Tea Q. 43 (4), 140-146. 1972. Printed in Sri Lanka.

*LOSSES OF TEA CROPS CAUSED BY *EXOBASIDIUM VEXANS* MASSEE ON TEA

I — LOSSES ON UNSHADED SEEDLING TEA

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Different doses of a cuprous oxide fungicide formulation containing 50% w/w metallic copper were sprayed on unshaded seedling tea at regular intervals over an entire four-year pruning cycle at the Tea Research Institute's St Coombs Estate. Different degrees of infection of Blister Blight (*Exobasidium vexans* Massee) were obtained on tea sprayed with 0, 35, 70, 140, 280 and 560 g/ha of the fungicide. Crops were measured on the same days that disease infection was assessed, from the sprayed plots, over the entire cycle.

It was found that crop was related to disease infection in the first year of the cycle, and to a lesser extent in the second year, but in the third and fourth years of the cycle, there was no crop loss associated with disease incidence. The significance of these results is discussed.

Early estimates of losses in tea crops caused by the blister blight fungus *Exobasidium vexans* Massee were reported by Portsmouth (1951) who found that unprotected tea produced 20 to 40% less crop than tea protected with copper fungicide, over a limited period. In 1967 it was reported (de Silva 1967) that there was a linear relationship between the dosage of copper fungicide sprayed, and the degree of protection of the tea shoots against the disease as assessed by the infection on the third leaf of shoots of seedling tea in the second year of a four-year pruning cycle. It was also reported that there was no significant difference between crops harvested from plots sprayed with ½ oz fungicide per acre (35 g/ha), of a 50% w/w cuprous oxide fungicide formulation, and 8 oz per acre (560 g/ha) of the same formulation. There was, however, a significant difference between crops harvested from plots sprayed with 35 g/ha fungicide and that from unsprayed plots.

This paper deals with the results of experiments on crop losses on unshaded seedling tea caused by *E. vexans* throughout a four-year pruning cycle at the Tea Research Institute's St Coombs Estate. The significance of these results is discussed.

EXPERIMENTAL

A seedling tea area at St Coombs (elevation 1200 m amsl) with plants spaced 0.9 m (3 ft) apart, planted about 35 years ago without interspersed shade trees was demarcated into four blocks, each consisting of six plots, totalling 24 plots. Each

* This paper was presented at the 27th Annual Sessions of the Ceylon Association for the Advancement of Science in December 1971.

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plot consisted of 100 plants. The treatments were allocated at random to plots in each block. Each treatment was, therefore, replicated four times. The experiment was sited on gently-sloping land and the blocks fitted into a contiguous area. The treatments are given below :

1—Untreated control
2—Perenox sprayed at the rate of 35 g/ha
3—Perenox sprayed at the rate of 70 g/ha
4—Perenox sprayed at the rate of 140 g/ha
5—Perenox sprayed at the rate of 280 g/ha
6—Perenox sprayed at the rate of 560 g/ha.

Perenox is a cuprous oxide WP formulation manufactured by the Plant Protection Division of Imperial Chemical Industries Ltd., U.K. and marketed by Chemical Industries (Colombo) Ltd., and contains 50% w/w metallic copper. The required fungicide dose was dispersed in water at a dilution of 170 L/ha and applied using knapsack-type sprayers with standard nozzles. The spray treatments were applied the day after each plucking round, and was done throughout the year.

Samples of tea flush (young shoots) consisting of the leaf bud and three successive leaves were collected from each plot for the purpose of assessing the degree of infection of disease immediately before collecting the harvest from the plot. Each sample consisted of not less than one hundred shoots. Infection was assessed by obtaining the percentage of shoots showing young or mature blisters on the third leaf. This practice is in accordance with previously-reported assessments of the incidence of Blister Blight carried out by the Tea Research Institute of Ceylon and other tea research stations.

Crop was harvested immediately after taking the sample of flush for disease assessment. The weight of the sample was added to the weight of crop from each plot. The standard of plucking was assessed at around 60% 'two leaves and a bud'. Plucking rounds were generally at seven-day intervals, but during periods where growth was unusually slow, the rounds were extended by a few days, so that there was sufficient leaf to harvest. All plots were sampled for disease infection and also harvested the same day. Each plot was demarcated by guard rows of tea plants which were allowed to grow up about 10 cm above the level of the plucking table of the plots. Possible spray drifts were thereby minimized.

The following quantities of fertilizer were applied uniformly to all plots :

336.3 Kg/ha/year $(NH_4)_2SO_4$
44.8 Kg/ha/year KCl
22.4 Kg/ha/year Saphosphosphate
44.8 Kg/ha/year $MgSO_4.7H_2O$
22.4 Kg/ha/year $ZnSO_4.7H_2O$

The NPK fertilizer was applied on the ground while the mixture of $MgSO_4$ and $ZnSO_4$ was applied as a foliar spray. All fertilizers were applied in four doses per year, except that one dose was omitted in the first year of the cycle. When pruning was done the plants in the guard rows were pruned six weeks before those in the plots. The area was 'clean pruned' according to the standard estate practice and was kept clean weeded manually. The treatments in the pruning year commenced from the time new buds appeared after pruning. The data presented for crop harvests for each plot are corrected for co-variance.

RESULTS

The mean levels of blister blight infection obtained with different doses of fungicides for each year of the pruning cycle are given in Table 1.

TABLE 1—*Blister blight infection on the third leaf of shoots of unshaded seedling tea obtained after spraying different doses of fungicide*

Year of Pruning Cycle	Mean infection per assessment 1st yr	2nd yr	3rd yr	4th yr	Total for Cycle
Number of assessments per year	19	49	41	44	153
Dose of fungicide g per ha					
0	6.284 *a*	16.397 *a*	15.358 *a*	17.777 *a*	15.261 *a*
35	3.642 *b*	8.559 *b*	7.366 *b*	11.918 *b*	8.594 *b*
70	3.863 *b*	6.906 *c*	6.478 *b*	11.629 *b*	7.772 *b*
140	3.484 *b*	5.208 *d*	3.658 *c*	8.148 *c*	5.424 *c*
280	2.074 *c*	4.010 *e*	3.049 *c*	7.566 *c*	4.533 *c*
560	2.047 *c*	2.408 *f*	1.809 *c*	5.191 *d*	3.003 *d*
LSD (P=0.05)	1.195	1.192	1.192	1.134	1.295

(Symbols *a* to *f* are used to indicate significance at P=0.05 in vertical columns only. There is no significant difference between figures with the same symbol in vertical columns)

It is seen from Table 1 that for each year of the pruning cycle, the degree of disease incidence was inversely proportional to the quantity of fungicide applied. The differences in infection between treatments were sometimes not large enough to be statistically significant (at P=0.05) but the trends are clearly evident throughout. It is interesting to note that for the second year of the cycle, each dose of fungicide used, without exception, brought about a statistically significant effect on disease infection.

Table 2 shows the crops obtained from plots treated with the different doses of fungicide for blister blight control.

TABLE 2 — *Crops harvested from tea sprayed with different doses of fungicide for the control of Blister Blight*

Year of pruning cycle	Yield (Kg/ha) (Corrected for covariance) 1st yr	2nd yr	3rd yr	4th yr	Total for cycle
Number of plucking rounds	19	49	41	44	153
Dose of fungicide g/ha					
0	648 *a*	1757 *a*	2049 *b*	2351 *ab*	6840 *a*
35	743 *ab*	1947 *ab*	2016 *b*	2236 *ab*	6956 *a*
70	713 *a*	1976 *ab*	2029 *b*	2421 *ab*	7005 *a*
140	821 *b*	1907 *ab*	1890 *a*	2345 *ab*	6998 *a*
280	759 *b*	1927 *ab*	1909 *a*	2157 *a*	6709 *a*
560	837 *b*	2081 *b*	1938 *ab*	2462 *b*	7247 *a*
LSD (P=0.05)	106	224	137	272	540

From Table 2 it is clear that in the first year of the pruning cycle, there was a significant crop loss due to inadequate disease control in plots sprayed with the lower doses of fungicide. Plots sprayed with 560, 280 and 140 g/ha fungicide, gave significantly higher crops than the unsprayed plots indicating that disease control in the first year of the cycle was economically worthwhile.

In the second year, only plots sprayed with 560 g/ha fungicide, yielded significantly more than the unsprayed plots. In the third and fourth years, none of the sprayed plots yielded significantly more than the unsprayed plots. In fact some of the sprayed plots yielded significantly less than the unsprayed plots. The implications of this result are discussed below. When the yields for the entire cycle were compared, there was no statistically significant difference between crops harvested from fungicide-treated plots and the untreated plots.

DISCUSSION

In the case of diseases which kill perennial plants, crop loss is ultimately 100%, but where a disease never kills plants but attacks a portion of it, crop loss is rarely 100%. *Exobasidium vexans* is an obligate parasite requiring living host tissue for its own survival. If it were to kill its host, tea, it would eliminate itself in the process. It would appear, therefore, that if tea plants were not protected against *E. vexans*, they would not be directly killed by the fungus.

In the assessment of crop loss caused by a non-lethal parasite like *E. vexans*, it is necessary to define and obtain different levels of disease before we can determine how much crop is lost as a result of a particular level of disease. Levels of infection of Blister Blight for unshaded seedling tea in the second year of the pruning cycle have been obtained by spraying different doses of a cuprous oxide fungicidal formulation (de Silva 1967). It was found that there was a relationship between levels of infection and fungicidal dose. In this investigation the relationship (Table 1) between fungicide dose and infection has been determined for each year of a four-year pruning cycle. It is seen that the relationship between fungicide dose and infection is clearest in the second year of the cycle. It might have been expected that the clear relationship obtained in the second year would have been observed in the other years of the cycle as well. There is, however, the possibility that spray coverage may have differed because the quantity of foliage on a tea bush is least in the first year and greatest in the fourth year of the cycle. In the first year, therefore, the quantity of spray deposited per unit area of foliage may have been greater than that in the second year. Similarly the quantity of spray deposited per unit area of foliage may have been less in the third and fourth years than that in the second year.

It is also well known that infection of tea plants by Blister Blight is dependent on weather conditions, particularly sunshine. This factor varies from day to day and, therefore, from year to year. The degree of infection obtained with a particular dose/ha of fungicide in one year could, therefore, be different from that obtained with the same dose/ha of fungicide in another year, because the general level of infection may be different from year to year. These factors may explain why the relationship between fungicide dose and infection so clearly obtained for the second year is slightly different for the other years of the cycle. Nevertheless the trends are the same for all years of the cycle and it is justifiably concluded that different levels of infection can be obtained by spraying different quantities of cuprous oxide fungicide formulation. This conclusion is supported by the fact that when the infestation levels for the entire pruning cycle are taken into consideration, there is a significant relationship between fungicide dose and blister blight infection.

It is well known that the tea harvest in the Dimbula District of Ceylon, is least in the first year of the pruning cycle and that crop increases considerably, in the second year. In the third and fourth years, the general level of cropping is usually even higher but it may sometimes tend to diminish in the fourth year. In some cases, where five-year cycles are employed, there is generally an increase of crop in the fourth year and a tendency towards a depression in the fifth year. Of all the factors that affect crop, the weather is one of the most important and it has a profound effect on crop itself, apart from the effects it may have on disease like Blister Blight.

In order to determine crop loss at different levels of disease incidence it is necessary to first obtain different levels of blister blight infection and then compare the crop obtained at each level of infection with that from the untreated control. This has already been done for unshaded seedling tea in the second year of the cycle. It was found (de Silva 1967) that there was a linear relationship between fungicide dose and disease incidence over the range of concentration of fungicide tested, but when crops were measured the same relationship was not evident. It was found that there was no significant increase in crop although there was a significant increase in blister blight infection. Subsequently, Venkata Ram (1968) reported the results of an experiment where he obtained increases in crop from fungicide treatments over the untreated controls, of 11% to 37% over a 26-week period of assessment, after 17 applications of fungicide. Assessments of infection were recorded 11 times. He states that only one treatment *ie* a mixture of copper fungicide and nickel chloride brought about a significantly lower shoot infection compared with the controls, and that another treatment ie 1 oz/acre copper fungicide did not bring about significantly different levels of infection of Blister Blight. It cannot be concluded that the difference recorded in crops was the result of blister blight infection, which was not statistically different between treatments. In fact it is apparent that the difference observed in crops must have been related to factors other than Blister Blight. He also states that 'whereas there was no significant differences in the level of infection between 3 oz and 1 oz copper fungicide treatments the crop increase at the higher dosage was considerably higher'. It is, therefore, clear that the differences observed between crops from plots given these treatments could not possibly have been directly related to Blister Blight which was not significantly different.

In our experiments we did obtain different levels of Blister Blight but this varied with the age from pruning. In the first year for example, there was a significant difference in infection between the controls and the other doses used, but there was no significant difference in infection between the 35, 70 and 140 g/ha doses. Further, the 280 and 560 g/ha doses gave significantly lower infection figures than the other doses. As regards crops, it is clear that in the first year following pruning, good control of Blister Blight is economically worthwhile, because there was a gradation in crop with increase in fungicide dose (Table 3) although some differences were not significant at the 5% level of probability. A significant increase in crop of 29.3%

was obtained from plots sprayed with 560 g/ha fungicide over that from unsprayed plots. Again, increases in crops over the control were 17.1% and 26.6% for plots sprayed with 140 and 280 g/ha respectively. It must be mentioned that the 29.3% increase between the extreme treatments amounted to 189 Kg/ha. Although yields are low in the first year, as plants have recovered only partially from pruning, it would still seem worthwhile to control the disease effectively because any crop loss in the first year may have a cumulative influence on crops in subsequent years. In this experiment, this effect is eliminated because the experiment commenced in the second year of the cycle, prior to which the disease was well controlled. When considering the second year of the pruning cycle only plots sprayed with the highest dose, 560 g/ha, gave significantly more crop than the unsprayed controls. The yields increase over the controls, in plots sprayed with 560 g/ha amounted to 18.4% or 324 Kg. It appears therefore that good control of Blister Blight is also necessary in the second year of the cycle although the advantage in terms of percentage increase in crop is less in the second year. The crop difference in the second year over that in the first was 324 Kg/ha *vs* 189 Kg/ha. The increase was larger because tea yields considerably higher in the second year.

TABLE 3—*% change in crops in unshaded seedling tea as a result of controlling Blister Blight*

	% change in crop				
Year	1st	2nd	3rd	4th	Cycle Total
Dose of fungicide g/ha					
0	100	100	100	100	100
35	110.1	110.8	98.4	95.1	101.7
70	114.8	112.5	99.1	96.1	102.4
140	117.1	108.6	92.3	99.8	102.3
280	126.6	109.7	92.9	91.8	98.1
560	129.3	118.4	94.6	104.7	106.0
LSD (P=0.05)	16.4	12.8	6.7	11.6	11.9

In the third year of the cycle it was observed that although the plots receiving fungicide treatment had less blister blight infection than the unsprayed controls, the latter yielded the highest. Only in the case of two treatments, (140 and 280 g/ha) however, was the depression in crop significant. It is difficult to interpret this result and it certainly needs more careful scrutiny. One possible explanation can, however, be advanced. In the third year of the cycle the tea plant is yielding quite well and factors other than Blister Blight—such as the weather *etc* may cause any losses from the disease to be overshadowed or even, perhaps, compensated for. This however needs further investigation. The difference between extreme treatments amounted to 5.4% or 111 Kg and was not significant (P=0.05). Similar trends were again observed in the fourth year of the cycle, the treated plots sometimes yielded less than the control, but with one exception (560 g/ha) the losses in crop were not statistically significant. It is important, however, to note that in both third and fourth years, there was an indication that crops were less in plots receiving higher doses of fungicide. If this trend was evident in either the third or fourth years instead of in both years, we may be justified in suspecting an error in the experiment but the fact that the trend was noticed in both years must mean that it was a definite result and not an error in the experiment. It is possible that in the third and fourth years, although the higher doses of fungicide controlled Blister Blight better, they may have had a depressing effect on crop perhaps due to phytotoxity. This point needs careful investigation.

It would appear that there would be an advantage in reducing expenditure on blister blight control in the 3rd and 4th years of the cycle. Even if crops remained the same instead of increasing, the money spent on sprays could be saved.

It must be clearly stated again (see de Silva 1972) that these results may not be applicable to other conditions in different localities. The results of experiments on shaded tea, on VP tea of different clones and on the effect of Blister Blight on made tea have not been reported. These will be the subject of future papers in this series.

CONCLUSIONS

1—The control of blister blight infection was found to be proportional to the quantity of fungicide applied.

2—The effect of Blister Blight on tea crops was most marked in the early part of the pruning cycle and diminished towards the end of the cycle.

3—In the first and second years of the cycle, control of Blister Blight was economically advantageous.

4—In the third and fourth years of the cycle, there was no crop increase as a result of disease control.

5—Decrease in crop in the third and fourth years in the better-sprayed plots suggested that phytotoxicity of fungicide was a possibility. This would need to be investigated further.

6—These results are applicable only to unshaded seedling tea at St Coombs Estate, and are not necessarily applicable elsewhere on other types of tea growing under different conditions.

ACKNOWLEDGEMENTS

The authors wish to thank Mr P. Kanapathipillai, Statistician, TRI, and Mr W. R. F. Rodrigo formerly of the Plant Pathology Division of the TRI for assistance in this work.

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Accepted for publication—1st June 1972.