PRELIMINARY SMALL-SCALE FIELD EXPERIMENTS ON A CHEMICAL METHOD FOR THE PREVENTION OF SHOT-HOLE BORER (*XYLEBORUS FORNICATUS* EICH.) ATTACK ON TEA IN PLUCKING

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A. Introduction

In the writer's opinion chemical methods for the prevention of shot-hole borer attack on tea in plucking should be investigated from the following aspects:—

I. Entomological aspects, *i.e.* influence of the insecticides on

1. shot-hole borer,
2. parasites and predators of the pest of tea,
3. other pests of tea.

II. Phytotoxity aspect, *i.e.* influence of the insecticides on the plant tissue of tea.

III. Human health aspect, *i.e.* influence of the insecticides on the chemical contents of manufactured tea. (See also Portsmouth 1956 page 95).

IV. Technological aspect, *i.e.* influence of the insecticides on the flavour of tea.

V. Economic aspect, *i.e.* comparison of the costs of treatments with the value of yield increased as a result of the treatment.

All these points are equally important and a chemical for practical routine spraying can only be recommended if all of them were investigated and all the investigations gave satisfactory results.

B. Spraying experiments against shot-hole borer carried out earlier in Ceylon

Considering the abovementioned points, results obtained by Austin (1955 and 1956) and Baptist (1956 a and 1956 b) can be summarized as follows:—

(*a*) **Influence of the insecticides on shot-hole borer.** According to Austin (1956) and Portsmouth (1956) of the many insecticides tested dieldrin has given most promise of effective control. According to Baptist (1956 b) dieldrin is an effective insecticide for the destruction of shot-hole borer.

(*b*) **Influence of the dieldrin on the predators and parasites of pests of tea.**—According to Baptist (1956 a) and Portsmouth (1956) sprayings with dieldrin kill *Macrocentrus homonae* Nixon, the controlling parasite of tea tortrix (*Homona coffearia* Nietn).

(*c*) **Influence of dieldrin on the other pests of tea.**—According to Austin (1955) a serious attack of tea tortrix appeared on the experimental plots of tea treated with dieldrin against shot-hole borer, and also in some of Baptist's (1956 a) experiments with dieldrin and chlordane. According to Baptist (1956 a) dieldrin is more effective against *Macrocentrus homonae* Nixon than against tea tortrix. To avoid destroying the Macrocentrus, Baptist (1956 a) recommended that spraying against shot-hole borer with dieldrin should be carried out 2 to 3 weeks after pruning except in new clearings where the simultaneous application of a special insecticide for tea tortrix control is desirable.

(*d*) **Economic aspect of dieldrin treatment.** This point was investigated only partially *i.e.* by comparison of the yields of treated and untreated plots. According to Austin (1955) in one of the experiments carried at Calbode Estate to determine loss of crop due to shot-hole borer, the total yield obtained from the plots treated with dieldrin was, because of the tortrix attack, lower than from untreated ones. Yield of the experiments commenced by Baptist at Ingiriya Estate were examined by Joachim (1957) and no apparent effect on crop yield of treatment with dieldrin appear; it is possible that this was due to the low infestation of the experimental area with the pest.

The phytotoxity, human health and technological aspects of dieldrin treatments were not investigated. It would appear that of the 7 factors only one, *i.e.* the influence of the chemical on shot-hole borer was investigated and gave positive results. Investigations on the influence of dieldrin on *Macrocentrus homonae* Nixon and tea tortrix gave only partially positive results. Investigations on the economic aspects of dieldrin treatments gave negative results and the 3 remaining factors referred to above were not investigated.

It should be finally mentioned that the Tea Research Institute of Ceylon has on two occasions issued a warning in regard to the use of insecticidal applications for the control of shot-hole borer for the present (see Portsmouth 1956 and report of the Entomologist for the year 1955: Baptist 1956 b).

C. Spraying experiments carried out by the writer

1. **Objects of the experiments.** The objects of the experiments described below are the investigation of the influence of contact insecticides sprayed only on the lower parts of the tea bush, on shot-hole borer and on the plant tissue of tea.

This method of spraying, *i.e.* of the lower parts of tea, is based first of all on the results of investigations with sticky traps (Judenko 1958 c) which showed that a number of adult beetles appear on the lower parts of the tea bush. Then a number of entrances to the galleries made by shot-hole borer were found on the lower parts of the bush (Judenko 1958 d), and finally laboratory observations (Judenko 1958 a) showed that many adult beetles traverse the lower parts of the bush. This type of spraying would largely eliminate the chemical contaminations of the plucking tables of bushes, and at least partially, the destruction of *Macrocentrus homonae* Nixon, the controlling parasite of tea tortrix.

Large volumes of rather high concentrations of insecticides were used in these experiments, and it was planned in case these experiments gave positive results in respect of the destruction of shot-hole borer, to start the next series of experiments using smaller volumes of sprays and in low concentrations.

2. **Insecticides used.** Of those insecticides tested out in the laboratory, *viz.* chlordane, DDT, dieldrin and Lakil, the best results in regard to the destruc-

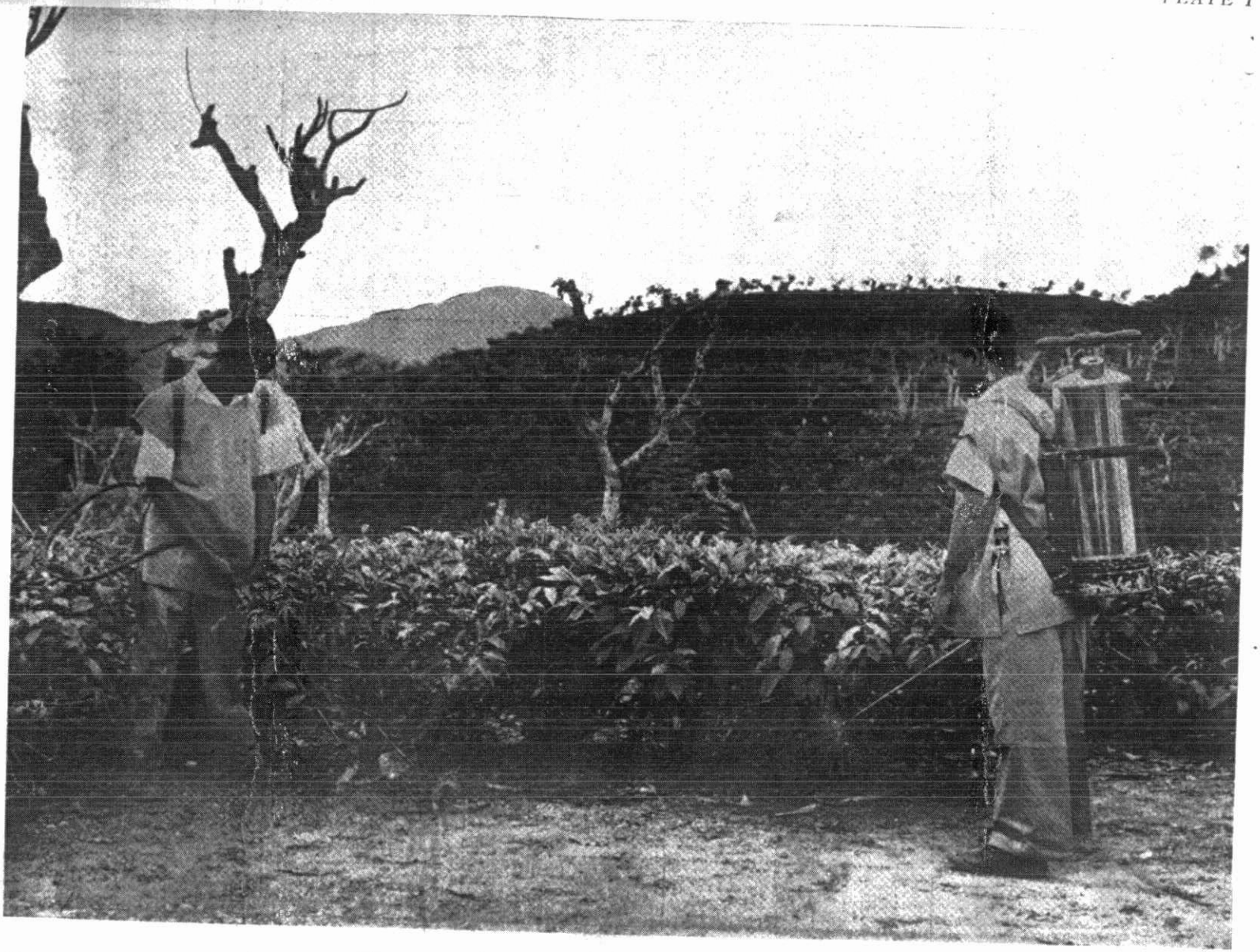
TABLE 1

Naluwella Group. Ratmalavinna Div. Field No. 2. Age: about 25 — 30 years. 23 months pruning cycle. Height of bushes at time of treatment: avg. 32", min. 21". max 41" Spraying 8th October, 1957. First rain after spraying: 14th October — 0.05".

Examination No.	Kind of Examination	Control	Chlordane 3.75% sprayed 12" above ground level. 211 gals. p.a.	Dieldrin 0.5% sprayed 12" above ground level. 255 gals. p.a.	Rainfall between day of spraying and day of examination	Age after pruning in months.
		Number of live adults per 50 standard units				
1	Pre-treatment	22	46	47	—	18
2	In 2½ months after treatment	24	1	0	39.05"	17½
	Population as % of that before treatment	109%	2%	0%		
3	In 6 months after treatment	26	1	0	76.54"	21
	Population as % of that before treatment	118%	2%	0%		
4	In 8 months after treatment	40	4	0	96.27"	23
	Population as % of that before treatment	182%	9%	0%		
		Number of live adults per 100 prunings				
5	In 8 months after treatment	403	143	82	96.27"	23
	Population as % of that on control	100%	36%	20%		

TABLE 2

Experiment No.	Estate, division, field age after planting in years	Height of tea in the experimental area at the time of treatment. Avg.	Min.	Max.	Post treatment examination No.	Chemicals and amount per acre	Height of spraying above ground level	Date of treatment	Nearest rain: Date	Nearest rain: Amount	Examination after time of treatment in months	Rainfall between day of treatment and day of examination	Live adults: Standard units. Population as % of that before treatment	Live adults: Prunings. Population as % of that on control	Age after pruning in months at the time of: treatment	Age after pruning in months at the time of: post treatment examination
I	Rye, div. 2, clear. 1949	15″	14″	18″	1	Chlordane 102 gals.	6″	10.9	10.9	0.30″	12	103.56″	34%	—	1	13
					1	Dieldrin 109 ,,	6″	9.9	9.9	0.14″	12	103.70″	12%	—	1	13
					1	Control	Nil	Nil	—	—	12	—	168%	—	1	13
II	Rye, div. 2, field 13, ab. 35 years	31″	24″	41″	1	Chlordane 250 gals.	12″	13.9	28.9	0.08″	7	75.34″	7%	—	14	21
					1	Dieldrin 229 ,,	12″	13.9	28.9	0.08″	7	75.34″	0%	—	14	21
					1	Control	Nil	Nil	—	—	7	—	61%	—	14	21
					2 & 3	Chlordane 250 gals.	12″	13.9	28.9	0.08″	12	103.26″	43%	74%	14	26
					2 & 3	Dieldrin 229 ,,	12″	13.9	28.9	0.08″	12	103.26″	63%	52%	14	26
					2 & 3	Control	Nil	Nil	—	—	12	—	164%	100%	14	26
III	Naluwella Gr., Ratnalavinna div., field 2, ab. 25-30 years	32″	21″	41″	1	Chlordane 211 gals.	12″	8.10	14.10	0.05″	2½	39.10″	2%	—	15	17½
					1	Dieldrin 255 ,,	12″	8.10	14.10	0.05″	2½	39.10″	0%	—	15	17½
					1	Control	Nil	Nil	—	—	2½	—	109%	—	15	17½
					2	Chlordane 211 gals.	12″	8.10	14.10	0.05″	6	76.54″	2%	—	15	21
					2	Dieldrin 225 ,,	12″	8.10	14.10	0.05″	6	76.54″	0%	—	15	21
					2	Control	Nil	Nil	—	—	6	—	118%	—	15	21
					3 & 4	Chlordane 211 gals.	12″	8.10	14.10	0.05″	8	96.27″	9%	36%	15	23
					3 & 4	Dieldrin 255 ,,	12″	8.10	14.10	0.05″	8	96.27″	0%	20%	15	23
					3 & 4	Control	Nil	Nil	—	—	8	—	182%	100%	15	23
IV	Pettiagalla, Upper div., field 2B., ab. 40 years	39″	31″	49″	1	Chlordane 258 gals.	12″	9.10	12.10	0.20″	2½	43.77″	43%	—	20	22½
					1	Dieldrin 273 ,,	12″	9.10	12.10	0.20″	2½	43.77″	7%	—	20	22½
					1	Control	Nil	Nil	—	—	2½	—	161%	—	20	22½
					2	Chlordane 258 gals.	12″	9.10	12.10	0.20″	6	82.38″	23%	—	20	26
					2	Dieldrin 273 ,,	12″	9.10	12.10	0.20″	6	82.38″	2%	—	20	26
					2	Control	Nil	Nil	—	—	6	—	100%	—	20	26
					3 & 4	Chlordane 258 gals.	12″	9.10	12.10	0.20″	12	127.46″	9%	71%	20	32
					3 & 4	Dieldrin 273 ,,	12″	9.10	12.10	0.20″	12	127.46″	4%	58%	20	32
					3 & 4	Control	Nil	Nil	—	—	12	—	48%	100%	20	32
V	Upper Balangoda, Bulubalanda field, ab. 34 years.	34″	26″	46″	1	Dieldrin 232 gals.	12″	10.10	12.10	0.09″	3	48.67″	2%	—	18	21
					1	Dieldrin 117 ,,	6″	10.10	12.10	0.09″	3	48.67″	3%	—	18	21
					1	Control	Nil	Nil	—	—	3	—	47%	—	18	21
					2	Dieldrin 232 gals.	12″	10.10	12.10	0.09″	9	97.12″	—	24%	18	27
					2	Dieldrin 117 ,,	6″	10.10	12.10	0.09″	9	97.12″	—	23%	18	27
					2	Control	Nil	Nil	—	—	9	—	—	100%	18	27



Showing method of spraying & protective clothings worn.

Showing precautions taken when concentrates are handled.

tion of adult beetles and the phytotoxity effect were obtained from chlordane and dieldrin. These insecticides were therefore used in the field experiments described below.

Chlordane was used in the form of a miscible oil formulation at a strength of 3.75% of the technical chlordane and dieldrine was used as 0.5% spray in the form of emulsion.

3. **Lay out of the experiments, equipment and the technique of spraying.** There were 5 plots for each treatment and control, *i.e.* 15 plots in each of the 5 experiments (see table 2) and the number of bushes in plucking per plot in case of experiment No. 1 was 32, and in the remaining experiments, 24. Two rows of bushes were left as buffer between individual plots. To prevent the migration of the beetles from the buffer rows to the plots along the adjacent branches, those on the boundaries were periodically cut.

The following durations of pruning cycle were adopted in the experimental areas:—experiments Nos. I, II and IV, 36 months, experiment No. III, 23 months and experiment No. V, 27 months.

The heights of 5 bushes on each of the plots were measured, and on the basis of these 75 measurements, data regarding the heights of the bushes (table 2) in the individual experiments were obtained.

Spraying was done with Birchmeier "Automat" self-acting knapsack sprayers with incorporated pressure pump. The liquid capacity of this sprayer is about 2¼ imperial gallons. The sprayers were fitted with single "Duro" nozzle with removable steel disc 1.65 mm. The individual bushes were sprayed first around the bushes from outside at heights of 6" or 12" above ground level, and afterwards the spraying lance was put inside the lower parts of the bushes at a height of 6" or 12" and again, only these parts were sprayed. Not only were the lower parts of tea copiously sprayed, but also some part of the soil surface adjacent to the tea bushes. In each experiment spraying was carried out once only in September and October, 1957.

The volumes of insecticides used were calculated on the basis of 2,500 bushes in plucking per acre (Tables 1 and 2).

4. **Weather conditions during the sprayings.** Rain started during both sprayings of experiment No. I and it also rained on the same days after the sprayings were completed. In the four remaining experiments, there was sunny weather during sprayings and the bushes were dry. In these experiments rain fell 2, 3, 6 and 15 days after spraying.

5. **Precautionary measures.** (a) MEASURES FOR THE PROTECTION OF OPERATORS HANDLING INSECTICIDES AND OF SUPERVISORS. In accordance with the recommendations of the Study Group on the toxic hazards of pesticides to man (1956) precautionary measures were taken to protect operators handling insecticides and also supervisors. On the advice of the late Dr. F. Gunaratna, a member of the abovementioned Study Group, operators and supervisors used aprons which covered the front and rear portions of the body, and long trousers (see plate I). This clothing was washed once weekly. The operators and supervisors also wore shoes. The operator handling the concentrates used rubber gloves while working (see plate II). After the spraying was over,

the operators and supervisors thoroughly washed the uncovered parts of their bodies with soap and water.

(*b*) PREVENTIONS AGAINST CONTAMINATION OF DRINKING WATER. All operations connected with the handling of concentrates, preparation of solutions, and washing of spraying equipment were done over specially dug trenches (see plate II) far away from any source of water. No experimental plots were sited near streams.

(*c*) MEASURES FOR THE PROTECTION OF THE PLUCKING TABLE OF TEA. The sprayings were done by two laboratory attendants. One of them was supervised by the writer and the other by his assistant. As was mentioned above, only such parts of the tea bush which were lower than 6" or 12" above ground level were sprayed and no droplets were seen to fall on the plucking table.

While the operators were moving between the rows of tea, the spraying lances were kept as low as possible, certainly much lower than the level of the plucking table.

6. **Examination of the Results of Experiments.** The number of live adults inside the given number of standard units (Judenko 1958 b) was considered as a criterion for the investigation of the influence of the chemicals on shot-hole borer. 15 standard units were collected from each of the plots in experiments Nos. I and II, and 10 in the remaining 3 experiments. If the number of live adults in the control plots in any of the post-treatment examinations was less than 45 per cent of that before treatment, such examinations were not considered and not shown in the table. This was one of the reasons why some examinations of experiment No. I (and also of some other experiments) were not considered.

There were also dissected 20 prunings in some of the post-treatment examinations collected from each plot (*i.e.* 100 prunings for each treatment and control) in the case of experiments Nos. II, III and V, and 40 prunings from each plot (*i.e.*200 prunings per each treatment and control in case of experiment No. IV.

Details regarding experiment No. III are furnished as an example in table 1 and a summary of all the experiments given in table 2.

Examinations regarding the phytotoxity effect were carried out a few days after the treatments and later, and no injury to the tea bushes as a result of spraying was observed.

7. **Conclusions.**

1. Only two examinations were done in the case of experiment No. I, and they do not permit any firm conclusions being drawn. However, these two examinations carried out 12 months after spraying indicate that some reduction in the number of live adults does take place when tea of the average height of 15" at 1 month after pruning is sprayed once to a height of 6" above ground level.

2. Four examinations carried out in experiment No. V, where the average height of bushes was 34" show, that there were no significant differences in the degree of reduction of numbers of live adults between the plots sprayed once at heights of 6" and 12" above ground level, 3 and 9 months after treatment.

3. 18 examinations of the experiments Nos. II-V, where the average height of bushes was 34", show that single sprayings at heights of 6" and 12" above ground level carried out 14, 15, 18 and 20 months after pruning caused a considerable reduction in the number of live adults 2½ to 9 months after treatment.

4. 8 examinations of the experiments Nos. II and IV, where average heights of bushes was 35" would indicate that single sprayings of tea at a height of 12" above ground level carried 14 and 20 months after pruning still caused some reduction in number of adults 12 months after treatment.

8. **Further experiments.** After the data from the first examinations of experiments Nos. III, IV and V were obtained a second series of experiments were started where spraying with single treatments of the lower parts of the bushes was done, the spray liquid being used at an average rate of approximately 110 gls. per acre.

There are investigated in these experiments dosages of insecticides, which approximate the average cost, in the case of both chlordane and dieldrin, of Rs. 10, Rs. 50, and Rs. 100 per acre.

9. **Summary.**

1. In these experiments chlordane of a strength of 3.75 per cent of the technical chlordane as the active ingredient and dieldrin of a strength of 0.5 per cent of active ingredient was used.

2. When tea was sprayed at a height of 6" above ground level, the spray liquid was used at an average volume of approximately 110 gals. per acre and when sprayings were done at the height of 1 ft. above ground level the corresponding volume was 245 gals.

3. Experiments with tea at the average approximate height of 3 ft. show there were no significant differences in the degree of reduction of numbers of live adults between the plots sprayed once at heights 6" and 1 ft. above ground level.

4. When tea of the average approximate height of 3 ft. at 14, 15, 18 and 20 months after pruning, was sprayed once at heights of 6" and 1 ft. above ground level, there was a considerable reduction in the number of live adults 2½, 3, 6, 7, 8 and 9 months after treatments.

5. No injury was caused to the tea by the spraying.

6. Owing to the favourable results obtained from these trials, a new series of experiments were started where single spray treatments of the insecticides were given in lower volumes and at lower concentrations to the lower parts of the bush.

7. No practical recommendations emerge from the experiments described.

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