system would apply low volumes (30-100 l/ha) using water-based sprays with droplets of 50-100 micron in diameter.

TABLE 2. Comparison of the average copper oxychloride cover (droplets/cm^2) achieved on coffee leaves with the Motax and Micro-ulva sprayers.

MOTAX			MICRO-ULVA	
Outside	Inside	Tree position	Outside	Inside
		adaxial surface		
176	87	top	89	81
261	172	middle	106	73
95	61	bottom	50	40
		abaxial surface		
119	65	top	45	31
179	59	middle	17	8
19	18	bottom	8	9

The first question to address was whether air-assistance would be required on the machine. In the initial stages of the project, the use of a spinning disc machine which used natural air movement to distribute the droplets had been considered as the most suitable for the steep slopes found in Colombia. A Micro-ulva was tested in the field and its deposition compared with that obtained with an experimental motorised machine (Motax) which employed a beam of turbulent air produced by an axial fan and whose flow rate and disc speed could be

controlled precisely. Both machines were used to apply 100 micron droplets at 50 l/ha. The results showed that the coverage obtained with the air-assisted Motax was much greater, particularly on the undersides of the leaves in the interior of the bush where conditions for establishment of rust are more prevalent (Table 2). Field applications using the two systems were also made to test persistence of effect. Leaves were harvested at weekly intervals and tested using the bioassay technique over a 2 month period; the air assisted Motax system had a marked advantage.

This supported previous work using potted coffee plants subjected to natural environmental conditions, which had shown that while the copper deposit had virtually disappeared on the adaxial surfaces of leaves within 2 weeks, a deposit on the abaxial leaves maintained its effectiveness for the 2 month period of the test (unpublished data). Furthermore, under adverse environmental conditions, operator contamination was 5-6 times less with the Motax compared to the Micro-ulva. The performance of the Motax was less dependent on the prevailing wind speed, temperature and relative humidity than the Micro-ulva, and could be used throughout the working day.

Once the decision had been made in favour of air assistance, a new prototype with a fixed flow rate and disc speed was designed and manufactured. The design took account of the findings of the laboratory bioassays and the practicalities of field use. This prototype machine has now been extensively tested under a wide range of field conditions.

CONTROLLING COFFEE LEAF RUST UNDER FIELD CONDITIONS

Previous work (Aston *et al*, 1991) had shown that laboratory bioassay alone was insufficient to establish the overall field efficacy and that season-long field studies would be necessary. A basic objective was to show that a low volume system could be developed which was at least as effective as the conventional high volume system for the control of rust.

Two long term field trials (CO1 and CO2) were undertaken to compare the performance of the Motax with that of a conventional spraying system (PPR). This paper describes results obtained during the first trial (CO1) in which five treatments were applied to heavily infested trees, *viz.* **Motax30** (5 sprays of copper oxychloride at 1.5 kg a.i. applied in 50 l/ha at intervals of 30 days between applications); **PPR30** (5 sprays of copper oxychloride at 1.5 kg a.i. applied in 250 l/ha at intervals of 30 days between applications); **Motax45** (4 sprays of copper oxychloride at 1.5 kg a.i. applied in 50 l/ha at intervals of 45 days between applications); **PPR45** (4 sprays of copper oxychloride at 1.5 kg a.i. applied in 250 l/ha at intervals of 45 days between application; **Control** unsprayed plots included as controls).

FIGURE 1. The effect of treatment on the proportion of leaves (15 assessed branches per plot, four plots per treatment) showing rust infection.

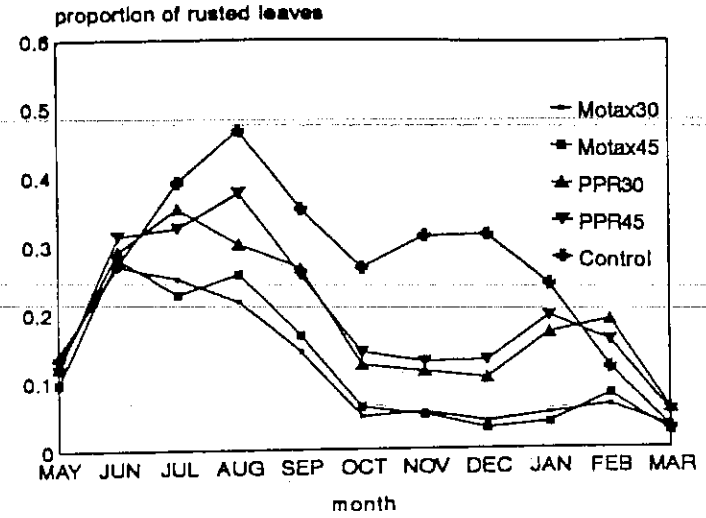
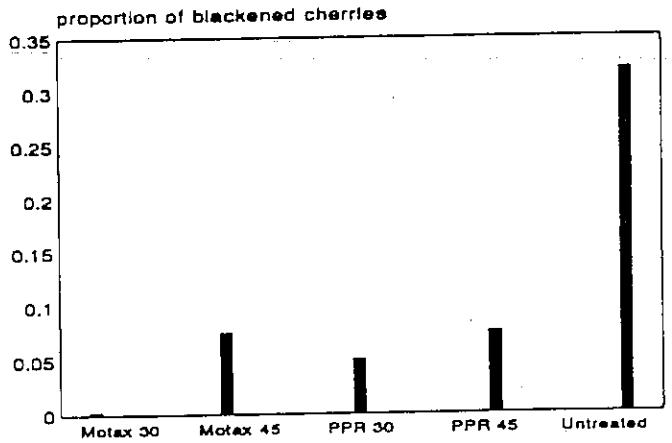


FIGURE 2. Effect of spray treatments upon proportion of blackened coffee cherries.



Rust levels were assessed monthly to estimate the proportion of rusted leaves (fig. 1). The level of rust infection was initially high (proportion of rusted leaves = 0.13), but the effects of the four fungicide treatments began to show by the third assessment (July). The rust, which continued to increase in the untreated control plots, was checked in the conventional PPR treated plots and started to decrease in the Motax treated plots. This pattern continued with the following assessment, after which date, rust levels declined in all the plots. Treatments using the Motax sprayer were more effective than the high volume PPR treatments.

At the time of harvest, blackened cherries were present throughout the trial area. An estimate of the proportion of blackened cherries was made just before harvest. All treatments with copper fungicide resulted in a dramatic reduction in the quantity of blackened cherries (fig. 2). Blackened cherries were never encountered in the plots treated using the Motax30 treatment, providing a clear indication of the beneficial effect of this treatment on yield in the season of application.

CONCLUSIONS

A CDA based control system for coffee leaf rust has been developed for use in Colombia. *In vitro* studies suggested that complete prevention of germination and infection would be possible if a cover of 30 drops/cm^2 could be achieved on the undersides of the coffee leaves; copper concentration and droplet size were unimportant over the ranges of these variables examined. Appropriate cover and hence effective and persistent crop protection was achieved in the field using the Motax, an air-assisted, rotating disc sprayer developed for the project by Micron Sprayers, Bromyard, U.K.. Compared with the conventional system, higher levels of disease control and more effective protection of coffee berries were obtained using this sprayer, a result attributed to the fungicide cover achieved on the undersides of coffee leaves.

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