RESEARCH ON NEW DEVELOPMENTS IN SHOT-HOLE BORER CONTROL

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I have recently published in the Tea Quarterly a comprehensive popular account of shot-hole-borer biology and control (Cranham, 1963), and today I want to tell you something about the research we are doing on new developments in chemical control.

In districts where Shot-hole borer is a pest, dieldrin is being used on a wide scale after pruning and the results, in terms of borer control and yield increases, are generally good. There, are, however, various reasons why we should study variations in the method of control, or the use of alternative insecticides.

The major reason is the marked Tortrix side-effect of dieldrin. If we can do away with this or greatly reduce it, we shall have made a useful step forward.

Secondly, the results show that, where tea is run for pruning cycles of longer than two years, we usually obtain good control of the borer for two years but there tends to be a third year build-up of infestation which is usually not more than half the peak of attack that would normally occur in the second year. Generally, we have done more than postpone the attack for a year — we have also reduced it considerably — but nevertheless the problem of the ' third-year build-up ' merits attention.

Thirdly, most pruning is done in wet seasons. Particularly in the wetter districts, it is not always easy to find suitable days when the dieldrin spraying can be done on dry pruned frames. This has not proved to be so serious a difficulty as we thought it might be, and the development of mist-blowing dieldrin has helped planters to make better use of the available dry days ; nevertheless, it is a problem still to be considered.

Fourthly, we want the methods of control available to be as practically useful and convenient as we can make them. And last but not least, we want, if we can, to reduce the cost of borer control, which at present also involves the cost of the accessory control of Tortrix.

Alternative insecticides :

Recent work has shown that the insecticides aldrin and Telodrin give an excellent initial kill of the borer. Employing rates which could cheapen the cost of control compared to dieldrin, the reduction in numbers within the first few weeks after spraying was faster than with dieldrin and quite as good.

The first trial was carried out on a very heavily infested new clearing in the Welimada district. The details of this trial I have reported elsewhere (Cranham, 1964).

In Figure 1 the counts of live adults and immature stages of the borer per 100 sample units are shown in histogram form. The black part of each histogram represents the number of adult beetles, and the unshaded part the numbers of young immature stages, larvae and pupae, in each case.

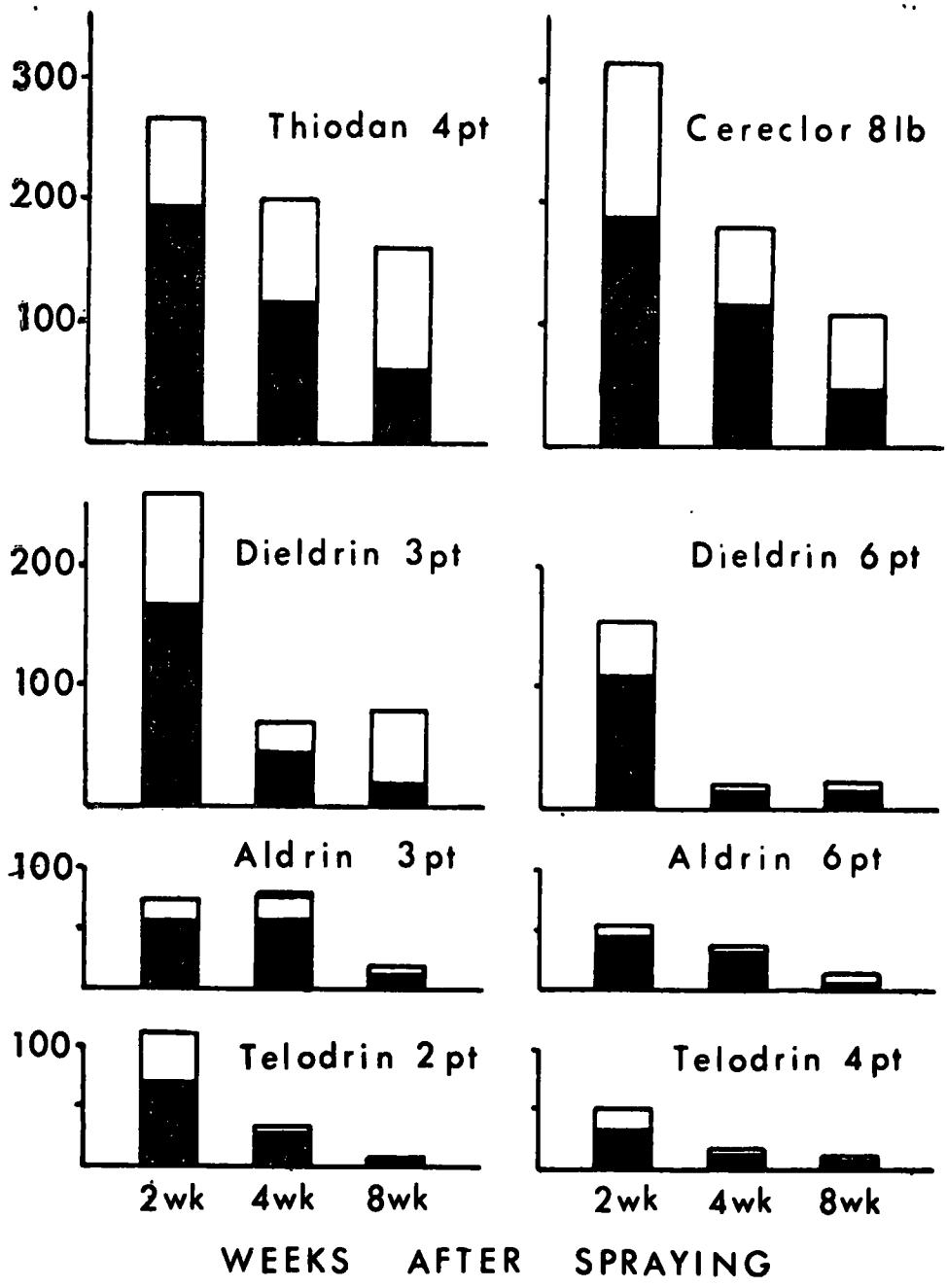

Fig. 1.—The results, in histogram form, of a trial comparing the control of Shot-hole Borer soon after spraying with various insecticides. The black part of each histogram represents the number of adult beetles and the unshaded part above it the number of immature stages per 100 four-inch sample units 2 weeks, 4 weeks and 8 weeks, after spraying.

The dosages of insecticides shown on the diagram are in pints or lbs. of the formulation per 100 gallons of water: the formulations used were 20% E.C.'s of aldrin and Telodrin, a 15% E.C. of Telodrin, a 35% E.C. of Thiodan, and 'Cereclor' W.P. containing 26% gamma B.H.C.

On the right we have the results of the higher rates of dieldrin, aldrin and Telodrin, and on the left the results of lower rates of these insecticides, and in each case we have given the numbers surviving 2 weeks, 4 weeks and 8 weeks after treatment.

There were no comparable untreated plots within the trial proper and for comparison I have included the results of two other insecticides, Thiodan and Cereclor (a gamma B.H.C. formulation) that gave a poor control of the borer.

The figures illustrate that by two weeks after spraying the reduction in numbers of adults and young was significantly better for aldrin and Telodrin than for dieldrin, indicating a more rapid reduction in numbers. Eight weeks after spraying, the results from the higher dosage rates of all three compounds were good and were not significantly different, but at the lower dosage rates aldrin and Telodrin gave a significantly better reduction of the numbers of young. Notably, the control of young on the Telodrin plots was almost complete.

In another trial we compared Telodrin and dieldrin at a range of three dosages—dieldrin at 2, 1 and ½ lb of technical dieldrin per 100 gallons and Telodrin at ½, ¼ and ⅛th lb of Telodrin per 100 gallons. In Figure 2, the results have been expressed as percentage control by comparison with the counts on the unsprayed plots.

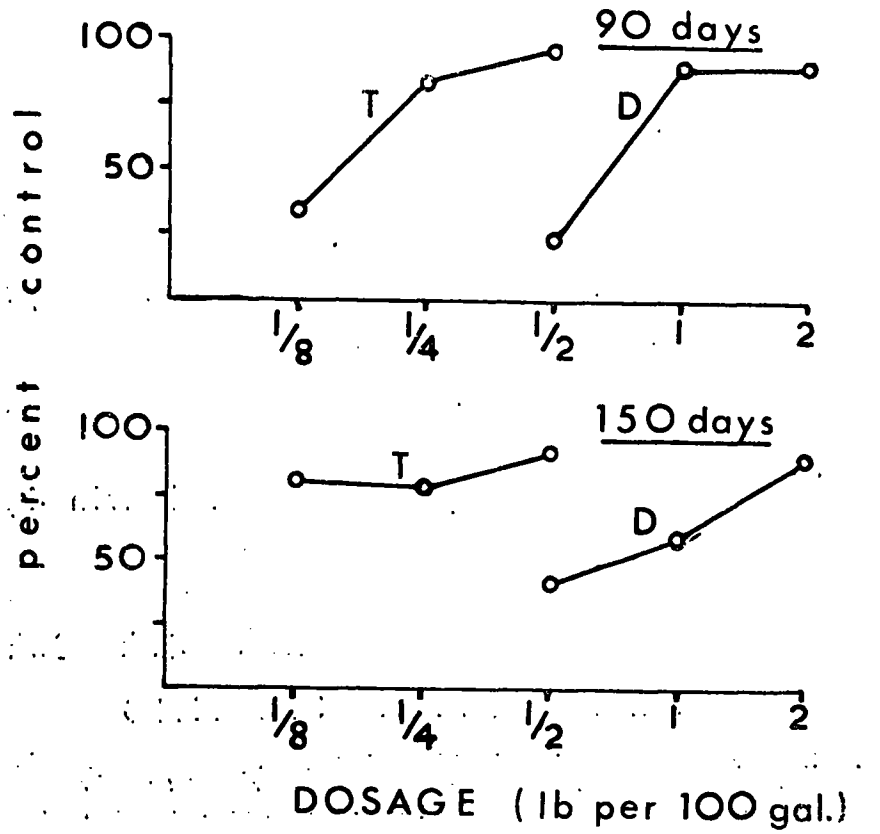

Fig. 2.—The results of a trial comparing Telodrin and dieldrin against Shot-hole Borer. Percentage control is plotted against dosage (log scale) · ninety days (above) and 150 days (below) after spraying.

The top figure gives the result 90 days after spraying when it will be seen that the results from Telodrin at this low range of dosages were very similar to the results from dieldrin at dosages which are four times greater,

The lower figure gives the results later — 150 days after spraying — when the percentage control from the two lower dosages of Telodrin appears to have improved relative to the control obtained from the two lower dosages of dieldrin, although the difference is not statistically significant.

These results show that Telodrin has a very powerful activity and we can conclude that this insecticide has an activity around four and possibly more times that of dieldrin against Shot-hole Borer, *i.e.* it is equally active as dosages a quarter or less those of dieldrin.

In a third trial, we sprayed aldrin, dieldrin and Telodrin on the basal parts of the frames of some rather thin tea in plucking, 16 months from pruning and heavily infested. The tea was put temporarily out of plucking after spraying to avoid insecticide residues in made tea. For each insecticide we sprayed a plot 5 acres in size with a straight boundary against a similar area of unsprayed tea, in order to study whether there was a progressive re-infestation into the sprayed plots from the unsprayed ; to see if reinfestation might occur to a greater extent on the aldrin or Telodrin area than on the dieldrin area. Accordingly, we sampled points at the boundary and 10, 20, 40 and 60 yards from the boundary into the sprayed area and into the unsprayed area in each case, and continued sampling at intervals for ten months after spraying, by which time the infestation on the unsprayed areas had greatly declined as it normally does in the third year. During this period we did not detect any reinfestation of this character working in from the boundaries on any of the three treatments.

In Table 1 therefore I have recorded only the total counts for 250 sample units for each plot, giving the results for dieldrin and the adjacent unsprayed control area, aldrin and unsprayed control area, and Telodrin and control area, and recording results before spraying — which are of the same order in each case —and the counts made at 7, 12, 24, 33 and 41 weeks after spraying. It will be seen that the results from aldrin and Telodrin compare well with dieldrin — a better reduction initially and a similar result later. The numbers on the Telodrin plot were particularly small after spraying.

Having briefly sketched the results of some of our first experiments with these two insecticides, I should like to discuss some of the points we must consider and evaluate before we can come to make recommendations for their use.

Aldrin is an insecticide that is closely related to dieldrin and is in fact a stage in the synthesis of dieldrin. Aldrin is very much more volatile than dieldrin with the result that residues of aldrin on plant surfaces have a very much shorter life than dieldrin ; however, a small part of the aldrin is oxidised to dieldrin and when using aldrin we therefore have to consider residues of dieldrin as well as those of aldrin.

Telodrin is a relatively new insecticide in the same group of chlorinated hydrocarbons which includes aldrin and dieldrin. It is an extremely powerful insecticide, several times more toxic to many pests than aldrin and dieldrin, but also several times more toxic to man and other vertebrates. It is intermediate between aldrin and dieldrin in volatility and persistence. As noted, Telodrin has been found to be about four times as active against Shot-hole Borer as dieldrin, and if we can use it effectively at dosage one-quarter those of dieldrin the toxic hazard to spraying labour would still be greater than with dieldrin but not excessively so.

Does the activity of these two insecticides offer us superior alternatives to dieldrin ? Firstly we have to compare them with dieldrin for (1) Tortrix side-effect and (2) the duration of borer control. Because they give a good initial control it does not follow that they will give as good long-term control as dieldrin. We do not

know how far the duration of control obtained with dieldrin is dependent not only on the initial kill but on long residual effects in relation to reinfestation. Since both the Tortrix side-effect and the duration of borer control are greater the larger the area sprayed it is opportune in trials to use plots which approximate to whole fields in size. For this purpose, from late 1962 into 1963 we have, with the cooperation of estates, started ten large-scale trials, comparing aldrin, Telodrin, and dieldrin, sprayed after pruning on mature tea. These trials cover over 500 acres of tea and the plots average about ten acres in size. We have to wait until late 1964 before we shall begin to build up a picture of the long-term effectiveness of aldrin and Telodrin. Until we have proof of their long-term value as post-pruning sprays on mature tea I would not suggest that estates experiment with them on their own account. I would stress that at present we do not have a single trial giving proof of their long-term value.

These trials have already given us some results concerning the Tortrix side-effect. It is evident that aldrin, in line with its lower persistence, interferes with the parasite of Tortrix (*Macrocentrus homonae* Nixon) for a very much shorter period than dieldrin. Out of eight trials, there were two where the general incidence of Tortrix was high even on the unsprayed plots and the aldrin plots suffered severe attacks requiring chemical control *i.e.* although re-establishment of the parasite *Macrocentrus* occurred much faster on the aldrin plots than on the dieldrin and Telodrin plots, it did not occur fast enough to prevent serious Tortrix attack requiring chemical control. In the six other trials the aldrin plots suffered only very slight attack when the neighbouring dieldrin plots suffered more severe attack requiring spraying. The indications are, therefore, that if aldrin proves effective for long-term control, its use will produce very much less Tortrix side-effect and will seldom require accessory chemical control of Tortrix.

TABLE 1.—*The results of the third trial comparing aldrin, Telodrin and dieldrin.* (*See* text).

	Pre-count	After Spraying (Weeks)				
		7	12	24	33	41
DIELDRIN	292	113	93	62	24	14
Control	431	213	236	194	150	101
ALDRIN	280	26	43	66	20	7
Control	300	371	191	269	28	17
TELODRIN	340	22	11	6	7	4
Control	302	243	199	205	111	78

Telodrin on the other hand interferes with *Macrocentrus* to a degree more comparable with dieldrin. It is also much more toxic to Tortrix than aldrin or dieldrin. When tried for Tortrix control it gave a fairly good initial control but due to persistent toxicity to the parasite there was a rapid resurgence of Tortrix. Because of this, and the danger of Telodrin residues in made tea, it is quite unsuitable as a control for Tortrix. So far in our trials the degree of Tortrix attacks in the Telodrin plots has been intermediate between that on the aldrin and on the dieldrin plots.

If the low dosage of 2 pints of Telodrin 15% liquid proves to be effective for long-term control we can expect appreciably less incidence of Tortrix than after dieldrin spraying. But we still need to obtain all our results.

Other types of spraying :

So much for our new series of experiments on post-pruning sprays of aldrin and Telodrin. There are, however, other types and times of spraying worth considering as possibilities.

The average graph of infestation and galleries on the unsprayed plots of our 1960-1963 dieldrin trials (Figure 3) shows how the infestation on the unsprayed plots starts to build up on an average from the ninth month after pruning, increasing steadily to a peak in the 18th-22nd months, and then declining. When we spray after pruning we are applying measures to control an attack that begins 9-10 months later. It would be more logical, and asking less of an insecticide, to spray just before an attack begins.

I will not here discuss the reasons why post-pruning spraying works as well as it does. I will stress that it is a most practically convenient time to spray, to get at the frames and achieve good spray coverage, and to avoid insecticide residues in made tea. For these reasons it will probably always have a major place in practical control measures.

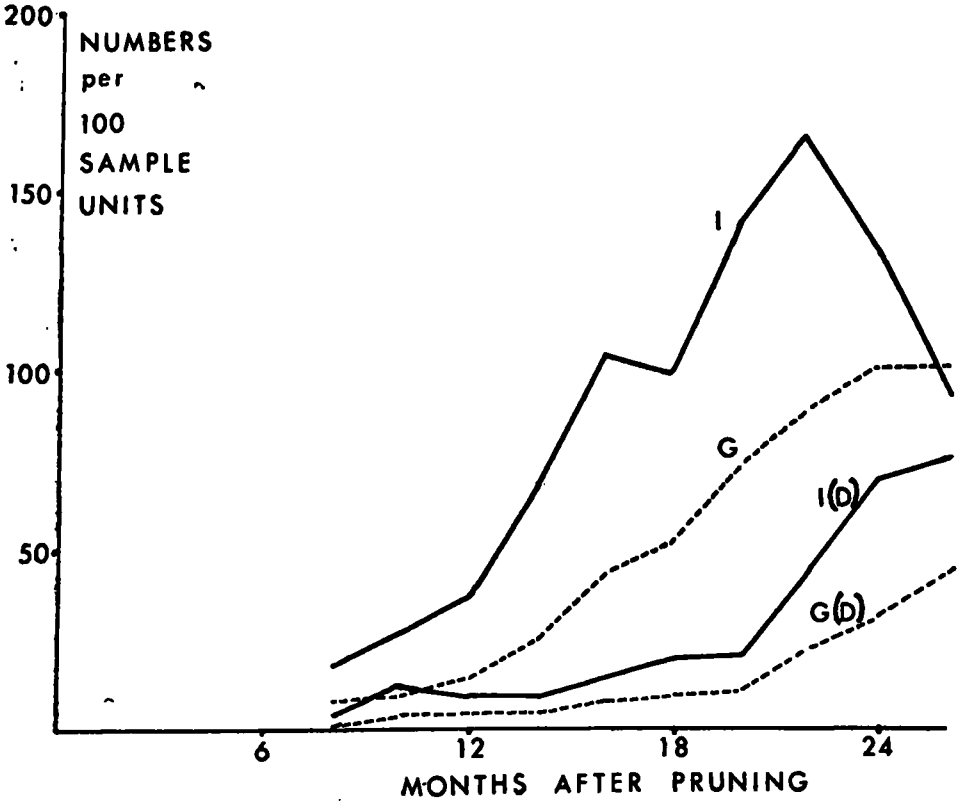

Fig. 3.—The average graphs of infestation and galleries from the 1960-1963 dieldrin trials. The number of live borers (I) and galleries (G) per 100 sample units on the unsprayed plots; and the number of live borers (I(D)) and galleries (G(D)) on the sprayed plots, to the 26th month after spraying.

One alternative is to spray the basal parts of the frames when the bushes are in full foliage, which could be done, say, about one year after pruning. Judenko (1960) found that this type of spraying was effective in control on small-plot experiments. It is only practicable when the frames are accessible for spraying (*i.e.* more particularly with high-jat bushes and an incomplete cover of tea) but it could be done on quite a fair proportion of mid-country tea. However, with dieldrin, it involves the chance contamination of the plucking table with a very persistent insecticide and thus necessitates resting the tea or discarding crop for eight weeks after spraying ; eight weeks we would consider a ' minimum safe period ' (M.S.P.) for dieldrin, necessary to avoid any residues in made tea. Also our experience shows that when this type of spraying is done on a field scale with dieldrin it can produce Tortrix outbreaks which can be even more troublesome on tea in full foliage than on tea recovering from pruning.

It is evident therefore, that what we require for this purpose is an effective insecticide which requires a shorter minimum safe period after spraying, and which does not aggravate Tortrix. So far, aldrin appears to go a long way towards meeting these requirements. We have carried out trial work to estimate the minimum safe period required after spraying aldrin. Analyses of the made tea samples were carried out at the Shell Woodstock Agricultural Research Centre in England. In order to estimate the maximum risk, we sprayed aldrin 20% E.C. at 4 pints and 8 pints per acre as a full foliage spray. The results show that residues of aldrin were negligible (less than 0.05 p.p.m.) after 14 days. A small part of the aldrin becomes dieldrin, and dieldrin residues lasted somewhat longer but were very low by 21 days after spraying (S.I.C.C. Ltd. 1963).

When spraying the basal parts of the bush frames, accidental spray drift on to the plucking table will generally be much less. Thus with this type of spraying a minimum safe period of three weeks is likely to give us the adequately large safety margin which we must have. During this three-week period, the tea could be rested and then brought back into plucking, or plucked once or twice and the flush discarded.

It is certain that the crop so lost will be small by comparison with that which is normally lost in the second year from serious borer attack. A practical advantage of this type of spraying is that we have more choice as to when to do it, compared to post-pruning spraying. Ideally I envisage that it could be done in the dry weather months two or three months before the monsoon so that this will give natural climatic factors the best chance to prevent any Tortrix trouble; which should enable this type of spraying to be done on a fairly large scale with very little risk of Tortrix.

With the promising activity of aldrin, our interest has been re-focussed on this type of spraying. Firstly, it should be of some value in those very wet districts where it is extremely difficult in the months when pruning is done to find suitable days for spraying on dry bark.

Secondly, it could provide an additional means of control with minimal risk of Tortrix outbreaks, so that, by a combination of spraying some fields after pruning and some fields after about one year or so from pruning, it will be possible for an estate to achieve an over-all reduction in borer incidence more quickly than would otherwise be possible ; this over-all reduction should be reflected in a better duration of control.

Thirdly, in relation to the problem of the third-year build-up in longer pruning cycles it may be useful to spray towards the end of the second year to maintain control in the later part of the cycle. In the development of this method of control we are now ready to arrange a limited number of field-scale trials on estates to try the method out in practice under observation by us. We are not yet ready to make a recommendation.

However, as I pointed out earlier, this type of spraying is only practicable where the frames are accessible for spraying. Where there is a very good cover of tea, or jats of tea with full skirts of side branches, it would not be practicable. Can we achieve control in any other way on this type of tea ? In one trial, we applied dieldrin and certain other insecticides by knapsack mist-blowers, directing the spray mist down into the plucking table of a fairly good cover of tea. With dieldrin we did achieve a fairly good control, but not with aldrin. We tried this out to see whether this method could give the sort of spray coverage that would achieve control, and with dieldrin it worked. Obviously, we would not suggest it as a practicable method of control with dieldrin since it would lead to maximum contamination of the flush and probably to maximum Tortrix trouble. However, the result obtained indicates that there is a possibility of achieving good enough spray coverage in this way, so that we might use this method if we had available an effective insecticide suitable for use on the plucking table. We are at present trying to determine whether such an insecticide exists amongst a number of organo-phosphorous insecticides of low toxicity.

The use of aldrin in new clearings :

Although it has not yet been shown that aldrin will give a similar duration of control to dieldrin when sprayed after pruning on mature tea, we have found that in new clearings control will last for a year or more. Since treatment is relatively cheap and carries little risk of Tortrix it can readily be repeated after a year or two if required. Spraying need not follow pruning so long as the frames are accessible for spraying.

If the new clearing is not in plucking, the question of a minimum safe period between spraying and plucking does not arise. If the clearing is in plucking, a safe period of three weeks between spraying and plucking is required — a much shorter period than the eight weeks required for dieldrin.

Hence we consider that planters can well try out aldrin in new clearings and the essential details of spraying are as follows —

1. Suitable ' emulsifiable concentrate ' formulations of aldrin available in Ceylon are listed below. These should be used at the dilutions noted *i.e.* 4, 5 or 6 pints per 100 gallons of water according to the concentration of the formulations used.

Supplier	*Formulation*	*Dilution*
The Shell Co. of Ceylon Ltd.	' *Aldrex* 2 ' (20%)	6 pints/100 gal.
Messrs A. Baur & Co. Ltd.	' *Baur's Aldrin' E.C.* (25%)	5 pints/100 gal.
Harrisons & Crosfield Ltd. and Messrs Fisons (Ceylon) Ltd.	' *Toxadrin* ' (30%)	4 pints/100 gal.

2. Spraying need not follow pruning so long as the frames are accessible for spraying. The spray should cover as much of the wood over a quarter-inch thick as is practicable but particularly the lower parts of the frames to a height of 12" or so. This type of spraying on new clearings will generally require between 50-100 gallons per acre depending on the size of the plants; even 30-40 gallons may suffice on very small plants. The cost per 100 gallons of spray is approximately Rs. 20-/ to Rs. 24/- and thus the cost per acre will often be no more than Rs. 10/- to Rs. 12/- for chemical. We have as yet no results from mist-blowing aldrin ; but in any event mist-blowing would be a very wasteful method on small plants.

3. Spraying should be done when the bark is dry. Rain occurring soon after spraying does not matter particularly.

4. If the new clearing has been in plucking, there should be a three-week interval between spraying and the next plucking on which leaf is taken for manufacture, either by resting the tea for three weeks or by discarding one or two rounds.

5. The advice on spraying machinery and safe-handling given for dieldrin in Cranham (1961) applies also for aldrin.

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