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RECENT DEVELOPMENTS IN THE CHEMICAL CONTROL OF BLISTER BLIGHT LEAF DISEASE OF TEA-EFFECTIVENESS OF EBI FUNGICIDES

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Blister blight leaf disease of tea is a disease of major economic importance. At present it is controlled by regular application of copper fungicides, because they are the cheapest and most effective fungicides available. In view of the rising cost of copper and the ever increasing wage structure, the cost of blister blight control has become a major component in the cost of production. The TRI has been regularly evaluating fungicides in order to find more effective and cheaper methods of control. In our recent studies, several ergosterol-biosynthesis inhibitors (EBI's) were evaluated in the laboratory and in the field to determine their efficacy against the disease. It was found that all the EBI fungicides tested gave excellent control of the disease even when used on extended spraying rounds. They were found to be both curative as well as protective in their action. Of the compounds tested tridemorph and bitertanol gave very good control of the disease even at low concentrations. However, the unrestricted use of these potentially powerful chemicals without simultaneous resistance management should be avoided and strategies will have to be worked out before these EBI fungicides are recommened for use in our tea plantations.

INTRODUCTION

Blister blight leaf disease of tea, caused by the fungus *Exobasidium vexans* Massee, is considered to be a disease of major economic importance to the tea industry in Sri Lanka and in other countries where it is prevalent, the cost of control of the disease being a major component in the cost of production.

At present, the most reliable and cheapest method of control of the disease is by the regular application of copper based formulations containing 50 % w/w metallic copper, during the period when the disease occurs as an epiphytotic. The monocultural conditions under which tea grows as well as the fact that the crop is maintained in the vegetative phase throughout the year, makes it easily susceptible to the disease under favourable conditions (Shanmuganathan and Arulpragasam, 1966). Heavy crop losses, which can be as high as 43% (Ordish , 1952) occur when the tea is unprotected during the period of disease occurrence and in order to keep the disease under the critical threshhold level it becomes necessary to spray at frequent intervals (7-9 days) with about 20-30 sprays annually, depending on the weather. More money is spent on its control than on the control of perhaps any other pests or diseases

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of tea. Approximately 100 metric tonnes of copper fungicides are imported annually for the control of blister blight. In view of the rising price of copper in the world market and the ever increasing wage structure, blister blight control has become a major component in the cost of production.

In order to find more effective and cheaper fungicides for the control of the disease, the Tea Research Institute of Sri Lanka has, over the years, tested several new fungicides to evaluate their efficacy against blister blight.

Earlier work has shown that Nickel salts have protectant as well as eradicant properties against the disease (Venkata Ram, 1963 ; de Silva, 1965), but due to phytotoxicity and other reasons, the recommendation for their use in Sri Lanka was withdrawn. Although 1, 4-oxathiin derivatives, Carboxin and Oxycarboxin offered excellent disease control when tested in potted plants, the control under field conditions was disappointing (Venkata Ram, 1969). Though Pyracarbolid has both protectant and eradicant properties against blister blight (Venkata Ram, 1975 ; Shanmuganathan and Saravanapavan, 1978) its use was restricted because of its cost and non-availability. Though Tridemorph was effective in India (Venkata Ram, 1974), the results were not very encouraging in preliminary trials in Sri Lanka (Arulpragasam, 1981).

In recent studies, the effectiveness of some ergosterol-biosynthesis inhibitors (EBI's), were tested in laboratory, glasshouse and field experiments (see Table 1) and the results of their evaluation are set out in this paper. These chemicals are nitrogen-containing heterocyclic compounds which can be classified as derivatives of morpholines, piperazines, pyridines, imidazoles and triazoles. EBI's have been reported to be very effective on a large range of diseases caused by fungi belonging to Ascomycetes, Basidiomycetes and fungi Imperfecti, since all of them synthesize ergosterol. Their rate of application has been reported to be often low compared to the conventional fungicides (Brandis *et. al.*, 1979 ; Schwinn, 1984). EBI's have been found to be both protective as well as curative in their action. The greater proportion of fungicides developed in the past two decades for use in agriculture has been identified as EBI's.

TABLE 1—*List of Ergosterol-biosynthesis inhibitors tested*

Chemical Group	*Common name*	*Trade name*	*Formulation*
Morpholines (RI's)	Tridemorph	Calixin	EC 750
Triazoles (DMI's)	Triadimefon	Bayleton	25 % WP
,,	Bitertanol	Baycor	EC 300
,,	Propiconazole	Tilt	EC 250
,,	—	PP 969	50 % WP

MATERIALS AND METHODS

Laboratory studies

1. Protective action against blister blight

The protective action of Calixin, Bayleton, Baycor, Tilt and PP 969 against blister blight was investigated in the laboratory by determining their effect on basidiospore germination on treated agar plates and tea leaves. The concentrations stated in the text are that of the active ingredient.

1.1 Inhibition of spore germination on agar plates

Calixin, Bayleton, Baycor, Tilt and PP 969 were incorporated separately in plain agar at a range of concentrations (0, 5, 10, 25, 50, 100 ppm) and each chemical was compared with cuprous oxide (50 % Cu) at the same concentrations in separate experiments. The treated plates were seeded with spores of *E. vexans* by placing the open plates under sporulating blisters overnight. The seeded plates were incubated at 25°C and spore germination recorded after 48 h. Each chemical was tested at least three times.

1.2 Inhibition of spore germination on detached leaves

Detached young leaves of clone TRI 2024, which is very susceptible to blister blight, were used for this study. The leaves were selected from unsprayed actively growing young shoots. The method used was that of Shanmuganathan and Saravanapavan (1978) for testing pyracarbolid. The test fungicides were used at concentrations of 0, 25, 50 and 100 ppm. The spore germination was recorded after 48 h.

Glasshouse studies

2. Blister Blight–Curative action of the EBI's

For these experiments, one-year-old plants of clone TRI 2024, grown in pots, were used. The main and lateral shoots were trimmed at 25–30 cm, eight weeks prior to the commencement of the experiments, to induce formation of new shoots susceptible to infection. The plants were sprayed lightly with distilled water and then inoculated by painting the first fully opened leaf on each shoot with basidiospores obtained from naturally infected leaves held at 100% relative humidity under a bell jar. After inoculation the pots were placed in a humid chamber in the glasshouse at 20–24° C for 48 h, then removed from the chamber and left on the bench until the completion of the experiment.

The fungicides were applied to run-off with an atomiser, either 3 days before or 6 days after the appearance of translucent spots or the first visible symptoms of the disease on the inoculated leaves. Observations continued up to 21 days from the day of inoculation. Two plants were used for each of the concentrations and for each of the fungicides tested. Two plants were used for the control on each occasion.

Field trials

3. Efficacy of EBI's under field conditions

The effectiveness of the fungicides were evaluated in a series of field trials at St. Coombs Estate at the Tea Research Institute of Sri Lanka, from 1982 onwards. In these trials, though fungicides other than EBI's were also included only the performances of the EBI's *vis a vis* standard copper formulations are presented in this paper. The experiments were of the randomised complete block design with the treatments being replicated five times. Each plot contained 100 bushes and the fungicides were applied at 7- or 14-day intervals in trials on the tea in plucking and at 7-day intervals in the trial on tea recovering from pruning. The spray volume was 170 l ha^{-1} applied with a hand operated knapsack sprayer. Disease incidence was measured according to the method of Webster and Park (1956), on random bushes by assessing infection on the third leaf of pluckable shoots of tea in plucking while in the pruned bushes this was assessed by counting the number of infected shoots. The disease assessments were done prior to the spray applications in the case of tea in plucking and once a month in the case of tea recovering from pruning.

In 1982, two experiments were carried out, both with Bayleton :

Experiment 1–Field No. 12, unshaded seed tea, pruned August 1981. Duration of experiments : June–September 1982 ; Spray applications : 8 ; Disease assessments : 9 ; Treatments : Control, Cuprous oxide (280 g ha^{-1}), Bayleton (280 g ha^{-1}).

Experiment 2–Field No. 16, unshaded clonal tea (TRI 2024). Duration of experiment : June–September, 1982 ; Spray applications. 8 ; Disease assessments : 10 ; Treatments : Control, Cuprous oxide (280 g ha^{-1}), Bayleton (280 and 420 g ha^{-1}).

In 1984, three experiments were done, one of which was on tea recovering from pruning :

Experiment 3–Field No. 10, shaded seed tea, pruned July 1982. Duration of experiment : June–September 1984 ; Spray applications : 8 ; Disease assessments : 10 ; Treatments : Control, Cuprous oxide (125 g ha^{-1}), Baycor (0.03% ha^{-1}), Calixin (140 ml ha^{-1}).

Experiment 4–Field No. 12, unshaded seed tea, pruned August 1981. Duration of experiment : June–September 1984 ; Spray applications : 8 ; Disease assessments : 10 ; Treatment : Control, Cuprous oxide (250 g ha^{-1}), Baycor (0.06% ha^{-1}), Calixin (280 ml ha^{-1}).

Experiment 5–Field No. 16, clonal tea recovering from pruning, pruned September 1984. Duration of experiment : September–December 1984 ; Treatments : Control, Cuprous oxide (420 g ha^{-1}), Baycor (0.05 % ha^{-1}), Calixin (170 ml ha^{-1}).

In 1985 two experiments were carried out :

Experiment 6–Field No. 10, shaded seed tea, pruned 1982. Duration of experiment : June–November, 1985 ; Spray applications : 19 ; Disease assessments : 21 ; Treatments : Control, Cuprous oxide (250 g ha^{-1} weekly), Baycor (0.05 % ha^{-1}, weekly and fortnightly), Baycor (0.025 % ha^{-1}, weekly) and Tilt (0.1 % weekly).

Experiment 7–Field No. 16, clonal tea, pruned–June 1984. Duration of experiment : June–November, 1985 ; Spray applications : 19 ; Disease assessments : 21 ; Treatments : Control, Cuprous oxide (250 g ha^{-1}, weekly and fortnightly), Calixin (85 ml ha^{-1}, weekly, and fortnightly and Calixin (255 ml ha^{-1}, fortnightly).

RESULTS

Laboratory studies

1. Protective action against blister blight

1.1 Inhibition of spore germination on agar plates

Cuprous oxide was found to inhibit spore germination completely at 25 ppm, Calixin also at 25 ppm, Bayleton at 50 ppm, Baycor at 25 ppm, Tilt at 50 ppm and PP 969 at 50 ppm (Table 2). Except in the case of cuprous oxide, deformation of the germ tubes was observed at concentrations below the inhibiting concentrations.

TABLE 2—*Inhibition of Basidiospore germination on agar plates*

Fungicide	*Complete inhibition of spore germination at*	*Germ tube deformation at*
Cuprous oxide	25 ppm	Not observed
Calixin	25 ppm	10 ppm
Bayleton	50 ppm	25 ppm
Baycor	25 ppm	10 ppm
Tilt	50 ppm	25 ppm
PP 969	50 ppm	25 ppm

1.2 Inhibition of spore germination on detached leaves

In the case of the EBI's germ tube deformation was observed at concentrations lower than the inhibiting concentration (Table 3).

TABLE 3—*Germination of spores of E. vexans on detached tea leaves, treated with different fungicides (Mean of* 3 *trials)*

Concentration of fungicide (ppm)	*Calixin*	*Bayleton*	*Percentage germination* *Baycor*	*PP 969*	*CuO*
0	98.2	96.1	94.1	96.8	98.7
25	20.1	28.2	8.6	30.1	74.4
50	11.2	14.3	0	15.1	60.8
100	0	0		0	40.3

Glasshouse Studies

2. Blister Blight—Curative action of the EBI's

The results are presented in Table 4. When the fungicides were applied before the appearance of translucent spots, they almost completely prevented the development of blisters. Few or no blisters appeared on the treated leaves. However, small, non-sporulating yellow flecks, which later turned necrotic were observed on some of the inoculated leaves. When the fungicides were applied to the leaves after the appearance of translucent spots, further development of the lesions was arrested. These lesions failed to develop and sporulate and became necrotic. The necrosis of the lesions was observed to be severe in the leaves treated with Baycor and PP 969. In the untreated controls, 70 - 90% of the lesions developed into sporulating blisters.

TABLE 4—*Curative action of the EBI's*

Fungicide	*Concentration of the fungicide (%)*	*No. of leaves inoculated*	*Interval between inoculation and treatment*	*No. of lesions formed*	*No. of sporulating blisters*
Calixin	0.0	14	—	112	103
	0.1	12	3	2	0
	0.2	12	3	1	0
	0.4	14	3	0	0
	0.1	11	6	6	3
	0.2	12	6	2	1
	0.4	11	6	0	0
Bayleton	0.0	10	—	120	86
	0.1	10	3	3	1
	0.2	10	3	3	0
	0.4	11	3	1	0
	0.1	9	6	8	3
	0.2	10	6	6	1
	0.4	8	6	2	0
Baycor	0.0	12	—	98	90
	0.1	11	3	0	0
	0.2	12	3	0	0
	0.4	10	3	0	0
	0.1	12	6	4	0
	0.2	9	6	2	0
	0.4	10	6	1	0
PP 969	0.0	11	—	120	99
	0.1	10	3	0	0
	0.2	9	3	0	0
	0.4	11	3	0	0
	0.1	10	6	3	0
	0.2	14	6	1	0
	0.4	11	6	0	0

Field trials

3. Efficacy of EBI's under field conditions

The results of experiments 1 and 2 (Tables 5 and 6) indicate that although Bayleton gave adequate control of the disease, it is not effective as copper, even at the rate of 420 g ha^{-1}. In experiments 3 and 4 (Tables 7 and 8) both Baycor and Calixin gave better control of the disease than copper (Fig. 1).

TABLE 5—*Effect of cuprous oxide and Bayleton on blister blight infection in unshaded seed tea (Experiment 1)*

Treatments	*Rate ha^{-1}*	*Mean % infection*
Control	Unsprayed	26.79
Cuprous oxide	280 g	17.09
Bayleton	280 g	22.74
LSD (P = 0.05)		2.36

TABLE 6—*Effect of cuprous oxide and Bayleton on blister blight infection in unshaded clonal tea (Experiment 2)*

Treatments	*Rate ha^{-1}*	*Mean % infection*
Control	Unsprayed	30.31
Cuprous oxide	280 g	15.76
Bayleton	280 g	19.16
Bayleton	420 g	18.50
LSD (P = 0.05)		5.12

TABLE 7—*Effect of cuprous oxide, Baycor and Calixin on blister blight infection in shaded seed tea (Experiment 3)*

Treatments	*Rate ha^{-1}*	*Mean % infection*
Control	Unsprayed	64.8
Cuprous oxide	125 g	35.1
Baycor	0.03 %	27.7
Calixin	5.0 fl oz	33.1
LSD (P = 0.05)		4.7

TABLE 8—*Effect of cuprous oxide, Baycor and Calixin on blister blight infection in unshaded seed tea (Experiment 4)*

Treatments	*Rate ha^{-1}*	
Control	Unsprayed	45.9
Cuprous oxide	250 g	28.1
Baycor	0.06 %	22.4
Calixin	10.0 fl oz	23.1
LSD (P = 0.05)		5.6

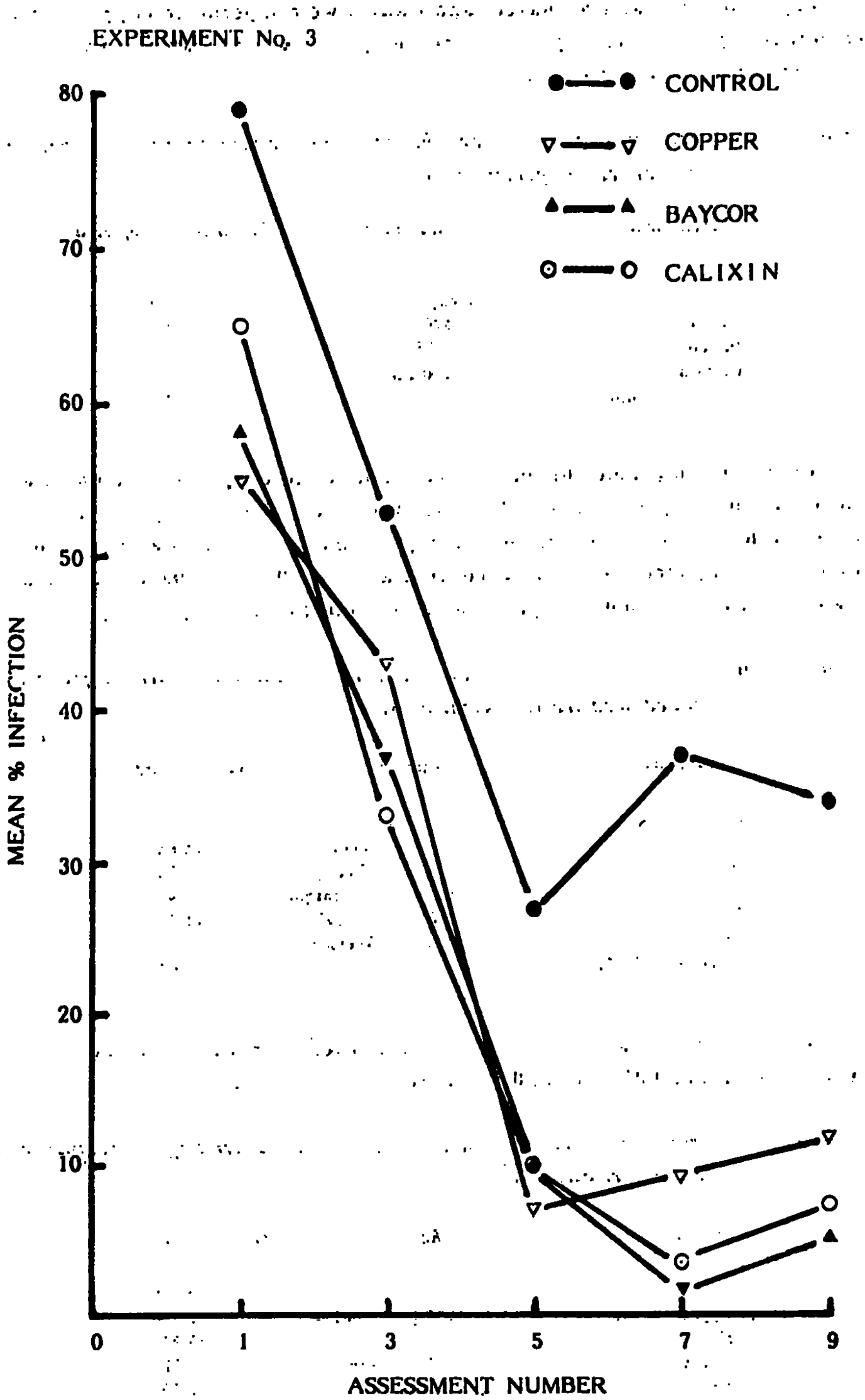

Fig. 1 — Effect of Baycor and Calixin on infection of tea by E. vexans (Experiment 3).

In experiment 5 (Table 9), Baycor and Calixin were superior to copper in protecting tea recovering from pruning, even when employed at the rates used for tea in plucking and at weekly intervals.

TABLE 9—*Effect of cuprous oxide, Baycor and Calixin on blister blight infection in clonal tea (Experiment 5)*

Treatments	*Rate* ha^{-1}	*Mean No. of infected shoots*
Control	Unsprayed	38.9
Cuprous oxide	420 g	15.7
Baycor	0.05 %	1.2
Calixin	170 ml	1.6
LSD (P = 0.05)		7.3

In experiment 6 (Table 10), Baycor was superior to copper when applied at 0.05% and equal to the performance of copper when applied fortnightly at the same concentration. In this experiment the performane of Tilt was equal to that of copper when applied weekly at a concentration of 0.1 %. Baycor applied weekly at a concentration of 0.025 % gave the same protection as copper (Fig. 2).

TABLE 10—*Effect of cuprous oxide, Baycor and Tilt on blister blight infection in shaded seed tea (Experiment 6)*

Treatments	*Rate ha*$^{-1}$	*Mean % infection*
Control	Unsprayed	37.09
Cuprous oxide	250 g -weekly	24.68
Baycor	0.05% -Weekly	21.98
Baycor	0.05% -Fortnightly	24.81
Baycor	0.025%-Weekly	24.03
Tilt	0.1% -Weekly	23.35
LSD (P = 0.05)		2.65

In experiment 7 (Table 11), the results showed that Calixin could be used at weekly intervals at 0.05 % or at 0.1 % at fortnightly intervals (Fig. 3).

TABLE 11—*Effect of cuprous oxide and Calixin on blister blight infection in clonal tea (Experiment 7)*

Treatments	*Rate ha*$^{-1}$	*Mean % infection*
Control	Unsprayed	48.09
Cuprous oxide	250 g -Weekly	32.57
Calixin	170 ml-Weekly	30.32
Calixin	170 ml-Fortnightly	35.01
Calixin	85 ml-Weekly	32.09
Calixin	85 ml-Fortnightly	38.61
Calixin	255 ml-Fortnightly	33.27
LSD (P = 0.05)		2.15

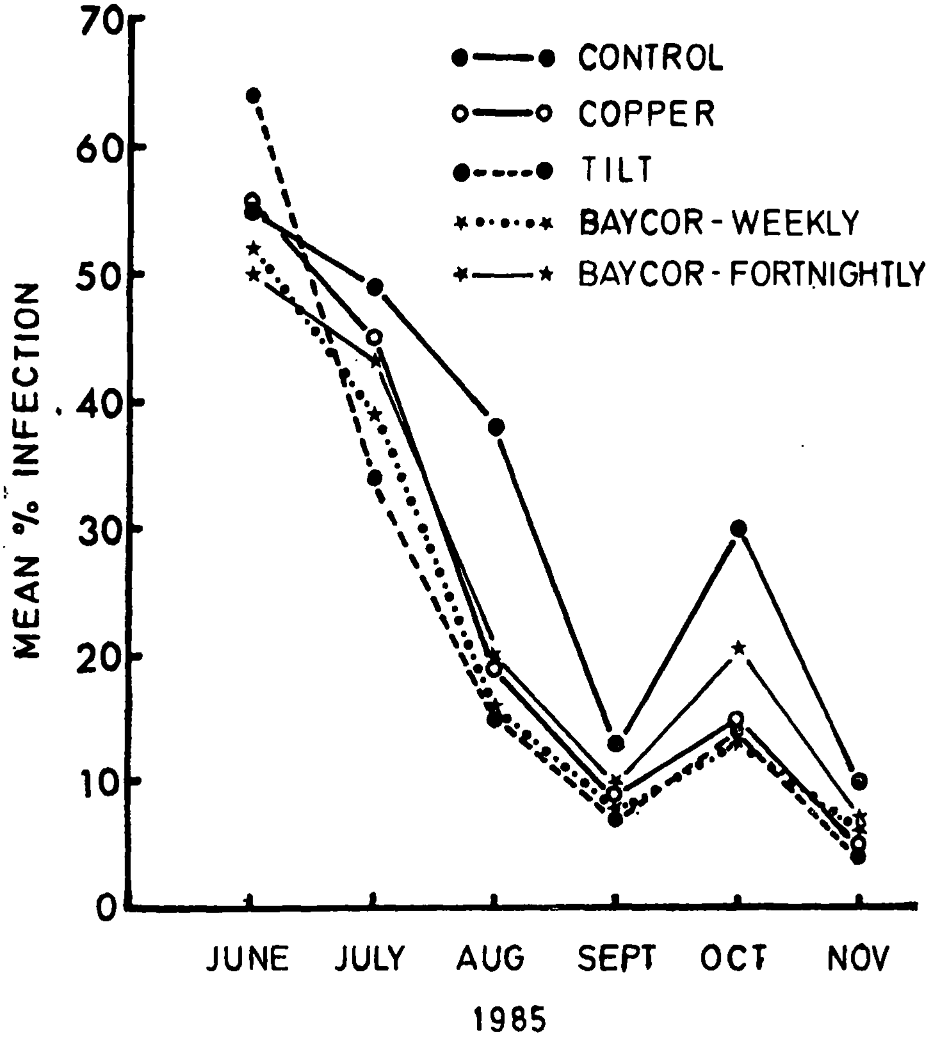

Fig. 2 — Effect of Baycor and Tilt on infection of tea by E. vexans (Experiment 6).

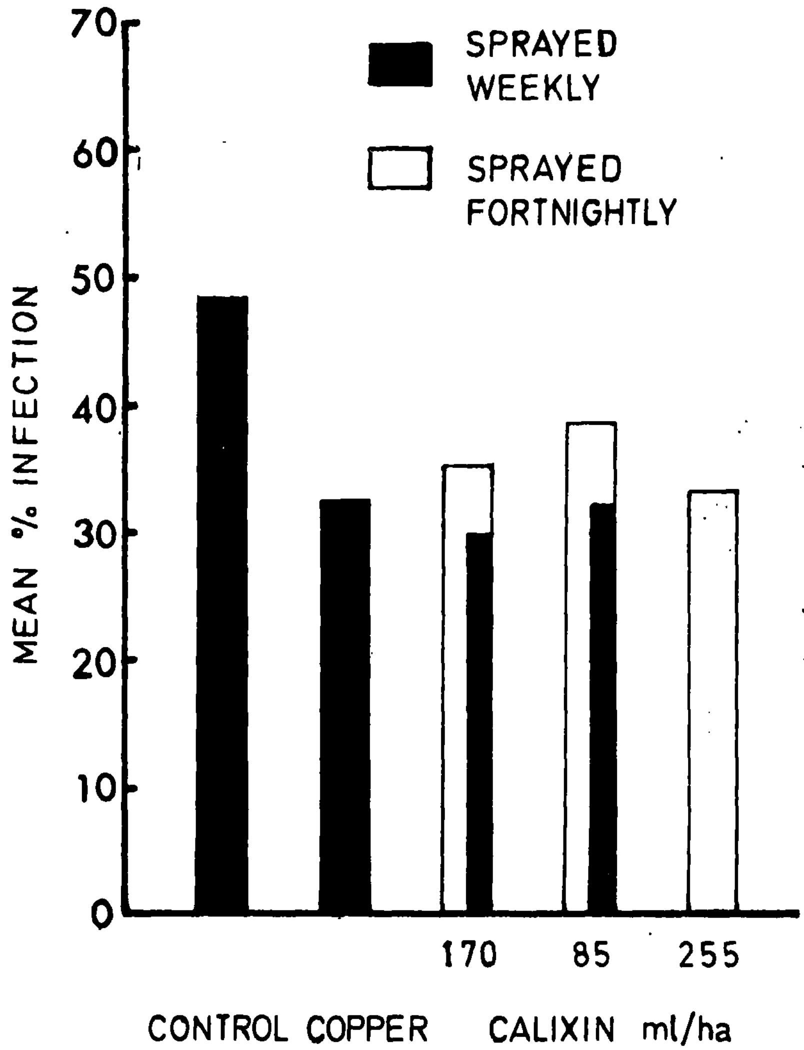

Fig. 3 — Effect of weekly and fortnightly sprays of Calixin on infection of tea by E. vexans (Experiment 7).

DISCUSSION

The results of the experiments indicate that the EBI's tested have both protective and curative action against blister blight leaf disease of tea. The minimum inhibitory concentration of the EBI's are lower than that of the copper fungicides and hence their protective action will be superior to that of copper, as demonstrated in the spore germination studies (Tables 2 and 3).

Experiments carried out on the curative action of the fungicides indicate that these fungicides when applied before or after infection can cure the disease by preventing the development of sporulating blisters (Table 4). The rapidity with which the level of infection is brought down in the field by these fungicides is an indication of their curative action (Figures 1 and 2). These fungicides were found to be more effective than copper fungicides because of their protective-cum-curative action. Except for Bayleton, the other fungicides tested in the field were found to give better disease control than copper (Tables 5 to 11). While timing of spray applications can be more flexible with these fungicides, the need for prophylactic sprays would not arise as it may be possible to delay the application of the systemics until disease symptoms are apparent, thereby eliminating the need for routine and often wasteful pre-symptom applications. They can be used to bring down the level of infection, if there is a sudden build up of the disease due to very adverse weather conditions or due to non-implementation of the spraying schedule due to managerial or other problems.

The rate of application of EBI's have been found to be relatively low when compared with copper fungicides with the additional advantage that they can be used less frequently thus reducing labour costs. These fungicides with curative action can perhaps be best used when performance of the conventional fungicides is insufficient. Perhaps the best use for these fungicides in tea is for disease control in fields recovering from pruning. In these plants, almost the entire plant is susceptible to infection and very often when spraying is done most of the susceptible areas do not receive the fungicides. This problem does not arise with the EBI's which because of their systemic nature are able to move from the treated areas to the distant untreated areas, and thus offer protection to the entire plant.

The main disadvantage with systemic fungicides are their narrow spectrum of activity and the rapidity with which fungi develop resistance towards them. This has not been the case with EBI fungicides, which are now being used on a wide variety of crops and hence subjected to a high selection pressure, which should have led to wide-spread development of resistance under field conditions, except in certain isolated instances like the powdery mildew of cereals.

However, the unrestricted use of these potentially powerful chemicals without simultaneous resistance management should be avoided and strategies will have to be worked out before these EBI fungicides are recommended for use in tea plantations. Residue of these fungicides in made tea will also have to be determined.

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