AN ALTERNATIVE METHOD OF APPLYING COPPER TO CONTROL COCOA POD DISEASES

T.N. SREENIVASAN, T.R. PETTITT

Cocoa Research Unit, University of West Indies, St. Augustine, Trinidad

S.A. RUDGARD

CAB International, Development Services, Wallingford, Oxon. OX10 8DE, U.K.

ABSTRACT

Spraying of copper fungicides has been the only method of limiting losses in cocoa to black pod diseases (Phytophthora spp). Repeated applications are necessary during one season, often only achieving unreliable control. Water is required for dispersal of inoculum and infection, so disease pressure is normally highest when conditions are least favourable for retention of copper on plant surfaces. As an alternative to spraying, water-permeable reservoirs of copper fungicide were attached to cocoa stems so trunk flow and canopy drip would continuously wash copper down to pods concentrated on the lower architecture. This technique proved very successful, and data are presented from a small trial conducted in Trinidad showing the distribution of copper on bark and pods and the efficacy of the deposits against P. palmivora. Copper was distributed most efficiently when disease pressure was greatest.

INTRODUCTION

The cocoa pod pathogens Phytophthora spp. (black pod disease) can cause heavy crop losses. For many years the only economic method of limiting losses to this disease has been the spraying of protectant copper fungicides onto pods. Spraying can be costly and often unreliable, and rapid dilution of fungicide deposits by rainfall and pod growth means that effective doses have to be maintained by frequent spraying (Jollands & Jollands, 1989). Water is required for infection by the two pathogens mentioned above, and disease pressure is normally greatest during periods of high rainfall (Gregory & Maddison, 1981).

Copper fungicides readily redistribute in water (Hislop & Cox, 1970). Pereira (1985) suggested the exploitation of this property in a single application technique. This involved spraying the entire canopy once in a season, and allowing rain to redistribute fungicide onto the target pods. Conventional spray machinery is designed to provide good cover on targets that are widely dispersed through space. However cocoa pods grow directly from the main branches of trees and are concentrated in a small area. The present paper describes a field trial of an alternative technique to spraying for the application of copper fungicides to cocoa pods.

MATERIALS & METHODS

The redistribution of copper from a point source situated within the pod growing area of the canopy was studied using absorbent collars impregnated with controlled quantities of fungicide. The collars were attached around trunks at c. 2 m above the ground, with the intention that water flowing down from the upper canopy would collect copper and carry it down to the pods lower on the same branch.

The collars consisted of non-absorbent cotton wool, in which a wettable powder (WP) formulation of cuprous oxide 'Copper Sandoz' was distributed at three rates: 5, 10 and 15 g a.i., wrapped in a man-made fibre material (Johnson & Johnson Ltd., Trinidad). A sheet of non-absorbent cotton wool 20 cm wide, 70 cm long and 0.5 cm thick, was laid flat and fungicide powder was evenly sprinkled over one surface. The sheet was folded in half lengthwise and further fungicide was sprinkled on the upper surface. The sheet was folded once more and wrapped in the outer coating material.

Three replicate trees were treated for each rate of active ingredient, plus three controls with copper-free collars. Pods were assessed at intervals during the rainy season for susceptibility to infection with Phytophthora palmivora zoospores by patch inoculations (Sreenivasan, 1984), after which total amounts of copper on pod surfaces were determined.

During the period of the collars trial, two applications of cuprous oxide by mistblower (Stihl SG17) were assessed on different sets of trees (Figure 1). The wettable powder and a suspension concentrate (SC) formulation 'Sandoz Copyflo' of cuprous oxide were sprayed at a rate of 1.12% a.i.. The machine gave a flow rate of 45 ml s^{-1}, giving approximately 5 g a.i. per tree with vmd values of 336 μm for the WP and 288 μm for the SC formulation. All trees were cleared of any diseased pods prior to spraying and random samples of immature pods were taken for copper determinations and bioassay at spraying and at two dates afterwards.

All experiments were carried out on mature cocoa trees (progeny of open pollinated TSH 1076 clone) planted at a 1.8 m x 1.8 m spacing at Centeno Field Station, Republic of Trinidad & Tobago. Rain gauges were placed in 10 positions on the ground underneath and outside the cocoa canopy and daily rainfall volume was recorded throughout the experiments. Copper determinations were carried out colorimetrically in 1M HCl extracts, by the method of Somers & Garraway (1957) adapted for use on a portable flow-injection analysis system (Heliflow - WPA Instruments Ltd., Cambridge).

RESULTS

Bioassays with P. palmivora zoospores indicated that at surface copper concentrations of 0.25 $\mu g\ cm^{-2}$ or below, 100% infection occurred. At concentrations between 0.25 to 0.85 $\mu g\ cm^{-2}$ and 0.85 to 1.45 $\mu g\ cm^{-2}$, 75 and 70% infection occurred respectively. At concentrations above 1.45 $\mu g\ cm^{-2}$ no infection occurred on rain-eroded fungicide deposits, although some infection did occur on uneroded mistblown deposits of the WP formulation at concentrations of 1.82, 3.54 and 8.54 $\mu g\ cm^{-2}$. Inoculations were only carried out on the second and third harvests from collar-treated trees (Figure 1) and no successful infections were recorded except on controls.

TABLE 1. Surface concentration of copper fungicide redistributed onto pods from fungicide-impregnated collars placed on main stem.

Sample time (Days)	Rain inside canopy (mm)		Amount of copper in collar (g)			Least significant difference (at P= 0.05)
		Cumulative	5	10	15	
20	23.5	23.5	0.35	3.14	0.85	1.99
35	105.9	82.4	5.40	10.23	8.27	4.18
59	153.3	47.4	5.20	6.76	5.23	N.S.
115	185.8	32.5	0.36	0.23	0.21	N.S.

The amount of copper on pod surfaces was greater when more rain fell (Table 1). The distribution of fungicide over pod surfaces was very even, in contrast to sprayed deposits where copper was more concentrated on the distal portions. Dispersal of copper was also linked with the streaming of stem-flow water. Concentrations of copper on pod surfaces generally increased with increasing distance below the collar (Table 2), although this was not reflected in the amounts detected on the bark (Table 3).

Amount of copper deposited on pods over the period of the experiment was independent of the amount of active ingredient present in the collars.

TABLE 2. Results of a destructive sample, taken on day 35 from a tree with two branches; one without a collar, the other with a 10 g a.i. collar.

Treatment	Height of pod from ground (cm)	Surface copper concentration ($\mu g\ cm^{-2}$)	No. of infections in bioassay (Counts out of 4)
Collar	78	18.97	0
	74	5.57	0
	72	7.50	0
	69	9.55	0
	55	10.87	0
	55	10.66	0
No Collar	87	0.52	4
	71	0.29	4
	71	1.05	4
	79	0.33	4
	48	2.67	3

Figure 1 :
Rain during copper application trials in Trinidad and amount of pod disease in various treatments with and without copper fungicides

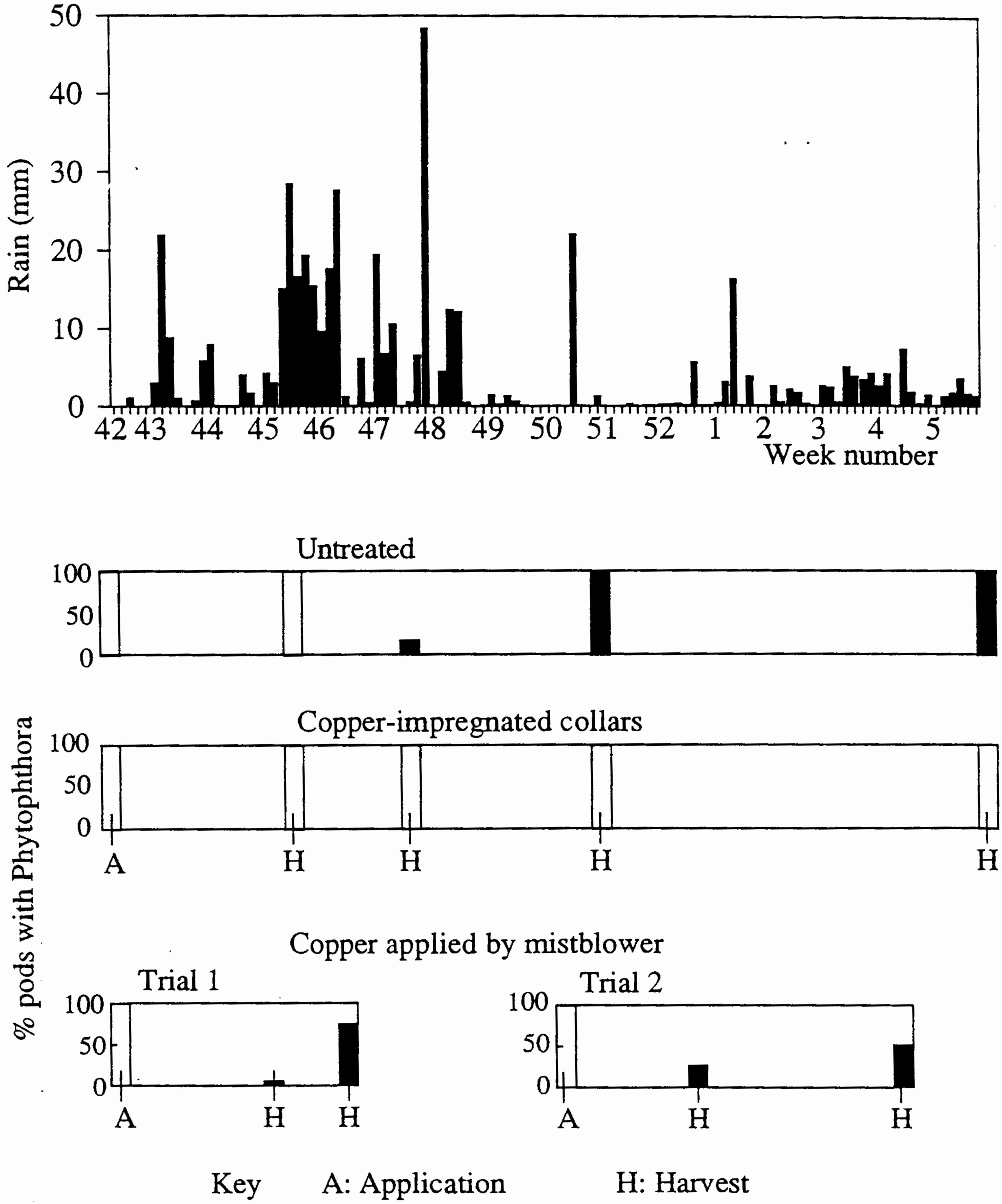

TABLE 3. Copper concentrations on bark samples taken from collar-treated trees after 115 days.

Distance from collar (cm)	Amount of copper in collar (g)		
	5	10	15
50	23.5 (5.3)	28.1 (17.1)	21.5 (6.7)
100	16.9 (7.3)	27.7 (8.3)	18.3 (0.1)

Four samples were taken at each position, 90° from each other. Values in brackets are standard errors of the means (d.f. = 3).

TABLE 4. Copper concentrations on pod samples taken from trees sprayed with cuprous oxide formulations using a mechanical mistblower.

Trial 1				Trial 2			
Sample time (days)	Rain inside canopy (mm)	Formulation		Sample time	Rain inside Canopy (mm)	Formulation	
		WP	SC			WP	SC
0	0	12.3 (2.1)	13.6 (0.9)	0	0	14.7 (1.1)	11.3 (0.8)
17	30	0.8 (0.1)	9.6 (0.8)	20	18.2	10.2 (0.5)	8.2 (0.4)
45	98.9	0.4 (0.0)	1.1 (0.1)	29	83.3	0.6 (0.1)	1.5 (0.1)

Figures in brackets are standard errors of the means (d.f. = 19)

The dilution and loss of copper from mistblown fungicide deposits on pod surfaces was rapid and large (Table 4). Disease control broke down after 2–3 weeks in both trials (Figure 1). The flowable formulation of cuprous oxide was the best of the two compounds tested in terms of tenacity and efficacy.

Copper concentrations on pods declined towards the end of the experiment on all collar trees (Table 1). However incidence of Phytophthora was lower at this time (day 115), and copper concentrations on the bark were still quite high (Table 3). The amounts of copper remaining in the collars by day 115 were also still large (approximately 40–50% original amounts).

DISCUSSION

The concept of collar application is similar to the single application technique proposed by Pereira (1985). During the course of the field work reported here, nine impregnated collars successfully prevented disease on trees located in the middle of a serious 'black pod' epidemic, when control on sprayed trees broke down. However Pereira (1985) reported that the single application technique gave control only to a similar level to the regime of three-weekly spray intervals.

In work not reported here, a large proportion of the water incident on pods was found to be derived from trunk-flow. The movement of copper from collars was mainly in the trunk-flow water, and pods were constantly being bathed in a fungicide solution during rain events. The resulting even deposits of copper on pods gave the improved efficacy observed. Copper accumulated on pods lower down the main trunk, which are the pods at greatest risk from infection by Phytophthora from soil-splashed zoospores (Gregory & Maddison, 1981). Copper concentrations were not always above critical amounts (1.5 μg cm^{-2}) at times of low rainfall. However, there was a tendency for copper to concentrate in areas of the pod where water accumulated, which were also the most likely infection sites for Phytophthora. Continuous washing of trunks with copper may also give protection to flower cushions and prevent canker formation, thereby reducing another major source of Phytophthora 'black pod' infection.

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