INVESTIGATIONS WITH NEW FUNGICIDES FOR THE CONTROL OF BLISTER BLIGHT (*EXOBASIDIUM VEXANS* MASSEE) ON TEA

R. L. de Silva

Introduction

For many years cuprous oxide and cuprous oxychloride formulations, and certain colloidal copper formulations have been successfully used to control Blister blight (*Exobasidium vexans* Massee) in tea growing areas in Ceylon and India. Various other compounds have also been tested, but none have so far achieved the effectiveness of the copper based formulations. In 1964, two new fungicides, nickel chloride and 'Perezin', were tested against a standard copper fungicide, 'Perenox', for the control of Blister blight.

Fungicides	*Active ingredients*	*Metal contents*
Nickel chloride hexahydrate ($NiCl_2.6H_2O$)	Nickel chloride	24% Nickel
'Perezin'	Cuprous oxide & Zinc oxide	25% Copper 30% Zinc
'Perenox'	Cuprous oxide	50% Copper

Copper acts as a protectant fungicide because the spray deposit protects the leaf from subsequent fungus infections. Protectant fungicides have no effect on fungus already present inside the leaf. In addition to protectant properties, nickel chloride has what are called eradicant properties. An eradicant fungicide is able to act against the fungus present inside the leaf. Zinc is known to have fungicidal properties, although in general it is less toxic than copper to many fungi.

The present article reviews the literature pertaining to the use of nickel chloride and combinations of compounds of zinc and copper for the control of Blister blight on tea. It also describes the results of recent experiments and field trials with nickel chloride and 'Perezin'. The significance of these results is discussed.

Review of Literature

Nickel

Mulder (1961), reported that nickel chloride when used alone, or in combination with 'Zineb' (zinc ethylene bisdithiocarbamate) controlled Blister blight satisfactorily, in short term field trials carried out in Ceylon. He mentions that the addition of 'Zineb', however, did not result in improved control.

There are many reports from South India on the effect of nickel chloride in laboratory tests on *E. vexans*, as well as on the control of Blister blight in small scale field experiments. Venkata Ram and Jayaraman (1961), observed that when 3 oz of nickel chloride were applied at weekly intervals to tea plants, there was a reduction in shoot infection from 84 to 24% after three weeks, and to 13% after five weeks.

They stated that although nickel chloride had good eradicant properties, its protective ability remained poor. Venkata Ram (1961 ; 1961a), reported that nickel chloride, at a nickel concentration equivalent to one fourth that of copper, was superior to copper in its ability to control Blister blight. Venkata Ram and Jayaraman, (1961a), found that nickel chloride, applied at the rate of 3 oz in 15 gallons of water per acre using knapsack sprayers, gave the same control as 6 oz of this product. At the rate of 6 oz per acre, nickel chloride was superior to standard cuprous oxide when sprayed at weekly intervals, but the position was reversed when fortnightly applications were made.

In small scale field experiments using a randomized block design with quadruplicate plots of 10 bushes each, Venkata Ram and Jayaraman (1962), reported that nickel chloride hexahydrate was superior to copper fungicides at equal rates of application given weekly. Venkata Ram (1963) found that blister development was arrested, and sporulation suppressed by post-infection applications of the chloride, nitrate, sulphate and acetate, but not the carbonate and hydroxide of nickel. Venkata Ram (1963a), stated that good control of Blister blight resulted from the application of 3 oz of nickel chloride (with 0.01% 'Teepol' as a wetting agent) in 5 gallons of water per acre using mistblowers ; the degree of control was comparable to that obtained by applying 6 oz of this substance in 15 gallons of water per acre using pressure knapsack sprayers. Nickel dusts were reported to give better control than copper dusts.

Venkata Ram (1964), stated that tea plants growing in soils augmented with nickel ammonium sulphate and nickel nitrate developed resistance to Blister blight. He further states that one tea clone which is immune to Blister blight contained 14-25 ppm of nickel in the leaves, whereas two susceptible clones growing in the same locality contained only 6-10 ppm of the metal. He suggests that this is an indication that nickel might play an important role in host resistance to Blister blight.

There have been reports that nickel chloride does not impart taints to made tea, (Venkata Ram 1961 ; 1961a ; Venkata Ram and Jayaraman 1961), and that it is non-phytotoxic at concentrations which will suppress the sporulation of blisters (Venkata Ram 1963).

Copper/Zinc mixtures

Mulder (1960 ; 1961), stated that a proprietary formulation containing copper sulphate and zinc dimethyl dithiocarbamate gave approximately the same control of Blister blight as 'Perenox'. Mulder (1961), also reported that various proprietary fungicides containing copper oxychloride and either zinc ethylene bisdithiocarbamate or zinc dimethyl dithiocarbamate gave good control. Shanmuganathan (1962), however, reported that one of these fungicides, a proprietary formulation containing a mixture of copper oxychloride and zinc ethylene bisdithiocarbamate, was significantly inferior to 'Perenox' in controlling Blister blight.

Kerr (1963), reported that 'Perezin' (under the synonym YF 6011) gave as good protection as 'Perenox', and suggested that because of its composition, it may possibly find use on estates where zinc deficiency is prevalent.

Field Trials

Field trials were carried out in 1964 on No 6 Field at St Coombs Estate (elevation 4500 ft). A randomized block design with quadruplicate plots, each of the 64 plots containing 200 bushes, and covering about 1/15 acre, was used. The bushes in the double guard rows were left unplucked so that they not merely demarkated the plots, but also checked the possible drift of spray from one plot to the next. Shade

was more or less uniform throughout the experimental area and was provided by *Grevillea robusta* trees spaced 20 ft × 30 ft and *Erythrina lithosperma* (dadap) trees spaced 15 ft × 30 ft.

Nickel chloride hexahydrate ($NiCl_2 . 6H_2O$) and 'Perezin' were compared with 'Perenox' at the rates of application of 4, 2, 1 and ½ oz of fungicide in 15 gallons of water per acre using knapsack sprayers. In all the nickel chloride treatments, 0.01% 'Teepol' was used as a wetting agent. Low concentrations were deliberately used in order to sharpen any differences between fungicides. The spraying was done every 8-10 days, on the day following each plucking round. The trial commenced at the beginning of May and was continued until the end of 1964, during which period 30 assessments of blister infection were made, and 30 spraying rounds of fungicides applied.

Blister blight infection was assessed by selecting at random from each plot, two groups of 15 bushes. The shoots from these 30 bushes were plucked, and a sample of not less than 100 shoots selected at random from the bulk and examined for blister blight on the third leaf. The disease was estimated in terms of the percentage of shoots showing infection on the third leaf.

During the period of the trials, daily records were maintained for sunshine and rainfall. The density of spores of *E. vexans* in the atmosphere was estimated for each day using the Hirst spore trap.

Results

Average Blister blight infection in the plots sprayed at the rate of 4 oz fungicide per acre, and also in the control plots, is shown in Figure 1, together with daily sunshine and rainfall records, and the number of spores of *E. vexans* per cubic metre of air per day. This gives a picture of how sunshine and rainfall influence both atmospheric spore density and blister infection of tea shoots, as well as the extent to which the latter has been controlled by the various fungicides.

Statistical analysis of the results obtained from the field trial was carried out after both angular and logarithmic transformations of the data. From the analysis, the following information was obtained :

1 Blister blight infection in the fungicide treated plots was significantly less ($P < 0.001$) than that in the unsprayed plots.

2 All three fungicides controlled Blister blight satisfactorily at the rate of 4 oz per acre. 'Perenox' was, however, significantly superior ($P < 0.01$) to 'Perezin' at each rate of application—*viz* 4, 2, 1 and ½ oz per acre, and also to nickel chloride at each of these rates of application.

3 There was no significant interaction of the rates of application with the types of fungicide. In other words, the pattern of response of each fungicide to increasing rates of application was similar.

4 There was no significant difference between the degree of disease control obtained with 'Perezin' and that obtained with nickel chloride, at each rate of application.

5 For each fungicide, the 4 oz rate of application gave significantly better control than the 2 oz rate ($P < 0.05$), and the 1 and ½ oz rates ($P < 0.001$) ; also, for each fungicide, the 2 oz rate of application gave significantly better control than the 1 and ½ oz rates ($P < 0.01$). There was no significant difference in disease control obtained with the 1 and ½ oz rates of application for each fungicide.

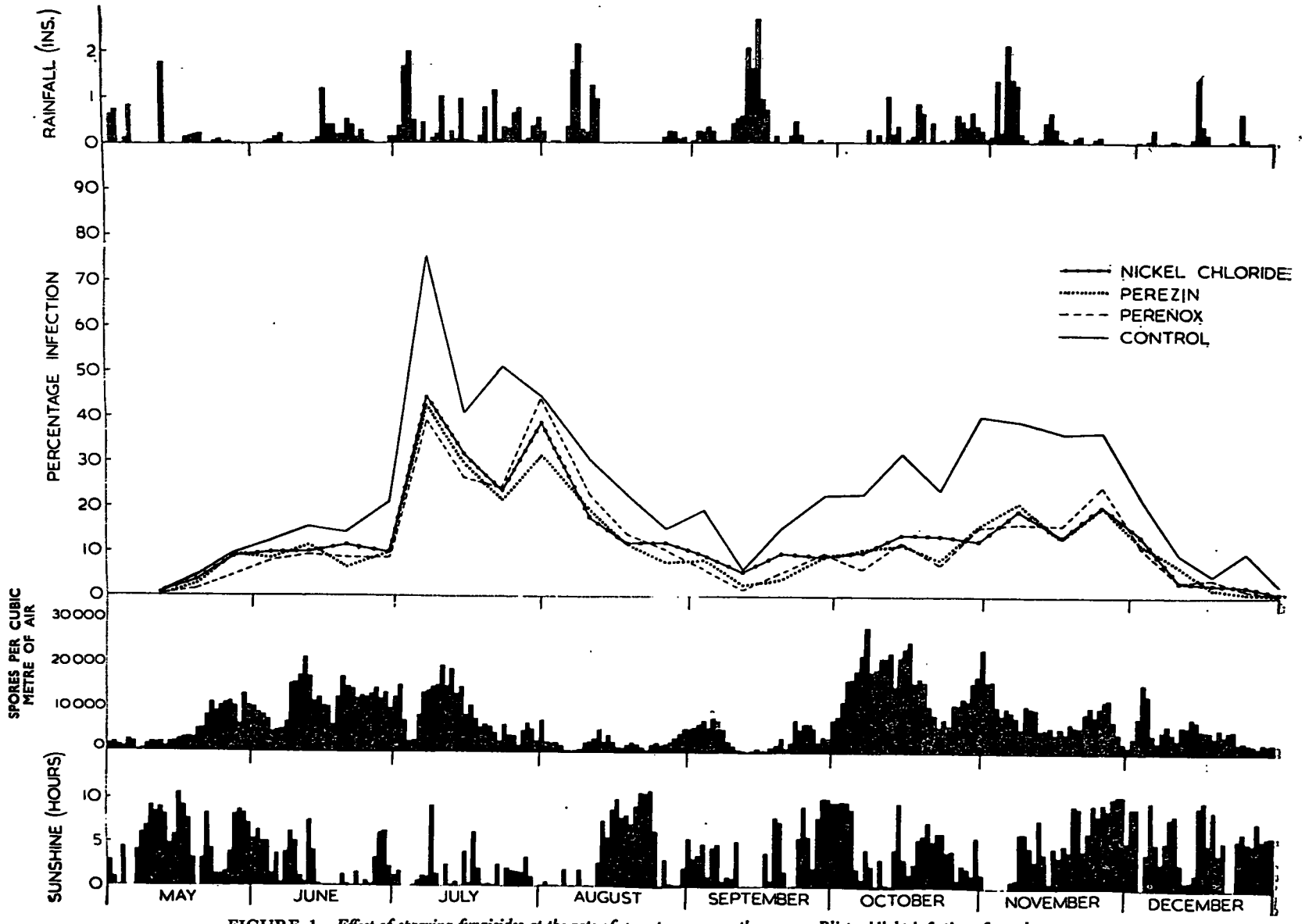

FIGURE 1—*Effect of spraying fungicides at the rate of 4 oz per acre, on the average Blister blight infection of tea shoots. Daily records for sunshine, rainfall, and the atmospheric spore density of* E. vexans *are also shown.*

6 In view of the fact that 'Perenox' contained twice as much copper as 'Perezin', it was decided to compare the fungicidal effect of 2 oz 'Perenox' with 4 oz 'Perezin'. There was no significant difference between the degree of disease control obtained with 2 oz 'Perenox' and 4 oz of either 'Perezin' or nickel chloride. Further, there was no significant difference between the degree of disease control obtained with 'Perenox' at the 1 oz rate and either 'Perezin' or nickel chloride at the 2 oz rate. ½ oz of 'Perenox' gave slightly better control (just significant at P = 0.05) than either 'Perezin' or nickel chloride at the rate of 1 oz.

Residue Analysis for Nickel

Samples of tea made from bushes sprayed with nickel chloride, were analysed for the presence of nickel residues. Manufacture of the tea was done using experimental rollers of 30 lb withered leaf capacity. The tea was plucked three times, the first round being on the day following the spraying of nickel chloride at the rate of 6 oz per acre. The second and third plucking rounds followed one and two weeks respectively, after the first round. Table 1 gives a typical set of results.

TABLE 1—*Nickel content of tea made from samples sprayed with nickel chloride*

Time from Spraying (days)	Rainfall since spraying (inches)	Nickel in made tea (p p m)	
		Sprayed	Unsprayed
1	0.02	36	7.3
8	0.82	19	6.1
15	1.22	11	6.4

From Table 1 it is seen that the maximum nickel content measured was 36 ppm on the day following the spraying round. It seems unlikely, therefore, that this figure will be exceeded, because plucking is normally done about a week after spraying instead of a day after it. So far as is known 36 ppm would be below the limits required for mammalian toxicity. From this point of view, nickel chloride appears to be acceptable. Further experiments on residues are being carried out.

Effects of Copper and Nickel sprays on the population of mites

Venkata Ram (1963), reported that copper sprays stimulate the build up of white purple mites in South India, whereas nickel sprays do not. White purple mites are fortunately not a problem in Ceylon tea.

The effect of copper and nickel sprays on the populations of Red Spider mites (*Oligonychus coffeae* Neitner) and Scarlet mites (*Brevipalpus californicus* Banks and *B. phoenicus* Geijskes) is under investigation. Preliminary results obtained by the division of Entomology indicate that copper sprayed tea has a higher population of Scarlet mites than either unsprayed tea, or tea sprayed with nickel chloride. Red spider mite populations do not seem to be strongly influenced by the fungicide sprays. Further investigations, however, are necessary before definite conclusions can be drawn regarding the influence of copper and nickel sprays on mite populations.

Taint tests

12 tea tasters from mercantile establishments in Colombo have reported that nickel chloride does not impart taints to made tea.

Discussion

It is known that *E. vexans* causes most damage to tea under conditions of high rainfall and low light intensity (Visser *et al*, 1961). In evaluating the effect of fungicides, it is therefore necessary to distinguish between the fungicidal effects of the chemicals used, and that exerted by sunlight, as well as the lack of moisture. During the present trials, monsoon conditions were very mild. Shoot infection in the unsprayed control plots exceeded the safe level of 35% in only 7 out of 30 assessments. In a typical year, this would happen on 15 to 20 occasions. Although both test fungicides gave satisfactory control of Blister blight, when sprayed at the rate of 4 oz per acre under mild monsoon conditions, it is not possible to predict whether they will be satisfactory at this rate of application under severe monsoon conditions, when the natural level of infection well be much higher. It is intended to test these compounds further during the monsoons of 1965, in order to investigate whether they will be able to control Blister blight adequately, should conditions become conducive to very high Blister blight infection.

Of the two new fungicides under test, nickel chloride is the more soluble one, and this compound is more likely to dissolve in rain water than the relatively insoluble copper compounds. On the other hand, because nickel chloride has eradicant effects on fungus already present inside the leaf, its high solubility makes it easily available. This might therefore be advantageous. Because copper compounds act as protectants, they should not be readily soluble and need to adhere to the leaf satisfactorily even during periods of heavy rains. 'Perezin' like 'Perenox' has satisfactory adherent properties.

Three metals are involved in these fungicides—copper, zinc and nickel. If disease control is compared in terms of the metal content of the various fungicides, then it appears that copper and nickel have about the same fungicidal effect, because nickel chloride gave the same control as half its weight of 'Perenox'. These results are in conflict with those of Venkata Ram (1961; 1961a), who stated that nickel was four times as effective as copper. However, it may be unjustified to compare the two sets of results because atmospheric conditions are variable, and no information is available on the conditions of the experiments carried out in South India.

The fungicidal effect of zinc is more difficult to assess. 'Perezin' and nickel chloride had the same fungicidal effect, and 'Perezin' gave the same control as half its weight of 'Perenox' which has double its copper content. The indication that it is the copper and not the zinc, in 'Perezin' that is the real active ingredient is subject to the minor limitation that the fungicidal effect of 'Perezin' could also be the result of the interaction between the copper and zinc compounds present in this mixture. Of course there are other advantages in using zinc. Tolhurst (1962), has considered the possibility of zinc deficiency in Ceylon tea becoming more prevalent, because zinc reserves of so many soil types are limited, and until recently, little was done to replace the zinc lost in crop removal. 'Perezin' contains zinc in the oxide form. It still remains to be confirmed that zinc oxide can be absorbed by the foliage of tea plants. There are slight indications (Tolhurst 1964), that the oxide is effective in curing zinc deficiency but confirmation is awaited. If this evidence is forthcoming, then this fungicide could become a convenient zinc source on areas where zinc deficiency is prevalent.

It seems, therefore, that the planter will be governed in his choice mainly by a question of economics. If it is necessary to spray more 'Perezin' than say 'Perenox', then the extra expenditure should be offset by the reduction in zinc sulphate application costs. If it is confirmed that nickel chloride spraying has no tendency to increase mite populations, this may be a considerable advantage in areas where mite attacks reach epidemic proportions. It must be pointed out, however, that nickel chloride is deliquescent, and its storage might therefore be difficult. Excessive amounts of nickel chloride could induce leaf scorch.

Conclusions

1 The two test fungicides 'Perezin' and nickel chloride hexahydrate, gave satisfactory control of Blister blight when sprayed at the rate of 4 oz in 15 gallons of water per acre using knapsack sprayers, under the mild monsoon conditions prevailing on St Coombs in 1964.

2 No significant differences were observed between the degree of disease control obtained with 'Perezin' and that obtained with nickel chloride. 'Perenox' was significantly superior to both test fungicides.

3 None of the three fungicides used, leave harmful residues, and none of them impart taints to made tea.

4 'Perezin' contains both copper and zinc but the fungicidal effect of zinc appears to be insignificant ; the use of this fungicide may be important in areas where zinc deficiency is widespread.

5 The performance of the test fungicides under more severe conditions will need to be assessed.

Summary

Two new fungicides, nickel chloride hexahydrate (containing 24% nickel), and 'Perezin' (containing 25% copper as cuprous oxide and 30% zinc largely as its oxide), were tested against a standard cuprous oxide formulation, 'Perenox', (containing 50% copper) for the control of Blister blight (*Exobasidium vexans* Massee) on tea, during the monsoons of 1964 at St Coombs estate.

Both nickel chloride and 'Perezin' gave satisfactory control of Blister blight, when applied at the rate of 4 oz in 15 gallons of water per acre using knapsack sprayers, although neither was quite as effective as 'Perenox'. Both the south-west and north-east monsoons in Ceylon in 1964 were unusually mild. These fungicides will be tested further in order to investigate their effectiveness under more severe weather conditions.

Nickel residues remaining on tea leaves sprayed with nickel chloride appear to be below the limits of mammalian toxicity. None of the fungicides impart taints to made tea.

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