USE OF CRU COLLARS TO APPLY COPPER FUNGICIDES FOR PREVENTION OF BLACK POD AND OTHER FUNGAL DISEASES OF COCOA

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ABSTRACT

Promising results were obtained for reducing pod losses due to *Phytophthora* black pod in a small-scale field trial of an alternative method of fungicide application to spraying. In this method, proposed by the CRU, copper fungicide was incorporated into water permeable collars placed high in the pod bearing canopy. These redistributed copper to all parts of the tree below in the rain water as it flowed down through the canopy. At the rates of active ingredient 5, 10 and 15 g tree^{-1} 100% control was obtained on all trees in a plot where untreated trees sustained approximately 60% losses to black pod. Details of copper redistribution and the efficacy of the resulting deposits were compared between collar treatments and a concurrent spray trial. These showed that the collar technique of application has great potential for disease control in crops such as cocoa where the target area for control is concentrated in a small zone around the main trunk.

KEYWORDS - *black pod - copper fungicide - fungicide application - collars*

INTRODUCTION

The present technology for black pod disease control often appears inadequate. Protectant copper based fungicides are sprayed onto the crop and the only way the activity of these can be maintained is by continually applying new doses before the compound is lost by rain erosion and growth dilution. This means that during a wet season with an average weekly rainfall of approximately 100 mm or more, the spray interval would have to be every two to four weeks soley as a result of losses to rain erosion (Rudgard, Pettitt & Hadley, 1990).

A recent small-scale trial at the CRU, Trinidad, testing a novel approach to fungicide application, produced some promising results. Many copper fungicides readily redistribute in water films (Hislop & Cox, 1970; Rudgard *et al.*, 1990). This property was exploited in a single application method by wrapping water permeable fungicide-impregnated collars around cocoa tree trunks high in the pod bearing canopy. The water that flowed down through canopies during heavy rainfall collected fungicide from the collars and relocated it lower down the stem and onto the pods where it was needed. This paper describes the production and application of the prototype collars and an assessment of their efficacy in terms of fungicide redistribution, disease determinations and bioassays.

MATERIALS AND METHODS

Water-permeable collars containing controlled quantities of copper fungicide were placed in the pod growing area of the canopy of cocoa seed-raised trees. The collars were constructed from non-absorbant cotton wool, in which a flowable granule formulation of cuprous oxide (Cobre Sandoz, Sandoz Ltd. Basle) was evenly distributed at one of three rates: 5, 10 and 15 g of active ingredient (Cu_2O). The cotton wool was folded and wrapped in a man-made fibre fabric supplied by Johnson and Johnson Ltd. (Trinidad). A sheet of cotton wool 20 cm wide, 70 cm long and 0.5 cm thick was layed flat and dry fungicide powder was evenly sprinkled over its entire surface. The sheet was folded in half lengthwise and further fungicide was applied to the upper surface. The sheet was folded once more and secured in the outer coating fabric using standard size stationary staples. Henceforth these devices are called 'CRU collars'.

Three replicate trees were treated for each rate of active ingredient, plus three controls with CRU collars containing no fungicide. Pod samples were taken from all trees at four times during the rainy season. Sample pods were divided into quartals (Figure 1) and each of these was assessed for susceptibility to infection by *Phytophthora palmivora* zoospores (10^3 in 20 μl sterile distilled water) by patch inoculations (Sreenivasan, 1984). After bioassay the concentration of copper fungicide on quartal surfaces was determined by colorimetric analysis of 1 M HCl surface extracts by the method of Somers & Garraway (1957), adapted for use on a portable flow injection analysis system ('Heliflow', WPA Instruments Ltd., Cambridge, UK) as described by Pettitt & Brown (1991).

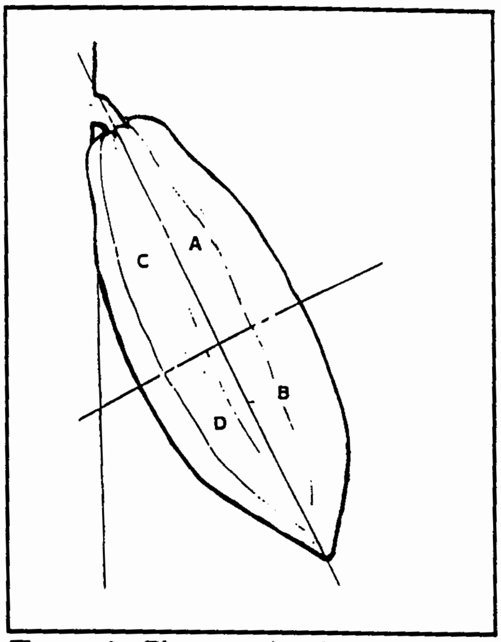

Figure 1 Diagram showing how pods were divided into quartals for determinations of copper concentration and fungicidal activity.

During the same rainy season as the trial described above, single applications of cuprous oxide by mistblower (Stihl SG 17) were assessed on a separate group of trees within the same field as the collar trial. These provided a useful reference for the efficacy of CRU collars. The flowable granule (Cobre Sandoz) and an experimental flowable formulation (Sandoz Copyflo) of cuprous oxide were sprayed in water at a rate of 1.12% (w/v and v/v respectively). The mistblower gave a mean flow rate of 45 ml s^{-1}, giving approximately 5 g a.i. per tree with vmd values of 336 μm for Cobre Sandoz and 288 μm for Copyflo. All trees were cleared of any diseased pods prior to spraying (although these were very few) and random pod samples were taken for copper determinations and bioassay by the methods described above at spraying and at two harvest dates afterwards.

All experiments were carried out on mature cocoa seedling trees (progeny of open pollinated TSH 1076 clone) planted at a 1.8 m x 1.8 m spacing at La Reunion Estate, Centeno Field Station, Republic of Trinidad & Tobago. Rain gauges were placed in ten positions on the ground underneath and outside the cocoa canopy and daily rainfall volume was recorded throughout the experiments. Runoff from pods was collected in plastic bottles (Solo Bottle Works, Churchill Roosevelt Highway, Trinidad) suspended below pod tips with 1 mm guage ('cutlass') wire supports.

RESULTS

The volume of runoff water collected from beneath pod tips varied greatly and was not related to the

Table 1 Movement and efficacy of copper fungicide from impregnated collars placed on the main stems of seedling cocoa trees.

Sample time (Days)	Rain through canopy (mm)	COPPER PER UNIT AREA[1] ($\mu g cm^{-2}$)							% of pods diseased in the field			
		Controls	Collars with copper (g a.i.)						Con	5	10	15
			5		10		15					
			A+C[2]	B+D	A+C	B+D	A+C	B+D				
20	23.5	0^{A}	0.4^{B}	0.4^{B}	3.3^{C}	3.0^{C}	0.9^{B}	0.8^{B}	0	0	0	0
35	105.9	0^{A}	6.2^{D}	9.3^{E}	9.6^{E}	10.9^{E}	7.9^{DE}	8.6^{DE}	21	0	0	0
59	153.3	0^{A}	5.4^{D}	10.3^{E}	7.1^{DE}	6.5^{DE}	4.9^{D}	5.6^{D}	100	0	0	0
115	185.5	0^{A}	0.4^{B}	0.7^{B}	0.2^{B}	0.2^{B}	0.3^{B}	0.2^{B}	100	0	0	0

1) Figures followed by the same capital letter (A–E) are not significantly different from each other at P = 0.05.

2) See Figure for explanation of quartals.

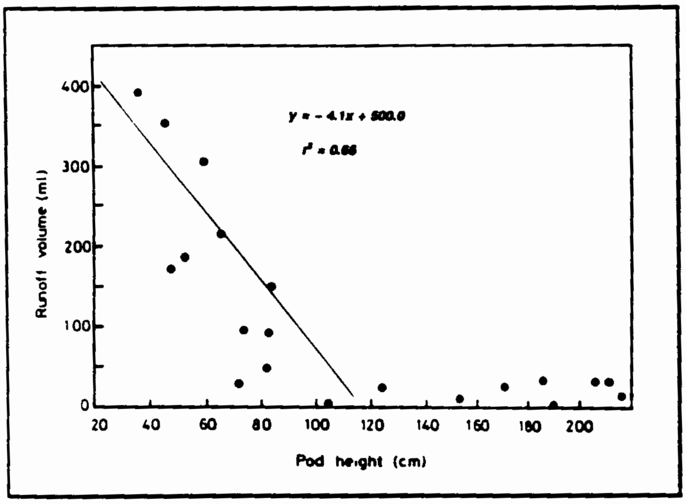

Figure 2 Decrease in the volume of runoff collected from pod tips with vertical height from the ground

surface area of the pods that intercepted water. However a relationship was found between runoff volume and the vertical height of pods from the ground (Figure 2) following rain showers of 20 mm or more. The volume of runoff from pods increased down the stem, indicating that it was principally derived from trunk-flow rather than drips from the canopy.

Bioassays on pod samples taken from CRU collar-treated trees were only carried out after the second and third harvests and in these none of the CRU collar-treated pods became infected. CRU collar-treated trees also showed no black pod disease on the pods below collars (Table 1), whereas all of the pods on control trees were diseased by day 59 of the trial. The distribution of copper from CRU collars was initially uneven but by day 59 there were no significant differences in quantities of copper on pods from trees treated with any of the three rates of cuprous oxide. Copper was fairly evenly spread over pod surfaces, although the concentration on individual pods was somewhat variable.

In the spray trial the distribution of copper over pod surfaces was uneven with more accumulating in the distal portions (Quartals D & B, Table 2) a result often observed with these formulations, even when spraying to runoff was avoided (Pettitt *et al.* 1988 & 1989 (Unpublished data)). Some pods treated with Cobre Sandoz became infected by bioassay inoculations before rain erosion of their fungicide coatings, indicating that these were patchy deposits. Cobre Sandoz (Cu_2O) deposits were rapidly eroded and control of black pod was lost on pods sprayed with this fungicide after 17 days (Table 2). The experimental flowable formulation of cuprous oxide (Sandoz Copyflo) gave more tenacious deposits, although control of disease was still negligible after three weeks.

Table 2 Concentration and efficacy of cuprous oxide deposits on pods from cocoa seedling trees sprayed using a mistblower.

Sample time (days)	Rain through canopy (mm)	Formulation	Cu/unit area (μgcm^{-2})		% infection of quartals in bioassay with zoospores		Mean total Cu per pod (μg)	% of pods diseased in the field
			A+B	B+D	A+C	B+D		
0	0	CS	10.9	13.7	0	30	1261	0
		SC	11.1	16.1	0	0	506	0
17	30	CS	0.8	0.8	50	80	33	4.5
		SC	9.0	10.2	0	0	389	26.1
45	98.9	CS	0.4	0.4	90	100	45	86.4
		SC	0.9	1.3	90	60	116	69.6

DISCUSSION

Phytophthora, one of the two most economically important fungal pathogens of cocoa in Trinidad, requires rain-derived water for infection and greatest black pod disease pressure is normally associated with high rainfall (Gregory & Madison, 1981). Under conditions of high rainfall, deposits of cuprous oxide were rapidly removed from pod surfaces and the efficacy of sprayed fungicide cover was quickly diminished. Sprayed deposits are also rapidly diluted by increases in pod surface area with expansion growth (Hislop & Park, 1962). Of the two cuprous oxide formulations used for spraying experiments, Sandoz Copyflo was an improvement on Cobre Sandoz, especially for use with the mistblower equipment. It dispersed very readily in water, remaining suspended for a reasonable time and was clearly visible at low concentrations spreading well on application, Sandoz Copyflo was also more tenacious than Cobre Sandoz.

Pereira (1985) recommended a single application technique (SAT) for control of *P. palmivora*, whereby the canopy of each tree was sprayed once with a rate of active ingredient (usually copper) equivalent to a single season's spraying. The SAT used rain water to redistribute fungicide down from sprayed canopies onto the pods on the main branches throughout the season and gave control comparable to that achieved in normal spray programmes with the saving of a single application. A large portion of the water incident on pods is derived from trunk-flow and Sreenivasan (1981) suggested that if the trunk- flow water was intercepted by a device containing mobile copper fungicide, a more controlled SAT would be possible. With SAT methods, fungicide is carried to the pods during rainfall and tends to concentrate in areas where water collects which are normally potential sites for infection by *Phytophthora*. The CRU collar method directed fungicide mainly to the target areas where it was required, avoiding large application and redistribution losses.

CRU collars were shown to be very good dispensers of fungicide by rain-distribution and during the 1989-90 rainy season provided 100% control of black pod disease with a marked increase in efficacy over conventional sprays with identical compounds. These results however, represent only a small-scale field trial and further work is now under way to test the CRU collar with larger numbers of replicates in different locations in the world (Brazil, Ghana, Solomon Islands and Trinidad) with various formulations of copper fungicide.

ACKNOWLEDGEMENTS

The authors are grateful to the Biscuit, Cake, Chocolate and Confectionery Alliance for funding of this project.

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