SOME FACTORS AFFECTING THE EFFICIENCY OF DIELDRIN SPRAYS FOR SHOT-HOLE BORER CONTROL

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Initial recommendations for the control of Shot-hole Borer (*Xyleborus fornicatus* Eichh) were published in the Tea Quarterly in 1961 (Cranham, 1961). At that time there was insufficient experimental evidence to give firm guidance in respect of two modifications in the method of spraying which can sometimes be advantageous, namely, (1) low-volume application through motorised knapsack mist-blowers and (2) application of mixtures of dieldrin and lime ('Limbux'; *ex.* I.C.I. (Export) Ltd). Also at that time there was insufficient evidence on the value of two 20% emulsifiable concentrate (E.C.) formulations ('Dieldrex 20' and 'Dieldrex Extra', *ex.* Shell Company of Ceylon, Ltd), and a 50% wettable powder formulation of dieldrin, or mixtures of these formulations with lime. A further point of interest was the extent to which the efficiency of dieldrin sprays is affected by spraying on wet bark, and by heavy rainfall soon after spraying.

Two replicated plot trials were started at Kataboola Group, Kotmale (Lower B. Field) in May 1961 to obtain evidence on the above aspects, and these were concluded in 1963. In addition further evidence has been obtained from the 1960-1963 series of large-plot dieldrin trials on estates (Cranham, 1963, 1964) and from the practical experience of estate superintendents.

Kataboola Trials

Trial 1 was of randomised block design of four replicates with plots of 200 bushes, and involved treatments 1-10 given in Table 1. The three dieldrin formulations, two 20% emulsifiable concentrates and a 50% wettable powder, were each included at two dosage rates, to provide a better comparison of the formulations and to check the value of dosages lower than the standard 6 pints per acre of 'Dieldrex' E.C. (Cranham, 1961).

TABLE 1.—*Trial 1 (Kataboola)—Counts of Galleries and Infestation after spraying*

TREATMENTS (Rate per 100 gallons per acre)	Count per 100 Sample Units					
	Galleries After (Months):			Infestation After (Months):		
	17	25	29	17	25	29
1. 'Dieldrex Extra', 6 pints	7	24	54	9	64	84
2. 'Dieldrex Extra', 3 pints	5	26	76	4	79	177
3. 'Dieldrex 20', 6 pints	0	21	60	0	35	79
4. 'Dieldrex 20', 3 pints	5	21	81	0	58	202
5. Dieldrin W.P., 4 lb	8	14	57	23	28	110
6. Dieldrin W.P., 2 lb	4	26	67	3	41	154
7. 'Dieldrex 20', 6 pints plus LIMBUX	10	34	64	41	73	102
8. Dieldrin W.P., 4 lb plus LIMBUX	6	9	44	5	3	108
9. 'Cereclor' W.P., 8 lb	18	61	125	75	109	152
10. 'Cereclor' W.P., 4 lb	15	52	109	62	74	213
Least significant difference (P=0.05)	—	24.9	23.3 (2)	(1)	(1)	(2)
11. 'Dieldrex 20', 6 pints (WET BARK)	5	27	60	13	21	174
12. 'Dieldrex 20'. 3 pints (WET BARK)	4	21	68	3	42	153
Unsprayed area(Average)	34	84	112	82	116	134

N.B.—*Treatments* 11 *and* 12, *and the unsprayed area, were not included within the randomised block design of the trial but were adjacent to it.*

(1) *The means for Treatments* 7 *and* 8 *were significantly different.*

(2) *Of the first six dieldrin treatments, the average count for the three higher dosages was significantly lower than the average count of the three lower dosages.*

The other dieldrin treatments were 'Dieldrex 20' at 6 pints plus 1½ hundredweight of 'Limbux' in 100 gallons per acre (the usual rate of lime application for demossing); and the same rate of 'Limbux' with 4 lb of dieldrin W.P. 'Gamma-Cereclor', an experimental 26% W.P. of Gamma B.H.C. designed to give good persistence, was included at 8 lb and 4 lb per acre for comparison with the dieldrin treatments.

Eight extra plots, which were not within the randomised block design, were added to the outside of the trial (after it had been laid down) in order to study the effect of spraying dieldrin on wet bark as compared with spraying on dry bark, by deliberate choice of a wet and a dry day. Treatments 11 and 12 of 'Dieldrex 20' at 6 pints and 3 pints per acre, sprayed on wet bark, can be compared with Treatments 3 and 4, sprayed on dry bark.

In Trial 2, on 16 plots of one-eighth acre in size, the four treatments were completely randomised. The treatments, No's 13-16, are given in Table 2. 'Dieldrex 20' E.C. was sprayed low-volume by mist-blowers at the dosage rates of six pints and three pints in 10 gallons of water per acre, sprayed deliberately both on a wet day and on a dry day, as in Trial 1. The size of plot used, at one-eighth acre (20 by 30 yards), had been found to be the minimal size suitable for applying mist-blower treatments with very little spray drift on to other plots.

As a check for both trials, the build-up of the borer population in unsprayed tea was estimated by taking 300 sample units from the larger area of unsprayed tea surrounding the trials on three sides.

The trials were sampled at 9, 12, 17, 21, 25 and 29 months after pruning, by taking 25 sample units per plot on the smaller plots of Trial 1, and 50 units per plot on the larger plots of Trial 2. The results of the trials were shown principally in the counts of galleries and live borers made at 17, 25 and 29 months which are given in Tables 1 and 2.

TABLE 2.—*Trial 2 (Kataboola)—Counts of Galleries and Infestation after spraying*

'DIELDREX 20' TREATMENT (BARK WET OR DRY)	Count per 100 units					
	Galleries After (Months):			Infestation After (Months):		
	17	25	29	17	25	29
13. 6 pints (Dry)	3	15	68	1	25	129
14. 3 pints (Dry)	5	33	91	2	78	151
15. 6 pints (Wet)	7	26	66	11	47	136
16. 3 pints (Wet)	7	23	86	6	64	144
Unsprayed area (Average)	34	84	112	82	116	134

Results

In Trial 1, the plots treated with 'Gamma-Cereclor' W.P. showed a more rapid build-up of infestation than all dieldrin treatments and the counts were comparable with the unsprayed control area. Later trials confirmed the ineffectiveness of this insecticide. These plots made a useful comparison for the dieldrin treatments.

On the counts of galleries for the 25th and 29th months, all dieldrin treatments (except No. 7 at the 25th month) were significantly better than the 'Cereclor' treatments.

The low count of galleries and infestation shown by Treatment 8, (dieldrin W.P. plus lime) at the 25th month is notable; this was significantly better than the result of Treatment 7 ('Dieldrex 20' E.C. plus lime). This difference was no longer apparent in the 29th month, probably due to more general reinfestation of the plots.

There were no other significant differences between individual treatments but, of the six dieldrin treatments without lime, the average count for the higher dosages (1, 3, and 5) was significantly lower for infestation at the 25th and 29th months, and for galleries at the 29th month, than the lower dosages (2, 4 and 6).

The additional plots of Treatments 11 and 12 allow an approximate (non-statistical) comparison of the effect of spraying on wet bark on a rainy day with that of spraying on dry bark on a sunny day. Excellent contrasting conditions occurred within a period of four days; Treatments 1-10 were applied on dry bark on a brilliant sunny day. Treatments 11 and 12 were applied on wet frames in light drizzle and it continued to rain for the rest of the day. Under these conditions we would have expected the effect on the dieldrin deposit and the subsequent borer control to have been much reduced, but in fact the counts obtained were very similar to those for the same treatments applied dry (3 and 4) and compare similarly with the unsprayed area.

A similar lack of difference in the control obtained from the 'wet bark' treatments is the most notable feature of the results of Trial 2 (Table 2) in which the 6-pint and 3-pint dosages of Dieldrex 20 were applied in 10 gallons of water per acre by mist-blower. The 'dry bark' and 'wet bark' spraying were carried out separately on the same days as in Trial 1. In this instance, with a comparison within the design of the trial, the comparative results of the two dosages on wet bark and on dry bark were remarkably similar. The 6-pint dosage gave somewhat lower counts than the 3-pint dosage, similar to Trial 1, but the differences were not significant.

The comparison of the borer control obtained by high-volume spraying in Trial 1 and by mist-blowing in Trial 2 is not critical but the trials were adjacent in the same field. The counts obtained were very similar and may be compared with the counts from the large unsprayed area surrounding the trial.

Part of the function of these trials was to determine whether trials of such design, with replicated small plots, can be of value in sorting out points concerning the longer term (*i.e.* at least second-year) effect of treatments applied after pruning. It was feared that cross-infestation of the plots would obscure differences and for this reason untreated plots were left out of the design; firstly, because they provide a source of reinfestation which might affect adjacent plots more strongly, and, secondly, because they would probably not provide a fair measure of the build-up of the infestation on unsprayed tea.

It is clear that such trials cannot be assumed to evaluate the duration of control that a particular treatment might give on a whole field. Thus, although in Trial 1 there was evidence that the 3-pint dosage gave somewhat inferior control compared to the 6-pint dosage, this does not determine the value of the lower dosage when applied to whole fields. This is being evaluated in a series of large-scale trials involving dieldrin, aldrin and 'Telodrin' (Cranham, 1964).

However, despite the likelihood that movement of infestation has tended to reduce differences, Trial 1 showed up significant differences between dieldrin and 'Cereclor' treatments, and a significant average difference between the two dosage levels of the three dieldrin formulations. This gives us some confidence that the broad comparison made of the formulations, and of the 'wet bark' and 'dry bark' sprayings, is at least valid, although not precise.

We conclude that such trials can show up large differences between treatments. Better replication is desirable, and it is felt that the trial design could usefully be modified to expose all plots more or less equally to reinfestation from unsprayed tea.

Discussion

Efficacy of different formulations of dieldrin:—Both 'Dieldrex 20' and 'Dieldrex Extra' (*ex* Shell Company of Ceylon, Ltd.) are emulsifiable concentrates containing 2 lb of technical dieldrin per I.G. The latter formulation contains in addition a coumarone resin and was formulated originally to give increased resistance to rainfall of spray treatments against the Coconut Beetle (*Oryctes rhinoceros*). Compared at dosages of 3 pints and 6 pints/100 gallons/acre, these formulations in Trial 1 gave similar results and there was no evidence that the formulation with added resin ('Dieldrex Extra') gave a better duration of control.

In the various large-scale dieldrin trials, 1960-1963 series (Cranham, 1963, 1964), some estates used 'Dieldrex 20' and some used 'Dieldrex Extra'. The best, and poorer, results were obtained from both formulations. Thus, although here there was no precise comparison, there was no empirical evidence that the 'Dieldrex Extra' gave better results, nor therefore that the extra cost of using it is justified.

In Trial 1, Dieldrex W.P. at 4 lb and 2 lb/100 gallons/acre (2 lb and 1 lb of dieldrin per acre) gave similar results to the emulsifiable concentrates at 6 pints and 3 pints/100 gallons/acre (1.5 lb and 0.75 lb of dieldrin) and would appear to be effective in practice. Previously we had no evidence that dieldrin wettable powders would give long-term control; it seemed likely that the emulsions would stand up better to weathering by rainfall. In this trial there was no evidence that the wettable powder performed less well in the high rainfall area of Kotmale. The wettable powder has been used on whole fields by a very few estates at 3 lb per acre (1.5 lb dieldrin) with apparently good results.

It is somewhat cheaper per pound of actual dieldrin and the need for a more precise comparison of the relative activity of the wettable powder and emulsion formulations is indicated.

Mixtures with lime:—Interest in the wettable powder is particularly focussed on mixtures with lime (Limbux). A practical advantage, apart from the use of lime for de-mossing, is as an aid to supervision of spray coverage. For this purpose, if de-mossing is not required, one-half a hundredweight of lime per acre is probably sufficient.

In Trial 1 a good result was obtained from the mixture of 4 lb 'Dieldrex W.P.' with 1½ cwt of Limbux per acre; the counts at the 17th and 25th months after spraying were notably better than the mixture of 'Dieldrex 20' and Limbux.

The mixture of 'Dieldrex 20' with lime is also much less satisfactory with respect to physical compatibility—it forms a very thick sticky mixture—which may account for the relatively poorer result. The addition of the wettable powder to lime virtually does not alter the lime suspension so that it can be sprayed like lime alone.

At least one estate is known to have used this mixture of 'Limbux' and dieldrin 50% W.P. (at 3 lb per acre) with good results on a large scale. It would seem to have such particular advantages as to merit field-scale trial by estates.

Weather conditions and spraying:—The results obtained in these trials on the plots sprayed deliberately when the bark was wet and there was in fact light rain occurring, is in complete contrast to the previous evidence of Judenko's work (Judenko, 1960) which, together with empirical appraisal of the problem, resulted in the stress laid on the need to spray on dry bark only (Cranham, 1961).

In our trials it was actually raining when the 'wet bark' application was made; this was not the case in Judenko's trials. Also his trials were based on a comparison of the effect of a wide range of dosages applied to the basal frames of tea in plucking on a wide variety of sites.

The conclusions are so opposed, however, that further investigations of this interesting aspect of spray application will be required to clarify the issue. The result of the present trials cannot be explained, and until further results are obtained it would be rash to modify the recommendation to spray on dry bark only.

The results being obtained in heavy rainfall districts such as Lower Dickoya and Kotmale, strongly suggest, however, that rainfall subsequent to spraying has little effect on the degree of control obtained. Earlier doubts that post-pruning sprays of dieldrin could be successfully applied in the wetter districts have proved to be largely unfounded.

Mist-blower application:—In Trial 2, the control of the borer obtained from mist-blower application of the six-pint and three-pint dosages of 'Dieldrex 20' was similar to the control obtained from the high-volume (100 gallons per acre) sprays of the same dosages in Trial 1. The comparison is not critical but the trials were adjacent in the same field.

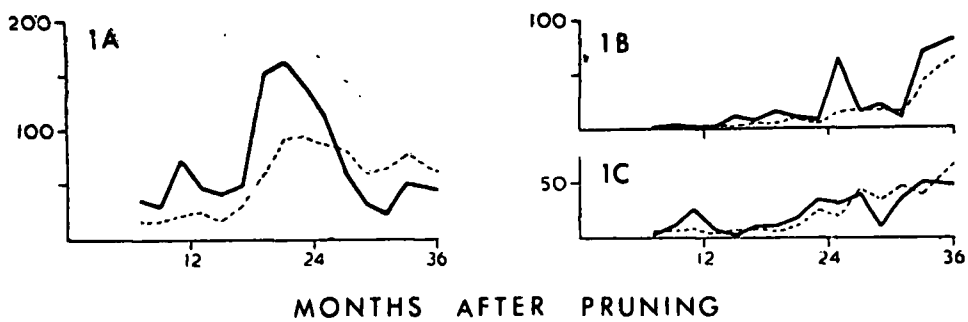

Figure 1.—The results to the 36th month after pruning of the trial at No. 8 Field, Uva Ketawella Estate: the number of live borers (heavy line) and of galleries (dotted line) per 100 sample units on the unsprayed plot (1A), on the high-volume plot (1B), and on the low-volume plots (1C) (see text).

A further comparison of mist-blower and high-volume sprayed plots was obtained from the large scale trial on No. 8 Field, Uva Ketawella (1960-1963 dieldrin trials; Cranham, 1963, 1964). The counts of infestation and galleries taken in bi-monthly samples are graphed in Figure 1. Figure 1A gives the data for the unsprayed control plot, Figure 1 B for the plot treated with two rounds of 3 pints 'Dieldrex Extra' in 90 gallons water per acre, and Figure 1 C gives the average data of 2 plots treated with one round of 6 pints 'Dieldrex Extra' in 8 gallons of water per acre applied by mist-blower. It will be seen that both high-volume and low-volume

treatment gave very good control of a similar order when compared to the unsprayed plot; although the high-volume treatment involved two rounds of 90 gallons of spray solution (with a total of 6 pints 'Dieldrex Extra' per acre) the result was very similar to that from the single mist-blower treatment.

Further evidence of the value of mist-blower treatments of dieldrin when applied by estates on a large scale has now been obtained by several estates, notably Uva Ketawella Estate, Hali-Ela, and Endane Estate, Kahawatta, where the bulk of the entire acreage has been sprayed in this way.

Recommendations

Resulting from this work we can summarise here the amendments to the recommendations on the chemical control of Shot-hole Borer given in the Tea Quarterly, December 1961.

1. We have found no practical advantage to justify the additional cost of using 'Dieldrex Extra' (*ex* The Shell Company of Ceylon Ltd), a 20% dieldrin E.C. containing added coumarone resin.

Suitable 20% dieldrin E.C. formulations available in Ceylon are:—

'Dieldrex 20' (The Shell Company of Ceylon Ltd).
'Baur's' dieldrin 20% E.C. (Messrs A. Baur & Company, Ltd).

2. When it is desired to use 'Limbux' (*ex* I C.I. (Export) Ltd. Colombo) for de-mossing, the most suitable formulation of dieldrin for admixture with the lime is the 50% wettable powder (*ex* Shell Co), at 3 lb (or 4 lb) per acre.

The 'Limbux' must be thoroughly mixed and sieved at the recommended dosage rate of 1½ to 2 cwt in 100 gallons of water per acre. The dieldrin W.P. is creamed and poured through a sieve into the tank of lime-wash while stirring well. Fairly coarse nozzles are required to spray this mixture, *e.g.*, Birchmeier 'Duro' 1.5 mm, or Favori-Colibri No. 520, disc 214/15. The very coarse old-fashioned 'lime-wash nozzles' are wasteful.

The admixture of dieldrin liquids (emulsifiable concentrates) with Limbux is much less satisfactory with respect to physical compatibility; they form a very thick sticky mixture which is very troublesome to spray.

A practical advantage of mixtures of 'Limbux' and dieldrin W.P., apart from the use of lime for de-mossing, is as an aid to supervision. For this purpose, if de-mossing is not required, 56 lb of Limbux per acre is sufficient. The deposit shows up clearly only when dry.

No suitable available material can be recommended as a 'tracer' for mixing with the dieldrin emulsion formulations.

3. Application of dieldrin by motorised knapsack mist-blowers, employing a standard dosage of six pints in 10 gallons of water per acre, has been found to give control of the same order as 'high-volume' spraying by ordinary knapsacks in 100 gallons of water per acre. Reference should be made to the Tea Quarterly December, 1961, pp. 180-182, for a description of the method and when it is advantageous to use it, *e.g.*, particularly after the light pruning practised in the low country, and in the wetter districts. Special care should be taken to prevent drift of the spray mist on to tea in plucking, and excessive contamination of the spray operator (Cranham, 1961).

References

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