†EPIDEMIOLOGY OF TEA BLISTER BLIGHT (*EXOBASIDIUM VEXANS*)

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We may be biased, but we believe that Blister Blight of tea is the ideal disease for epidemiological studies. Many of the advantages are inherent in the host and in the way it is cultivated. Tea is an evergreen perennial crop maintained in the vegetative state and pruned once every four years or so, and because of this, there is no marked change in susceptibility from season to season as occurs with most crops. Only young leaves are susceptible and tea is pruned and trained in such a way that all the young leaves are confined to the top of the bush where they are exposed to the atmosphere and there is no complication of micro-environment. Tea is plucked every week and consequently, disease incidence can be readily assessed every week. So with Blister Blight we can have 52 assessments per year, whereas with many other diseases we have to be content with one. As temperature is relatively uniform throughout the year, it can be almost ignored and in fact, only two major factors appear to be important in the epidemiology of the disease—the number of spores landing on susceptible leaves and the duration of leaf wetness. Before dealing with the epidemiology, however, we should like to introduce you to the disease and describe briefly its method of spread and control.

THE DISEASE

Figure 1 illustrates the disease. Blisters are approximately one centimetre in diameter, generally convex on the under surface of a leaf and concave on the upper, although occasionally the reverse occurs. Spores are borne on the convex surface and spore trapping in infected tea, reveals a marked diurnal periodicity with a maximum catch around midnight (Figure 2). The reason for this was investigated by considering the two most likely factors, temperature and humidity. For these experiments, cut shoots were used, because it was found that there was no difference in the pattern of spore production between cut shoots and intact shoots (Figure 3). When the relative humidity around infected leaves is kept at about 100% and temperature varies, spores are liberated continuously, and when temperature is kept constant, but humidity varies, spore liberation is directly correlated with high humidity (Figure 4). This applies whether or not infected shoots are removed from bushes. Diurnal spore liberation is, therefore, almost entirely due to diurnal fluctuations of relative humidity.

DAMAGE

Before studying the epidemiology of a disease it is necessary to determine what damage it causes and what is the critical level above which appreciable crop loss results. The incidence of Blister Blight is normally assessed by determining percentage infection on the third leaf and 35% infection has long been accepted as the critical level. When disease incidence is below 35% most blisters occur on leaves, but as infection rises above this level, an increasing number of blisters occur on leaf

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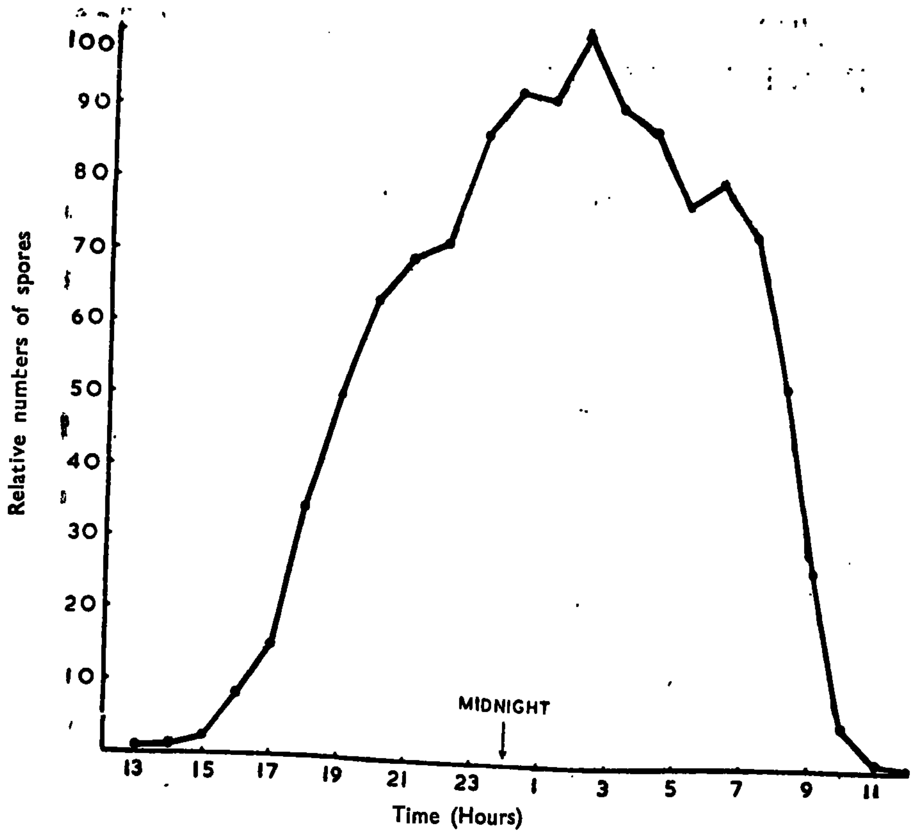

FIGURE 2 —*Mean diurnal periodicity of spores of* E. vexans *present in the atmosphere during a monsoon*

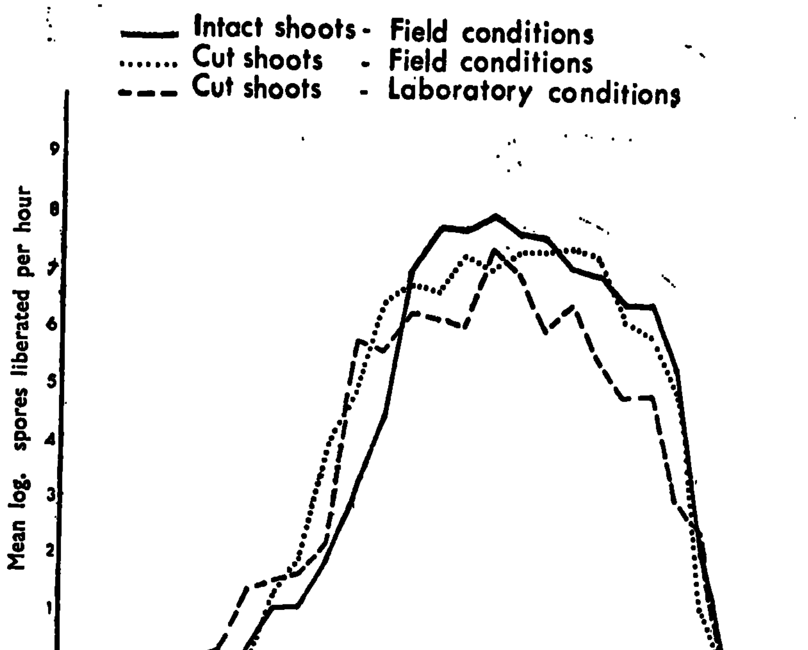

FIGURE 3 —*Mean diurnal periodicity of spore production by* E. vexans *from blisters present on cut and intact shoots in the field and in the laboratory over the same period*

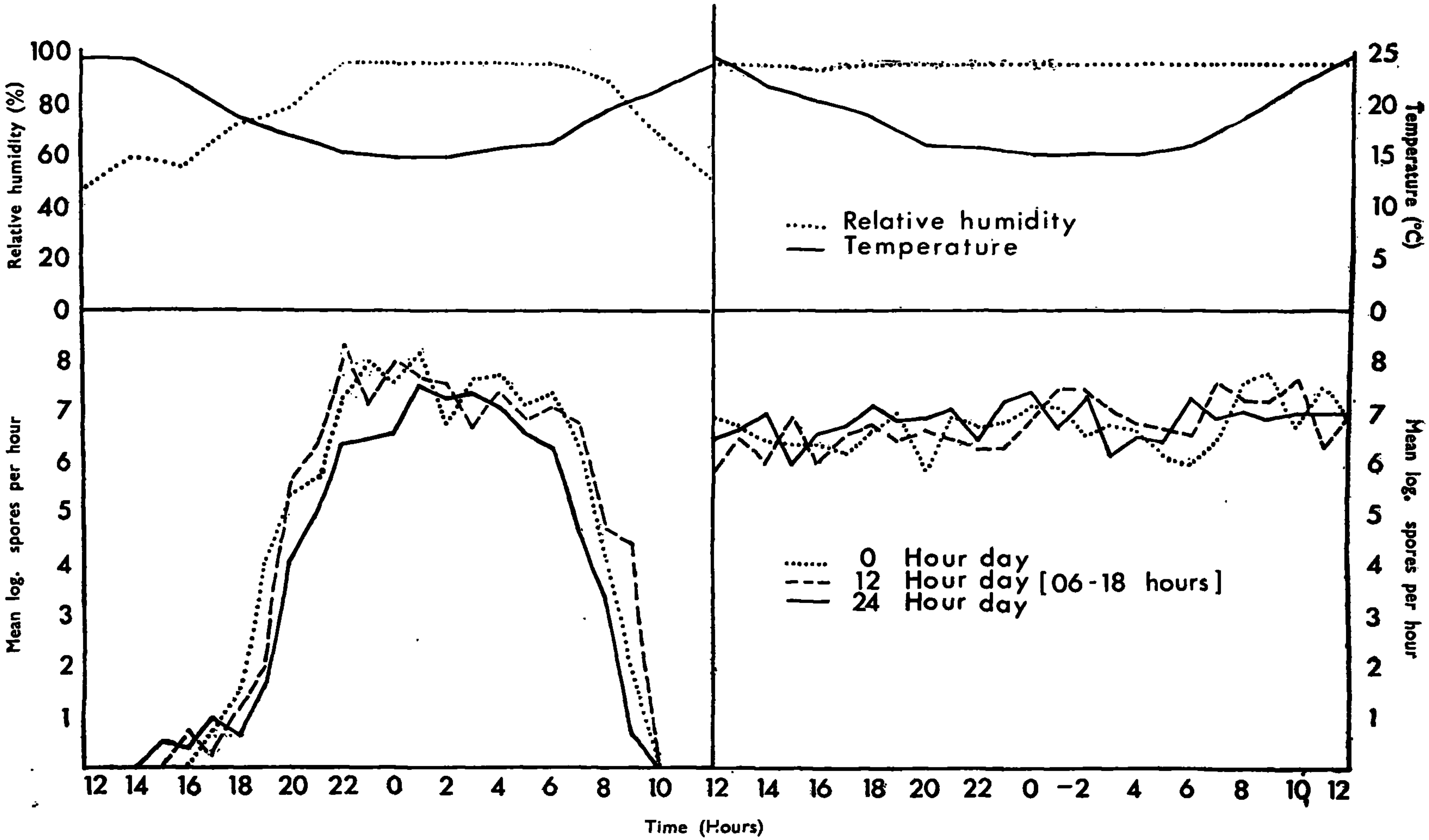

FIGURE 4 — *Variation of the mean diurnal periodicity of spore production by* E. vexans *with relative humidity*

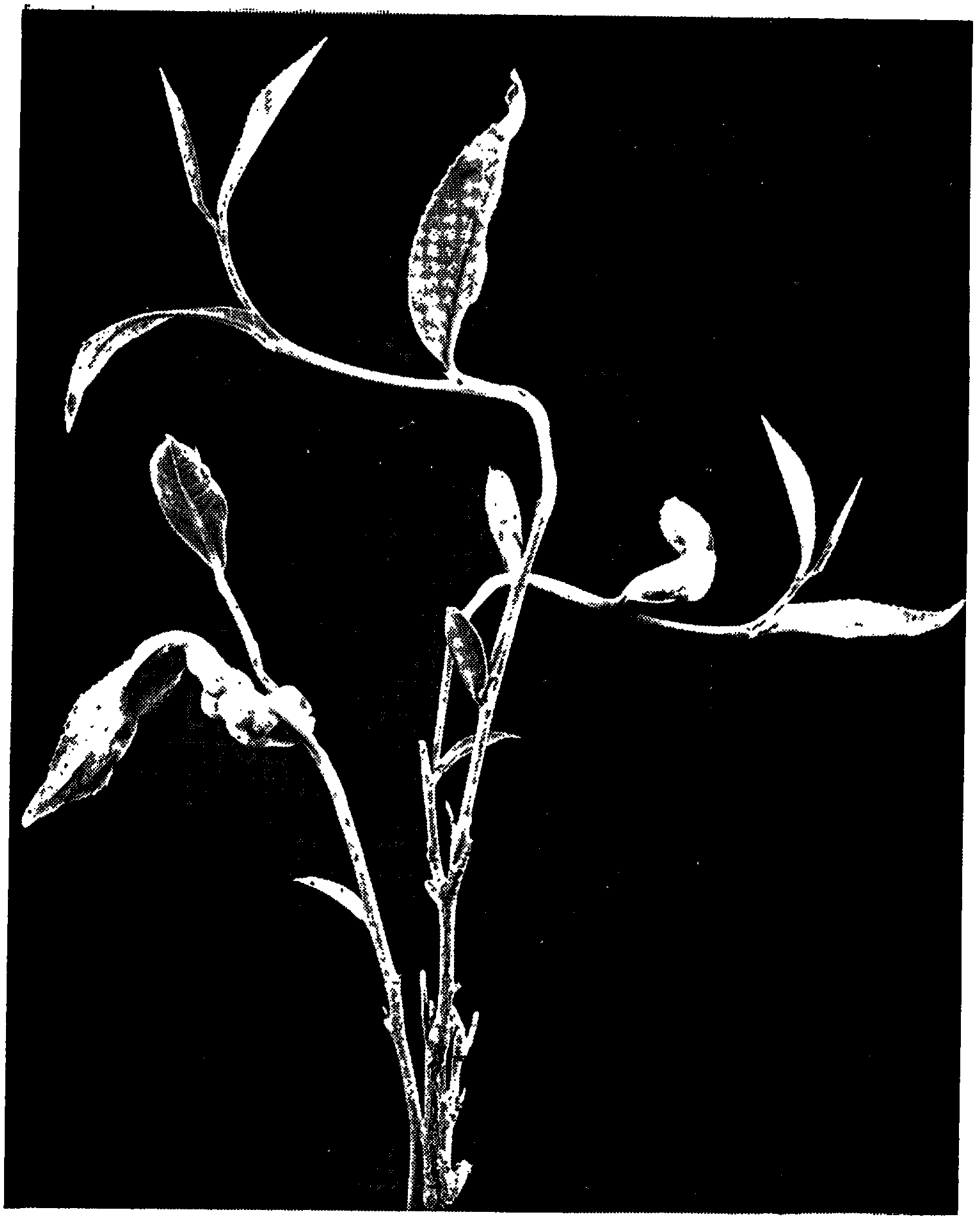

FIGURE 5 — *Blister Blight on tea stems*

petioles (Figure 5) which are completely girdled, leading to leaf fall and crop loss. So the purpose of any control measure is to prevent disease incidence rising above 35% on the third leaf. Even very low rates of fungicide can often achieve this, giving a marked increase in crop (Figure 6). It was further found that disease control was directly proportional to the log. of the dose of fungicide used (Figure 7).

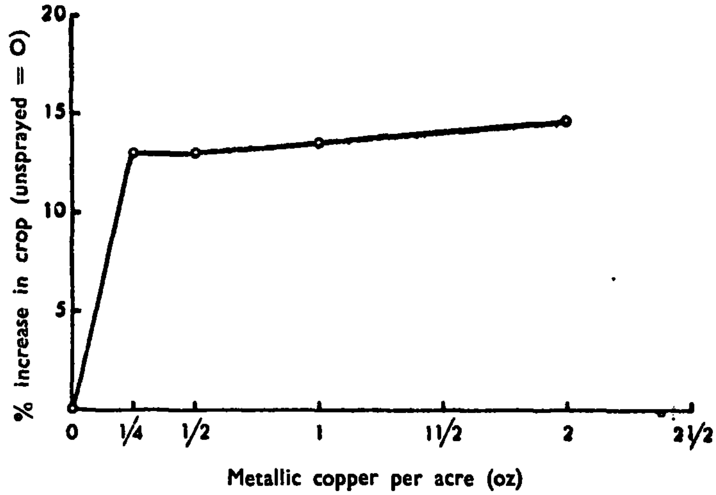

FIGURE 6—*Effect of the dose of metallic copper on tea crops as a result of the control of Blister Blight*

Disease is controlled by weekly sprays during monsoon periods. Thirty spray rounds per year are not uncommon, but theoretically, as few as four rounds may be adequate in some years. By accurate disease prediction and forecasting, considerable saving in the cost of spraying should be possible.

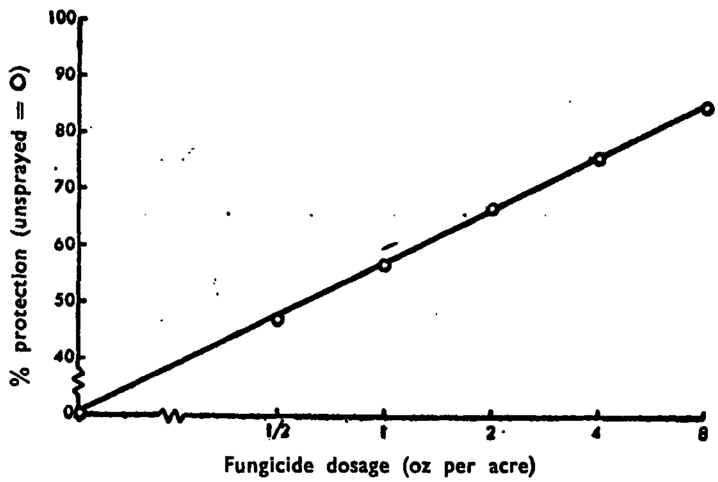

FIGURE 7—*The relation between the dosage of fungicide applied and the resulting degree of protection against Blister Blight*

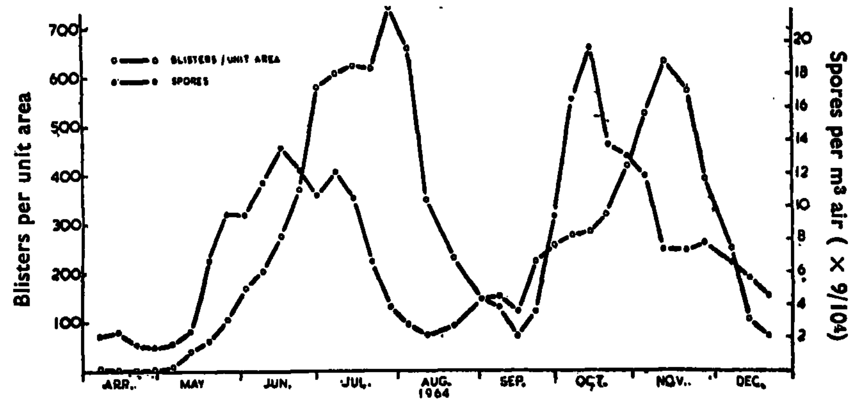

FIGURE 8—*The relation between the number of spores in the atmosphere and the number of blisters per unit area of tea*

SPORE NUMBERS

In studying the epidemiology of Blister Blight, spore numbers were first considered and it was assumed that they would be simply and directly related to the number of blisters per unit area of crop. Much to our astonishment, this was not the case (Figure 8). You will notice that as disease incidence is increasing, spore

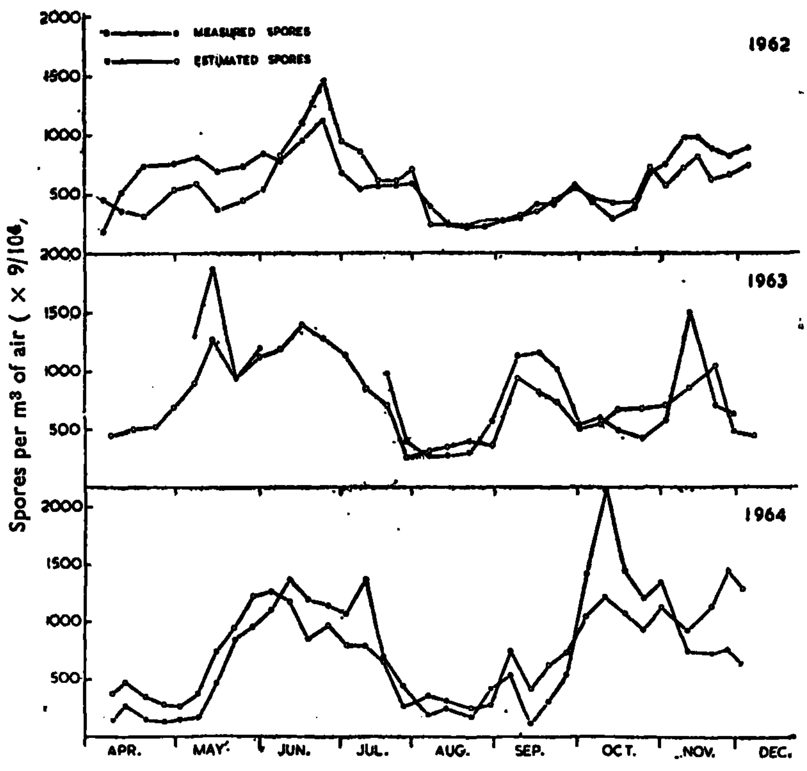

FIGURE 9—*The estimated and measured number of spores per cubic metre of air from 1962 to 1964*

numbers are higher than expected and *vice versa*. The reason for this is obscure, but it has to be allowed for when attempting to estimate spore numbers in the atmosphere, as will be seen later. We do not want to go into the mathematical relationships today. It would suffice to say that spore numbers can be accurately estimated (Figure 9). These estimates are for spore numbers in the atmosphere but, as might be expected, they are directly correlated with numbers deposited on susceptible leaves.

LEAF WETNESS

The relationship between disease incidence and leaf wetness is relatively simple. As duration of leaf wetness increases, so does disease incidence and this can be expressed mathematically. Duration of leaf wetness, however, is very strongly negatively correlated with duration of sunshine, and as the latter is more convenient for superintendents of tea estates to measure, we have used sunshine records in all our calculations to predict disease incidence.

PREDICTION OF DISEASE INCIDENCE AND DISEASE FORECASTING

By combining our estimates of spore numbers with sunshine records, we can predict disease incidence three weeks later fairly accurately. Unfortunately, disease forecasts issued from the Tea Research Institute would serve little purpose, because the tea country in Ceylon is mountainous with very variable climate over relatively short distances. An alternative is for disease incidence to be forecast on individual estates. Although the data required for this could be obtained on tea estates, several measurements are required and the calculations involved are rather too tedious for superintendents to adopt. These have been considerably simplified.

In our initial calculations, the number of blisters per 100 shoots was used to estimate spore numbers, but the relationship is nonlinear. If, however, the square root of percentage infection is plotted against spore numbers, the relationship is

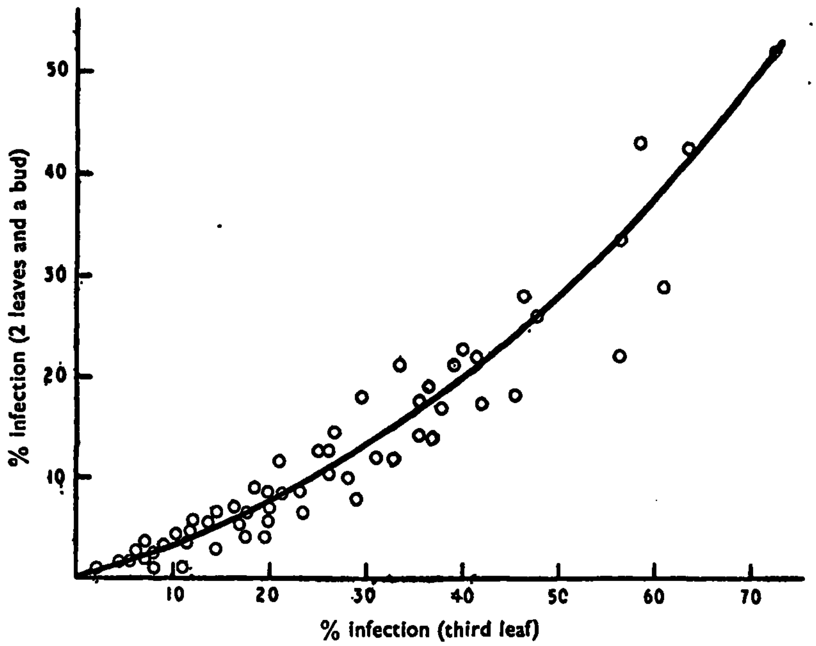

FIGURE 10—*The relation between percentage infection of Blister Blight assessed on the third leaf and on two leaves and a bud*

practically linear (Figure 10). In other words the square root of percentage infection can give an estimate of spore numbers, but the accuracy of the estimate can be markedly increased if the rate of increase of estimated spore numbers is also measured. The most convenient way of expressing this is by the partial-regression equation

$$Y = a + b_1x_1 + b_2x_2 \qquad \text{(1)}$$

where Y = log. estimated spore numbers

x_1 = log. $\sqrt{(\%\ \text{infection})}\ t_2$

x_2 = log. $\sqrt{(\%\ \text{infection})}\ t_2$ − log. $\sqrt{(\%\ \text{infection}\ t_1)}$

$t_2 - t_1$ = three weeks and

a, b_1 and b_2 constants.

The only measurement required to estimate spore numbers is percentage infection. Normally this is assessed on the third leaf but on commercial tea estates only the youngest two leaves and a bud are plucked for manufacture and it would be much more convenient for planters, if percentage infection could be assessed on leaf brought to the factory. The relationship between the two methods of assessment is shown in Figure 11. Using this graph, data obtained by either method can be readily interconverted.

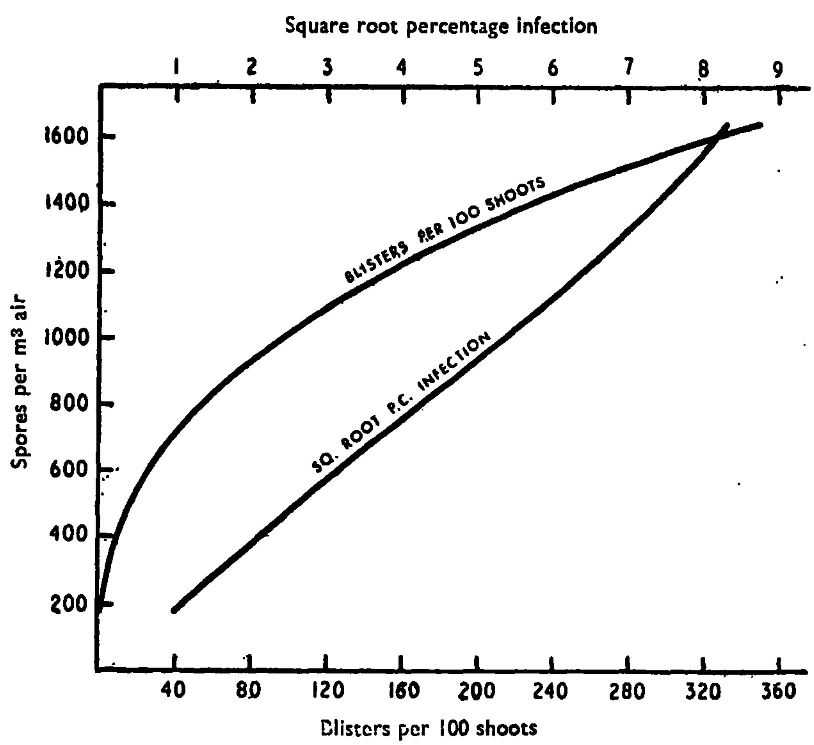

FIGURE 11—*The relation between the number of spores in the atmosphere, the number of blisters per 100 shoots and the square root of percentage infection*

It only remains to incorporate sunshine records into the partial regression and disease incidence, three weeks later, can be predicted. This can be represented by

$$Y = a + b_1x_1 + b_2x_2 - b_3x_3 \quad \text{.............................(2)}$$

where Y = predicted disease incidence at time t_2 + 3 weeks,

x_1 and x_2, are as in equation (1) and

x_3 = mean daily sunshine.

Values have been calculated for all the constants (a, b_1 b_2 and b_3) and both predicted and measured incidence are shown in Figure 12.

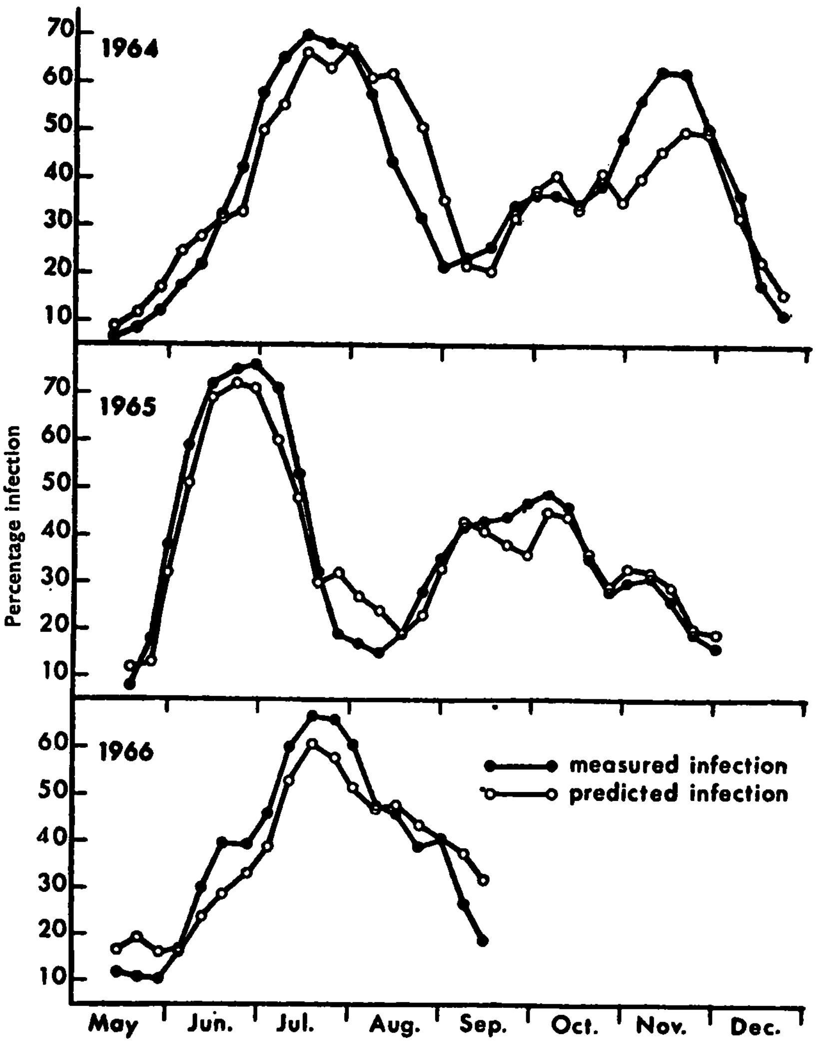

FIGURE 12—*Predicted and measured disease incidence of Blister Blight from 1964 to 1966 (3-week running means)*

To avoid square root and logarithmic transformations and arithmetic calculations, a simple calculating device has been constructed and is illustrated in Figure 13. The calculating device represents equation (2).

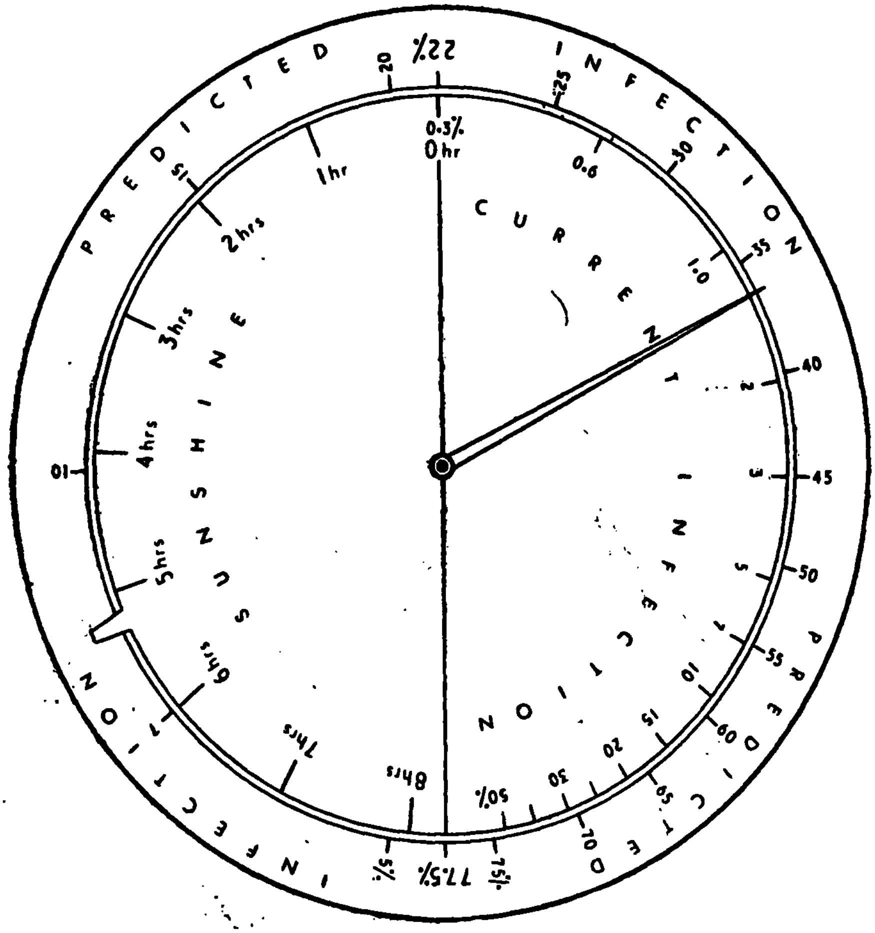

FIGURE 13—*Calculating device for disease forecasting*

We believe a simple practical method of disease forecasting can be developed and applied by superintendents on any tea estate in Ceylon where Blister Blight is an important disease. The method is still being tested in the field, but we believe that it can be safely applied to mature tea, one year or more from pruning and should save many rounds of spraying each year.