

# THE CHEMICAL CONTROL OF SHOT-HOLE BORER (*XYLEBORUS FORNICATUS* EICHH.) ON TEA

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## 1. Introduction

Experiments on the control of Shot-hole Borer, by spraying the insecticide dieldrin very soon after pruning, have achieved a considerable measure of success. A few estates had already carried out field-scale experiments with this method of control in 1958 to 1959, and a very few estates later adopted it routinely on all pruned fields. In December 1960 the Director announced that the T.R.I. was not yet ready to make a general recommendation, but that we should be glad to give such information as we had to those estates that wished to experiment on their own initiative and responsibility. Accordingly, a mimeographed pamphlet (dated 24th October, 1960) was prepared and copies of this were requested by and sent to a large number of estates and agency houses. In fact, a large number of estates have carried out experiments, most of which have not yet run for long enough to judge the long-term results. The T.R.I. has been engaged on its own trials, and also in co-operating in the lay-out and assessment of trials on fifteen estates where the spraying has been done by the estate. It will be appreciated that there is a difference between the T.R.I. obtaining results in trials and estates obtaining results in practice; the estate trials are intended to provide evidence on results in practice and on a field-scale.

These trials, mostly started in 1960, have also not run long enough to assess the results fully, but most of the initial results on control are promising. In addition there is earlier evidence of the value of dieldrin in controlling Shot-hole Borer from estate sprayings done in 1958 and 1959 and from the experiments of Dr Judenko on spraying the basal parts of tea bushes in plucking (Judenko 1958, 1960). Not all of these results have been good but there is now no doubt of the effectiveness of dieldrin in controlling Shot-hole Borer when sprayed to give good coverage on dry bark, and there are cases where the control has already lasted for three years. However there is still doubt about the length of time for which control will be obtained under a wide variety of conditions, and we have to await the full result of the T.R.I. estate trials started in 1960. It is intended to publish the interim results in the Tea Quarterly for March, 1962.

With regard to the Tortrix side-effect, we are satisfied that this is due to a temporary unbalance in the normal parasitic control by *Macrocentrus homonae* and in every case observed so far the natural control has been restored, in most cases without serious damage by Tortrix (Cranham 1961). Further, the use of DDT in controlling Tortrix has worked out better than we could have reasonably expected, because not only has DDT proved effective in control but also it does not interfere with the re-establishment of *Macrocentrus*. The Tortrix side-effect is not therefore serious enough to bar the use of dieldrin. No other widespread side-effects have been observed by us, though a few isolated cases of increase in other pests, probably due to dieldrin, have been noted.

In these circumstances, when Shot-hole Borer is such a serious pest in the mid-country and parts of the low-country, and when so many estates are experimenting on a fairly large scale with this method of control, we feel that the T.R.I. should make a definite statement of such guidance as we can give.

We recommend the use of dieldrin on the lines to be given below, *with certain warnings and provisos, to which we ask you to give your careful attention.* We suggest that estates that have not experimented before with its use should not rush in headlong and spray all pruned fields, but that they should go carefully and spray a field or two to begin with. It is reasonable for those estates that have already obtained good results on a field-scale to go on to routine use on all pruned fields.

The natural balance of pests and parasite on tea is a valuable heritage, as yet largely undisturbed by the use of pesticides (Cranham 1961) and it is not without most careful thought, and a great deal more evidence than can be given here, that we now recommend the use of the persistent insecticide dieldrin for the control of the most serious insect pest of tea, Shot-hole Borer, because all cultural and other methods of control have failed. It is virtually certain that dieldrin will cause changes in the insect fauna of tea but it does not follow that such changes will be economically important or, in the total result, injurious. Some, such as the partial control of scavenging termites, may be beneficial. The use of dieldrin is a calculated risk—like much in tea planting—and, in making this initial recommendation, we have done all we can so far to calculate the risks involved. Our job is far from finished—the continuous appraisal of the many aspects of results, and work on refinements of the method, must necessarily go on.

In this work we have been greatly stimulated by the enthusiasm of many planters, and we express our sincere gratitude for their very real co-operation—long may it continue! With these thanks, and warnings, we wish you success in controlling this injurious pest, and express the hope that these measures will contribute appreciably towards a better economy of mid-country estates.

## **2. The method and how it works**

In essence, the method is simple: a dose of 6 pints of 'Dieldrex 20' (or 'Dieldrex Extra') in about 100 gallons of water per acre is sprayed on the dry bush-frames very soon after pruning and before bud-break.

Shot-hole Borer breeds mostly in the young wood, between one-quarter and one-half inch thick; normally the rate of increase is greatest in the early part of the pruning cycle, after the new wood becomes thick enough for galleries. Peak numbers are usually reached in the latter part of the second year and then numbers decline, but sufficient continue and later survive in the pruned frames to increase again in the next pruning cycle. Dieldrin spraying after pruning gives a high degree of control of the beetles and young stages of the borer left in the pruned frames, thus leaving very few to increase in number again in the next pruning cycle.

It has been shown that there is a sharp decline in numbers even within the first few weeks after spraying (Cranham 1961a), but we do not yet know how much of the total efficacy of the dieldrin is attributable to its persistence beyond the first 2 or 3 months.

Shot-hole Borers do of course disperse and reinfestation of the sprayed area from outside is a factor to be taken into account. We still know very little about the dispersal of this insect, but evidence so far suggests that it is quite slow and that,

in their effect on how long control will last, the numbers left on the field after the spray has done its work are more important than reinfestation from outside by immigration of beetles.

If this is so, it is very fortunate, but it does mean that spraying must be very effective initially and two points need stressing—*spray only on dry bark* and see that there is *excellent supervision*. If bushes are missed, or control is patchy because some was done in wet conditions, these will provide foci of infestation from which numbers can again build up, and this is likely to prove more important than reinfestation from outside. Naturally, the bigger the continuous areas that are treated with dieldrin, the less important will reinfestation be but we also have to consider the immigration of the parasite of *Tortrix Macrocetrus homonae* (see Section 4 below).

There was reason to hope that if we could obtain control of Shot-hole Borer for two years, the wood (regrowth from pruning) would afterwards be much less suitable for the breeding of Shot-hole Borer (Gadd, 1949). Some recent evidence, however, shows numbers on sprayed areas, which were small in the second year, to be increasing in the third year. We now have to answer the question: is the normal decline in numbers after a peak due to the wood becoming unsuitable as it ages, or does the wood simply become unsuitable due to overcrowding of shot-hole-borer galleries? Many data will have to be obtained to answer this question.

The practical issue is that with 2-year pruning cycles, spraying can if necessary be done after every pruning, but with 3-year or 4-year cycles, there may be a build-up in numbers in the latter half of the cycle and, if this happens, we cannot contemplate spraying dieldrin on the frames of tea in plucking—the risk of residues of dieldrin in made tea, which are not permitted by importing countries, is too great, even if the tea is put temporarily out of plucking. *Under no circumstances should spraying be done of tea in plucking.*

We do not yet have a general picture of long-term control. There is no reason to be pessimistic; indeed, in some instances, there is evidence of control being still good after three years. The observations do, however, again stress the need for the initial spraying to be done as well as is possible.

The method is not perfect nor is it very convenient, although the results to be obtained are worth the trouble. We are well aware that most pruning is done in wet seasons when it is not easy to find days when the bark is completely dry and, indeed, may be impossible in districts such as Lower Dickoya or Ratnapura. However, pruned frames dry out remarkably quickly and some promising results are being obtained even in these districts. We will go on trying to find the best and most convenient method for these districts. Again, spraying at 100 gallons per acre with knapsack sprayers is slow and tedious, and it may be difficult to get good coverage even with 100 gallons per acre when the frames are very large or the number of bushes per acre is large. To meet these difficulties, we are doing work which is described under Section 7.

### 3. Dieldrin spraying

Dieldrin is sprayed soon after pruning on the dry bush-frames, and the essential details are as follows:—

#### 3.1 THE INSECTICIDE

The Shell Company of Ceylon, Ltd., supplies 'Dieldrex 20' and 'Dieldrex Extra'; both of these formulations contain 20% w/v of the insecticide dieldrin

(2 lb. per Imperial gallon). 'Dieldrex Extra' also contains a resin which is said to give greater persistence of the insecticide, but no difference in the control obtained has yet been proven. 'Dieldrex 20' is a little cheaper per gallon. It is not yet known whether 'Dieldrin 50% Wettable Powder' is effective.

Either liquid formulation may be used on clean-pruned mature tea, but where foliage remains, as on young tea, or after lung-pruning or pre-pruning, we at present advise 'Dieldrex 20'.

### 3.2 DOSAGE

The dose to be applied for mature and adolescent tea is one round of 6 pints of 'Dieldrex' (1.5 lb. of actual dieldrin) per acre. This must be applied in a sufficient volume of water to cover the bush frames thoroughly and, using knapsack sprayers, this is generally about 100 gallons per acre, depending on the size of the bush frames. There is only one round of spraying to be done and it must be done very well.

If you can genuinely obtain good coverage with less than 100 gallons per acre, use the 6 pint dose in whatever volume of water is used per acre, e.g. in 70, 80 or 90 gallons per acre.

If you have to use more than 100 gallons per acre because of large bush frames or a large number of bushes per acre (e.g. 5,000 or more per acre) use the concentration of 6 pints per 100 gallons and use more of it.

Only for very young tea, which represents much less wood to spray, or for fields with an unusually low number of bushes, due to vacancies, use the concentration of 6 pints per 100 gallons and use whatever volume is necessary to cover the frames thoroughly; this should never be less than about 50 gallons per acre.

*N.B.*—Previously, we have suggested two spraying rounds of 3 pints per acre at a three-week interval, as an alternative. This can be used, but results so far suggest there is no advantage in two rounds, and it is easier to find one dry day than two, and one round requires less labour and supervision.

### 3.3 WHEN TO SPRAY

Spray as soon as possible after pruning so that spraying is completed before bud-break occurs. This varies from about one month after pruning in the higher mid-country to only two weeks or so in the low-country. Experiments have shown that the effect of dieldrin is very much reduced if sprayed when the bark of the frames is wet, and it is important that spraying should be done when the bark is dry and that the deposit should dry on before rain occurs. If it rains after spraying has been begun, spraying should be suspended until the frames are dry again. The occurrence of rain after the deposit has dried on is thought to be less important, although continuous very heavy rain may reduce the degree of control obtained. If spraying is delayed owing to the weather, it may still be done when buds are just about to break, i.e. there is a latitude of about one month after pruning in the mid-country, but less in the low-country. Do not spray any later than this (see Section 3.7 below).

Prunings must either be removed, stacked in drains or, if small, packed down well between the rows, in order to allow free access to the sprayers. It may be desirable after pruning to wait before spraying until the leaves on the prunings have dropped, but the most important criterion is the weather.

### 3.4 HOW TO SPRAY

On clean-pruned tea, or after cut-across pruning, spray the whole frame thoroughly from above and from all sides to cover all the bark, including younger wood, the trunk, and the main branches. Where pre-pruning or lung-pruning are done, spray the whole of the frame to the height of the prune, but not the foliage. If pre-pruning is done, spray soon after the pre-prune; plucking of the unpruned halves of the bushes *must* be stopped after spraying, since contamination with dieldrin is unavoidable and dieldrin-contaminated leaf must not be manufactured (*see* Section 3.7 below).

In new clearings, spraying is best done after a cut-across or prune, unless serious attack occurs when the plants are still very young and pruning should not be done. It is desirable to cover all wood from the base up to wood of pencil thickness, though this is sometimes difficult because of the lower foliage, and this will get sprayed too.

*N.B.*—We do not recommend that pruning should be altered in time or type to suit the spraying, if there is a danger in so doing. Prune the bushes in the way that is culturally best.

Most types of knapsack sprayers are suitable. Pressure-retaining sprayers, particularly with pressure regulators, are most suitable for uniform output and spray economy. It is necessary to spend several seconds on each bush to obtain good coverage, spraying downwards from above and upwards from all sides, so that nozzles giving a fairly low rate of output will economise spray fluid. Whereas fan jets are suitable for blister-blight spraying, nozzles giving a cone of spray are more suitable for most insect control. The following nozzles of certain popular makes are considered very suitable:—

<i>Make</i>	<i>Nozzle</i>	<i>Approximate time of output of 2½ gallons at 55 lb pressure</i>
Birchmeier	'Duro', 1 mm. disc	21 min
Birchmeier	'Horto-Sapphire', 0.9 mm.	28 "
Favori-Colibri	No. 520, disc 214/8	21 "
" "	" " disc 214/10	18 "
Four-Oaks	'Duiker' No. 2	28 "

For other makes, use nozzles giving a cone of spray and similar output times. The time is required to obtain good coverage of all the bark.

### 3.5 SUPERVISION AND TRAINING OF LABOURERS

It cannot be emphasised too strongly that *good supervision is vital*. This is not like blister-blight spraying; there is only one round and every bush must be thoroughly sprayed.

Labourers can be trained by spraying water. A simple calculation will show that at 100 gallons per acre, a tank of 2½ gallons must cover from say 50 bushes (density of 2,000 bushes per acre) to 100 bushes (density of 4,000 bushes per acre). The volume required increases somewhat with the bush density, but not in proportion.

The labourer has, therefore, for example 20 minutes (1,200 seconds) for 100 bushes and he can spend an average of 12 seconds on each bush. This gives an idea of what the pace should be, and it is worth checking in the first instance how many bushes are in fact being covered by one tank.

Alternatively, mark off one-fifth acre plots (*see* Section 7.1 below) and check that the right amount goes on each plot. This is suggested for training labour, but it would have merits as a routine.

A great aid to supervision would be a clearly visible deposit (*see* Section 7.2 below).

### 3.6 CAUTION—SAFE HANDLING OF DIELDRIN

Dieldrin has been very extensively used in agriculture and in public health work, with a good record of safety as regards any hazard to the spray operators. Nevertheless, insecticides are poisonous and dieldrin is one that can be absorbed directly through the skin in harmful quantities. Due care should be taken in handling it and superintendents are strongly advised to acquaint themselves with the manufacturer's advice on handling, and especially to arrange for adequate supervision to prevent misuse. The common-sense measures recommended are as follows:—

- (a) keep dieldrin formulations in labelled containers, away from food and out of reach of children and animals. Empty cans should be punctured and buried so that they cannot be used for drinking water, etc.;
- (b) when handling or mixing the concentrate, avoid spilling it on the skin and keep it out of the eyes, nose and mouth. If any is spilled, wash it off the skin and clothing immediately;
- (c) *wash thoroughly with soap and water* before eating or smoking and at the end of the day's work;
- (d) it is highly desirable to provide labourers with spraying clothes, which they change after work, and to have these washed regularly. A piece of hessian tied round the waist to cover the legs will prevent a good deal of skin contamination, provided this is discarded or washed when it becomes contaminated;
- (e) apart from gross contamination due to misuse, it is very unlikely that workers can have any genuine ill-effects except after prolonged working exposure. It is therefore wise, if extensive spraying is being done more or less every day, to switch spraying gangs after a month; the relieved gang should then be out of all contact with dieldrin for a month before being put back on to spraying;
- (f) to protect fish and animals, be careful not to contaminate streams or ponds with dieldrin. Do not clean spray equipment or dump excess spray material near such water. Dig a hole and bury it;
- (g) in the unlikely event of the insecticide being swallowed, induce vomiting by giving one tablespoonful of salt in a glass of warm water; and repeat until vomit fluid is clear or the odour of the solvent is gone. Have the victim lie down and keep quiet, and call a physician immediately.

### 3.7 RESIDUES IN MADE TEA

Residues of dieldrin in made tea are not permitted by importing countries and could be dangerous. Do not allow tea in plucking in adjacent fields to catch chance spray or drift. Spraying of tea in plucking should *never* be done and spraying should not be done later than recommended (*see* Section 3.3 above).

### 3.8 COSTS

The cost of chemical per acre (6 pints) is about Rs. 30/-, varying slightly with the quantity purchased. Generally, 4-5 labourers per acre are required; the nozzles recommended are of fairly slow output and ten loads of 2½ gallons, plus refilling time, per labourer per day, is quite good. Thus the labour cost is usually Rs. 10/- to 12/- per acre. There is also the matter of labour for stacking or packing down prunings. Together with the cost of spraying DDT (*see* Section 4.4 below) the total cost per acre is of the order of Rs. 60/-, two-thirds of which is for insecticide. On a two-year pruning cycle the cost of control is thus only Rs. 30/- per annum, which should be well worth while on the benefits gained.

## 4. DDT spraying and Tortrix

Tortrix outbreaks have occurred in such a large percentage of sprayings that we recommend spraying DDT as a routine prophylactic, not only when Tortrix is seen. It is important that planters should be particularly *vigilant* in looking for Tortrix on dieldrin-sprayed areas, or indeed for any increases of other pests which might be due to dieldrin. Vigilance is the price of freedom from pests. Permit a few Tortrix, which will help to support the parasite *Macrocentrus*, but if an outbreak does occur again after the DDT spraying, do not hesitate to use DDT again—this should rarely be necessary. Do not allow Tortrix to spread to other fields from an outbreak, which it can quickly do. The use of DDT will not interfere with the natural re-establishment of *Macrocentrus*, which is usually achieved about four months after spraying dieldrin (Cranham, 1961).

It is of course necessary that *Macrocentrus* should be available on adjacent unsprayed tea, so as to hasten its re-entry of the sprayed area to recover natural control of Tortrix. For this reason, it is desirable that sprayed fields should border unsprayed fields, or fields sprayed more than six months previously, on at least one side. There have also been indications that *Macrocentrus* can come in from adjacent jungle, but not from patana. This restriction does not prevent one from spraying large continuous areas of many fields over a period of time—and this will reduce the re-infestation by immigration of Shot-hole Borer from outside.

Never put tea out of plucking because of Tortrix; this will make the attack worse; plucking is a partial control measure. Markedly higher rates of dieldrin than those recommended are liable to lead to worse Tortrix attacks.

Damage from Tortrix is worst in the early stages of recovery from pruning; later a small number of Tortrix per bush will not be serious. It has been noted that it can be particularly nasty, where pre-pruning is done, on the young re-growth from the secondary prune.

#### 4.1 INSECTICIDE

Emulsion formulations of DDT are recommended, including the following:—

<i>Supplier.</i>	<i>Trade name</i>	<i>Percentage DDT</i>
I.C.I. Ltd., & Agents	'Didimac 25' liquid	25%
Fison's (Ceylon) Ltd.	'Sillortox'	25%
Shell Co. of Ceylon, Ltd.	'Arkotine D18'	18%
A. Baur & Co. Ltd.	'Deenol 25'	25%

#### 4.2 DOSAGE

The rate recommended is 4 to 6 pints per acre in 50-60 gallons of water applied to cover the maintenance foliage from above. Use the higher dose of 6 pints for bad attacks or for dense bush stands.

#### 4.3 WHEN TO SPRAY

Apply just after tipping, or earlier only if a bad attack develops before tipping. The foliage should be dry at the time of spraying and the deposit should dry on before rain occurs. With pre-pruning, apply it just after the secondary prune and, on new clearings, two months after the dieldrin spray. This should prevent a build-up of Tortrix, but if one does occur later, DDT may be used on tea in plucking. It is necessary to spray just after a plucking round and to discard the following (one) round. DDT will not taint or affect quality; the discarding of one round is necessary to minimise DDT residues in made tea.

*N.B.*—We are experimenting with the use of DDT applied with the dieldrin on clean-pruned or cut-across pruned tea instead of separately. No recommendation can yet be made. This method cannot apply to pre-pruned or lung-pruned tea, since the type of spray coverage required is quite different, *i.e.* DDT has to cover the foliage and dieldrin the bark.

#### 4.4 HOW TO SPRAY

Apply so as to cover the maintenance foliage effectively from above and the sides. It is not necessary to put the nozzle under the foliage and spray upwards. This spraying can be done much more quickly than the dieldrin spraying. Use the same nozzles, or better, use the same nozzles with larger discs, or use double nozzles.

<i>Make</i>	<i>Nozzle</i>	<i>Approximate time of output of 2½ gallons at 55 lb pressure</i>
Birchmeier	Double 'Duro', 1 mm.	12 min
	Single 'Duro', 1.5 mm.	12½ "
Favori-Colibri	No. 520, double, discs 214/10	9 "
	No. 520, single, disc 214/15	12½ "

DDT is less toxic than dieldrin but the same common-sense care should be used. The cost for chemical is about Rs. 10/- to 12/- per acre, and for labour Rs. 5/- to 7/- per acre.

## 5. Records

For future reference, it is wise to record the following details of spraying:— Field No., acreage sprayed, date of pruning before spraying, dates of spraying, amount of dieldrin used ( $x$  pints of 'Dieldrex' per 100 gallons water sprayed at  $y$  gallons per acre), labour used, and costing, DDT used, dates of spraying, dosage used, labour and costing. Weather details (for dieldrin and DDT spraying):

Were the bushes dry before and during spraying?

Did heavy rain fall on the same day after spraying, or was there intermittent rain or drizzle?

The rainfall and sunshine figures, if available, for the weeks subsequent to spraying.

It is useful also to record the dates when Tortrix may be first noted and keep notes on the attack.

## 6. Assessment of results

### 6.1 CONTROL OF SHOT-HOLE BORER

It is usually at least six months and often nine to twelve months from pruning before the occurrence of shot-hole-borer galleries in the *new* wood can be assessed. Note that the galleries in the old wood do not heal up internally although the openings usually heal over. The full effect of control can be judged only after two years or more. It is quite easy for a planter to make a rough assessment of new attack at any time by cutting out new striped wood of branches that are  $\frac{1}{4}$  inch to  $\frac{1}{2}$  inch in thickness and splitting it down to examine for galleries. A minimum sample of hundred pieces taken from all over a field should be examined, and unsprayed and sprayed areas can be compared. The percentage of pieces with galleries is a useful measure of accumulated attack at any time.

### 6.2 YIELD—INCREASE IN CROP

There will naturally be a great deal of interest in the increase in yield which may be obtained by controlling Shot-hole Borer. The precise evaluation of yield differences requires detailed replicated trials, which we are doing. We do not have sufficient data yet to know what the general trend may be; in any event there are likely to be wide local variations in response. There will not necessarily be an increase in the first cycle after spraying, though in some cases this seems to have occurred (see Newton, 1960).

A word on how you assess crop figures may be timely. It is possible to compare green crop weights on a basis of pounds per acre for large sprayed and unsprayed plots in the same field, if the surveyed acreages of the plots are known. However, natural differences in yield between different parts of the same field can be very large, even if not obvious, and such data mean very little unless plots can be individually pre-assessed for yield for at least several months before spraying.

Equally, you may reach erroneous conclusions if you compare the crop from a field in the present cycle with the crop in previous cycles. There may be a marked difference but without a control area we have no idea how much of this is due to treatment, if any at all. This sort of comparison is valid only if we compare the yields of several sprayed fields and of several unsprayed fields with the yields of their previous cycles. Even then it is not precise, but it can provide a better practical assessment than the other methods, and it is an abundance of this sort of data, that can provide us in the long run with an assessment of the yield increases obtained under a wide variety of conditions.

### 6.3 BUSH FRAME AND STARCH RESERVES

Shot-hole Borer is believed to be a primary factor in the mid-country which sets in progress a vicious circle of deterioration of starch reserves and maintenance foliage, die-back, sun-scorch and wood-rot. Just how big a part Shot-hole Borer plays in this chain of events is not known at all clearly because previously it could not be controlled. Obviously it is not the only important factor at work in reducing starch reserves; for instance, the type of pruning and adequate manuring are vitally important. It is to be expected, however, that control of the Borer will greatly improve the bush frames and maintenance foliage, leading in time to a better level of starch reserves, with a lessening of the concomitant troubles that affect bushes with low reserves—die-back, sun-scorch and wood-rot. This is to be expected provided that other important cultural factors are not limiting; the response under a wide variety of conditions remains to be seen, although some promising results have already occurred in mature tea and particularly in new clearings.

It is suggested that if bush frames that have been reduced over the years to a poor rotten condition are to be slowly re-built, this must be done by a process of selectively pruning out poor wood over two or three pruning cycles rather than any drastic pruning that is more than the existing reserves will cope with.

We will be glad to know about planters' observations on these aspects.

## 7. New developments in the method of control

In this section, we deal with experimental work going on which we hope will make the method of control less tedious, more convenient, or of wider usefulness, or perhaps more effective, or with less Tortrix side-effect.

### 7.1 MIST-BLOWERS

Motorised knapsack mist-blowers are a fairly recent innovation for spraying Ceylon tea (see Cranham, 1961b for details of machines, and Elias, 1961 on blister-blight mist-blowing). There is a very definite possibility that mist-blowers may provide the most convenient, economical and perhaps the most generally effective means of spraying dieldrin for the control of the borer. The principle is to apply the same dose of dieldrin (6 pints) in much lower volumes of water per acre, say 10 gallons. The advantages of this method are:—

- (a) greater speed of operation, so that there is a better chance of doing spraying on the available dry days;
- (b) reduced labour cost per acre, and less carriage of water;

- (c) where frames are large, or awkward to spray at high-volume, or the bush density per acre is high, adequate high-volume coverage requires a bigger volume of the same concentration and therefore more dieldrin per acre. Mist-blowing provides the most convenient method of obtaining reasonable coverage of such frames and, if there is more wood or bushes, then more of the mist impacts on them. Mist-blowing does not require a bigger volume or dose per acre; it is ideally suited to dense planting, which also minimises drift;
- (d) with high-volume, it is necessary to walk in every row and prunings can get in the way. For mist-blowing, prunings can be stacked down between the rows in every alternate row and the sprayer travels on every other row.

There is also a distinct possibility that the requirement of dry bark for high-volume spraying is not so stringent for mist-blowing. There is no run-off. Provided the spray dries on before any rain occurs, it may be possible to start earlier in the morning on damp bushes and not have to wait until they dry out, as one does have to do with high-volume spraying. This is not certain but the above are the reasons why we are interested in mist-blowing.

There is one big danger—*drift* of the spray mist contaminating tea in plucking. Experience so far suggests, however, that this is greatly reduced in dense plantings, for which the method is most useful; the advantages over high-volume spraying in fields with a lot of vacancies are not so pronounced. On the edges of fields which adjoin tea in plucking, it will be necessary to spray the edge by high-volume, especially if the wind is blowing on to the tea in plucking. This, however, does not rule out the use of mist-blowing on the major part of the field.

Of course, wind is the enemy of mist-blowing. It can be done perfectly well in a light wind but should not be attempted in strong winds. As a general guide, if the spray will not reach two rows against the wind, give up spraying that day.

The details of the method being experimented with, which it is hoped will prove a working method, are as follows:—

All knapsack mist-blowers may be used. The lighter machines with engines of about 1 h.p. or less, and with air outputs of about 150 cu.ft per minute, appear to be quite satisfactory, although the machines with the bigger engines and air outputs may have advantages in giving wider coverage; this is not yet determined. A short lance is desirable for easy management in most tea, and there must be a device such as a reducing jet, for fixing the rate of liquid output so that it cannot be altered by the labourer when he is spraying. He should have only an on-and-off tap on the lance. The 6-pint dose per acre is applied in ten gallons of spray solution. For training labour, the method here described can be used and this has merits as a routine method too.

1. In row-planted tea, mark off by four corner stakes a more or less square plot 30 yards up the rows by 32 yards across, i.e. in 4 foot row spacing, 24 rows wide. This is one-fifth of an acre.

2. Mix 6 pints of 'Dieldrex' with water and make up the volume to 10 gallons of spray solution. Pour two gallons in the mist-blower tank.

3. The machine should be set to spray two gallons in 12 minutes. The labourer walks in every other row, up and down the plot, i.e. 1st row up, 3rd row down, 5th row up, and so on. He thus has 12 paths of 30 yards to do and should

take one minute for each path (30 yd/min.=approx. 1 m.p.h.). This is a slow walking space and gives him plenty of time to direct the spray. On each 30-yard path he directs the spray to cover four rows, two on either side of him. On the next path he covers the two rows on his right *again* from the opposite direction, thus ensuring that all the bushes are sprayed from both sides. He directs the lance forwards and downwards so that the spray impacts six to ten feet ahead and away from him, and he moves the lance slowly from side to side across an arc of about 90°, whilst walking slowly up the plot. If there is a little spray left at the end of the plot, he can walk back on every 4th row distributing it over the plot.

4. It will be noted that the prunings can be stacked well down on the alternate rows on which the spraying labourer does not walk. It seems likely in many instances, that the prunings can be placed there directly by the pruners with very little extra labour. They should be pressed as well down as possible, so that they do not interfere with the spray mist.

5. After completing one plot, two of the stakes can be moved on up the rows 30 yards and the spraying of the next plot done, and so on. Bring the refill to the sprayer in a can (we use polythene bottles) and refill on the spot without stopping the engine (slow it down) but do this on the ground, not on the labourer's back so that there is no danger of spilling it over him.

6. The marking of the plots with four stakes and two 30-yard long pieces of rope really takes very little time and seems well worth while as a means of ensuring that everything is sprayed. It is easy with a watch (better a stopwatch) to see whether the labourer is going faster or slower than the one minute per path. Train him to respond to a few simple hand signals, because of the noise of the engine, *e.g.* four signals which mean 'stop and turn-off', 'a little faster', 'a little slower', and 'go on'. The sequence of operating the machine should be—start, throttle eased up to full on, liquid on; liquid off, throttle down or off; observance of this sequence prevents spattering dieldrin about where it is not wanted. Labourers will vary in how they take to this work, but experience suggests that there are those on each estate who are capable of using and keen to use these machines; and they become very good at timing. The total day's work can actually be easier for them than knapsack spraying; nevertheless, more is achieved.

7. Other timings can be worked out to suit local convenience; that given above is only a generally convenient example. The method can also be applied to contour planting. However, whereas the labourer may have to go even slower than 30 yard/min on very steep ground, he should not go very much faster in any circumstances or he will not have time to direct the spray. In the above example, the actual spraying time for one acre is 60 minutes, which, with speedy refilling, means that it should be possible easily to do three or four acres a day with one machine taken alternately by two labourers.

8. It is not considered that the hazard to the spray operator is appreciably greater than with normal spraying, although there is more liability to breathe in droplets. However, no eye-shields or face masks tested have proved satisfactory and any protective devices or clothing that overheat the labourer are not to be recommended. Observe the precautions given in Section 3.6, especially the use of soap and water; it is strongly recommended that light cotton spraying clothes be provided, to cover as much of the skin as possible, and that these be washed twice a week; cotton denim overalls are ideal.

### **DDT spraying for Tortrix**

The results obtained by mist-blowing DDT for the control of Tortrix have been good, as with nettle grubs (Cranham and Fernando, 1960). We use the same dose per acre as for high volume, 4-6 pints, made up with water to 5-7½ gallons of spray fluid.

Referring to the example of the spraying method used for dieldrin, the following details may be applied, with the same machine output of 2 gallons in 12 minutes, speed of walking 30 yards per minute, and assuming the row spacing is 4 feet.

*Light machines of about 1 h.p.:* the labourer travels every third row; use 4-6 pints in 7½ gallons per acre. The spraying time for one acre is 40 minutes.

*Machines of about 3 h.p.:* the labourer travels every fourth row; use 4-6 pints in 5 gallons per acre. The spraying time for one acre is 30 minutes.

The direction of the lance is the same as for spraying dieldrin.

### **Recommendation**

We consider that experience with mist-blowing dieldrin and DDT has advanced far enough for planters to try it on a limited scale and gain experience of the method, especially where high-volume spraying is awkward. Only where planters have already obtained proven good results do we suggest that it could be adopted as a routine.

### **7.2 THE USE OF LIME WITH DIELDRIN**

We have had a number of enquiries as to whether Dioldrex can be mixed with lime ('Limbox', I.C.I. (Export) Ltd.) and retain full activity. 'Dioldrex' and 'Limbox' are chemically compatible, but it does not follow that the biological activity of the 'Dioldrex' is unimpaired. This point is being checked, and no recommendation can yet be made.

Apart from the convenience of using them together where both are needed, the 'Limbox' shows very clearly where the 'Dioldrex' deposit is, and so is an excellent aid to supervision. Even when 'Limbox' is not required for mossaing, there may be considerable point in adding it as a marker at a reduced rate (say ¼ cwt. per acre instead of the 1-2 cwt. used for mossaing). The cost per hundredweight is about Rs. 17/-. It is very unlikely that any other substance can be found which will be nearly as effective for this purpose at an economic rate. Work on this point is going on and a recommendation will be made if possible.

### **7.3 OTHER INSECTICIDES**

The T.R.I. is not ignoring the possibilities for other insecticides in the control of Shot-hole Borer, in the hope that a material may be found which is effective, and which does not have undesirable side-effects, and which may also be used if necessary on the frames of tea in plucking. There is no immediate promise in this direction.

Superintendents are sometimes asked by chemical firms and agencies to try out other insecticides for the control of Shot-hole Borer. In our view, this is usually a waste of the superintendent's time, and there are dangers. In any event, if you are very keen to try something new, please consult the T.R.I.

## 8. Summary of important do's and don'ts

For the chemical control of Shot-hole Borer in tea, dieldrin may be used at six pints of 'Dieldrex' in about 100 gallons of water per acre sprayed on the bush frames just after pruning.

- DO**
1. Spray very thoroughly and on dry bark only.
  2. Train the labour and see that supervision is thorough.
  3. Enforce common-sense precautions in handling dieldrin.
  4. Spray DDT just after tipping to prevent Tortrix outbreaks.
  5. Be vigilant in looking for Tortrix and other side-effects.

**DON'T** 1. spray when the buds have begun to break.

**DON'T** 2. spray tea in plucking at any time.

**DON'T** 3. allow drift to contaminate tea in plucking.

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