The Use of Mists in the Application of Insecticides to Cacao.

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SUMMARY.

MIST spraying is the most economic method of applying insecticides to cacao. The optimum size of the droplets is within the range of 30-100 microns, with the mean 50 microns, and must be combined with a high velocity to give good impact percentages on the target. Spraying machinery should be selected on the basis of correct droplet size and high airstream velocity. Volumes per acre in the order of four to eight gallons of spray material give adequate coverage of mature cacao.

Introduction.

The basis of successful pest control is the correct use of machinery, together with the choice of the right chemical for the particular application. With few exceptions, low volume techniques in the application of chemicals are generally followed throughout the cacao growing areas in the world. One of the main reasons for the emphasis on this type of spraying is the small amount of water required per acre, as most of these areas are lacking in storage and transport facilities for the quantities of water required for high volume spraying. In the African cacao growing areas low volume (Mist) spraying is used for the control of capsids. In this case five to ten gallons per acre are applied, the actual amount used depending on the number and size of the trees being treated.

Cacao growing areas are generally unsuitable for the use of large spraying machines, so that the types commonly found are the small shoulder mounted engine driven mist sprayers such as the "Motoblo Mistsprayer" or the "Limblo".

Misting has other advantages in addition to the low water requirements. The deposits produced by misting are more resistant to washing by the rain than those produced by high volume spraying (Goossen, 1958) and there is less tendency for chemical damage to the trees (Whittaker & Henry, 1959). Work done in Malaya indicates that misting is more efficient than fogging (Henderson, 1957) as a better distribution of material is obtained together with an improvement in the residual deposit.

FACTORS AFFECTING DEPOSITION FROM A MIST.

There are a number of factors which must be taken into consideration when applying a mist, if efficient deposition of the material is to be obtained. These factors are related, and upsetting one factor can affect the whole spraying procedure.

1. *Droplet size and Velocity of the Airstream.*

The droplet size, together with the speed of movement of the droplet through the air, are factors affecting actual impingement of the droplet on the target. A droplet with a diameter of approximately 50 microns (one 500th of an inch) is generally accepted as being ideal (Whittaker & Henry 1959). As no machine has yet been made which can produce and apply droplets of an even and ideal size, for practical purposes, the accepted range is between 30 and 100 microns. If the droplet size is below this range it must be moving with a high velocity to penetrate the air layer around the leaves and branches; very fine droplets fail to impinge on surfaces and remain suspended in the air. This is the case with fogs where the droplet size is very small and their velocity very low, so that fogs are generally used only for flying insects (e.g., mosquito control) or inside enclosed spaces.

Generally it may be accepted that the smaller the droplet, the higher its velocity must be to ensure satisfactory impingement on the target. With large droplets such as those obtained in high volume spraying low velocities give satisfactory impact percentages.

If the droplets are too coarse, however, surfaces will be over wet and chemical burning could occur; also distribution of the material is affected unless substantially higher volumes per acre are used. Goossen (1958) shows that a droplet size of 150 microns is ideal when volumes in the order of 20 gallons per acre are being applied ; with this large droplet size quite low velocities will still give good impact percentages.

Under certain conditions, evaporation can reduce the size of the droplets below the minimum suitable, so that "air-suspension" takes place. This is particularly the case when the mist has to travel long distances to the tops of the trees (e.g., with the shade trees, *Leucaena glauca* and *Albizzia stipulata*). Non-volatile carriers (distillate and other non-volatile oils) prevent this, but are expensive.

2. *Volume of Spray Material per Acre.*

The volume of spray material required per acre is dependent on droplet size and number of trees per acre. As there was some doubt as to what volume was actually required to give adequate coverage of mature cacao when using a motor-driven knapsack sprayer, a test was carried out at Keravat to determine the optimum amount. A method based on that described by Sharp, and used by Henderson (1957) which utilized a fluorescent tracer to detect spray deposits, was used.

Method.

Six plots of twenty-five trees each were selected from a block of eight-year-old cacao planted on a fifteen-foot triangle. Fluorescent dyes were added to a 1 per cent. Sevin/water mixture (water soluble Chemacid Brilliant yellow FF) to which a fixer had been added, and to an 0.5 per cent. Malathion/distillate mixture (oil soluble Oil Colour 7G). The same metering jet, which gave a flow of one gallon per 12½ minutes was used in the machine (a Motoblo Mistsprayer) for all the plots and the time taken to apply the measured amount to each tree checked with a stopwatch. Table I shows the different times required to apply the measured amount to each tree.

Table I.

Time required for different rates of application/tree, rate of application/time being constant at one gallon/12½ minutes.

Amount/200 trees	Amount/25 trees	Time/trees
2 gallons	1 quart	10 seconds
4 gallons	2 quarts	20 seconds
8 gallons	1 gallon	40 seconds
16 gallons	2 gallons	80 seconds

Following the treatments, and allowing enough time for the deposits to dry thoroughly, twenty leaves were taken from each of three heights (five, nine and 15 feet) in each block. The leaves were examined in a dark room under a fluorescent light, and placed in one of three classes, depending on the number and distribution of the droplets visible on either surface. The classes are shown in Table II.

Table II.

Classes giving distribution of droplets on either upper or lower surfaces of the leaves.

Class	Description of class
(3)	Distribution even over at least one surface of the leaf. More than ten droplets/square inch.
(2)	Distribution uneven, overall less than ten droplets/square inch.
(1)	No deposit visible.

Results.

The results of the examination of the leaves is given in Table III.

Table III.

Distribution of deposits as determined by examination under fluorescent light.

Height above Ground	Application rate/200 trees																	
	4 gals.* Dist.			4 gals.† LoVo			2 gals.† Fluxit			4 gals. Fluxit			8 gals. Fluxit			16 gals. Fluxit		
	Class 1	2	3	Class 1	2	3	Class 1	2	3	Class 1	2	3	Class 1	2	3	Class 1	2	3
5 feet	0	8	12	0	8	12	4	2	14	1	5	14	0	6	14	2	9	9
9 feet	0	7	13	0	0	20	1	7	12	0	2	18	0	2	17‡	0	0	20
15 feet	0	15	5	0	6	14	2	5	13	0	0	20	0	0	20	0	0	20
TOTAL	0	30	30	0	14	46	7	14	39	1	7	52	0	8	51	2	9	49

* Dist. = distillate. † LoVo and Fluxit are two types of commercial Fixer/Spreaders.

‡ only 19 leaves were taken in this sample.

Discussion of Results.

Overall, only a very low percentage of leaves showed no evidence of spray deposits, and it is thought that those from the five feet level were below the nozzle on the windward side of the tree, so that no drift landed on them. Normally they would receive spray from the drift when the next row was treated. Apart from this, distribution at all levels was quite even.

The table of results shows that four gallons per acre of the Sevin/water/Fluxit mixture gave adequate results, only one leaf having no visible deposit. The result for the three highest rates, four, eight and 16 gallons per 200 trees were very much the same, so that there would seem to be no advantage in using the higher rates. In actual practice however, while distribution is much the same, the deposits produced by the higher rates would be heavier, mainly due to the larger droplets produced at these rates.

ACKNOWLEDGEMENTS.

The material used in Appendix II was taken from an article published Gibson (1962) in the *Agricultural Gazette* of New South Wales.

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APPENDIX I.

SUMMARY OF THE REQUIREMENTS FOR THE MISTING OF CACAO.

1. *Control of Droplet Size.*

Droplet size is controlled by the design of the spraying machine itself, so that all the user can do is to ensure the machine will produce droplets of the size required (i.e., 30 to 100 microns) and is suitable in other respects, such as horsepower and weight.

2. *Control of Volume of Spray Material per Acre.*

Under the conditions of the experiment described above, four gallons of spray material per 200 trees gave adequate distribution. However, allowing for varying conditions in the plantation, the range four to eight gallons per 200 trees is recommended.

3. *Control of the Amounts of Active Ingredient per Acre.*

It is generally accepted practice that the amount of insecticide (the actual active ingredient) used per acre remains constant, independent of the volume of spray applied. Thus, it is important to remember that when using low volume techniques, substantially higher concentrations of insecticide or fungicide are required. For example, the recommendation for leaf eating caterpillars such as *Tiracola plagiata* and *Achaea janata* is 0.25 per cent. DDT as a high volume spray or 2.5 per cent. DDT as a low volume spray or mist. In this case six gallons of a 2.5 per cent. DDT mixture for misting would contain 4.8 pints of DDT concentrate (or approximately one and a half pounds of pure DDT) and would be equal to 60 gallons of an 0.25 per cent. DDT mixture.

Spray recommendations are often quoted in amounts of "active ingredient" or actual insecticide per acre, and in the above example would be quoted as one and a half pounds DDT per 200 trees. However, it must be remembered that the volume of spray required to give a good cover of insecticide will vary with the size of the trees, and that mature trees, closely planted, will require more spray and thus more insecticide than either small immature trees or those planted further apart.

4. *Control of Distribution over the Tree.*

The deposition of the small droplets used in misting depend to a large extent on their velocity ; the higher this is the greater is the chance of the droplet impinging on a branch or leaf. The machines generally used for misting in the Territory of Papua and New Guinea have very high airstream velocities at the nozzle (in the vicinity of 200 miles per hour) but this falls off sharply with distance. The more powerful the machine, the higher the velocity at any distance from the nozzle. For this reason the higher powered machines give better impact percentages than those with less power, so that power should not be sacrificed for lightness when purchasing a machine for use in cacao. Thus adequate power is the first requirement in control of distribution over the tree.

When spraying the tree, it is better to hold the nozzle steadily in one direction for a definite period, to allow the airstream to build up velocity near its extremity at the tops of the cacao 20 to 30 feet away. This effect can be readily seen if the machine is operated in the open.

The correct sequence of spraying is to treat the lower branches of the tree first, then the upper branches. When spraying the lower, nearer part of the tree, the nozzle should be moving to prevent overspraying of the branches close at hand. However, when treating the top part of the tree, the nozzle should be held steadily for five to ten seconds to give maximum velocity to the airstream.

5. *Control of Distribution per Acre.*

The method of calculating the time required to apply a given volume of spray material per acre is as follows :—

1. The rate of application by the machine must first be found, by measuring the time taken for the machine to spray a measured amount of material, for example one gallon. It has been found in practice that a figure close to 12 minutes for one gallon gives best results, though this would vary slightly with the different rates of application per acre (faster for the higher rates and slower for the lower rates).
2. The amount required for each tree should then be calculated, and also the time required to apply that amount to the tree.
3. From this figure, knowing the number of trees per acre, the time required to treat one acre can easily be calculated.

Example—

1. The machine has been found to take 12 minutes to apply one gallon.
2. If applying six gallons to 200 trees, then each tree would receive :

$$\frac{6}{200} \times 8 = \frac{1}{4} \text{ pint approximately.}$$

This would take $\frac{12 \times 60}{8 \times 4} = 20$ seconds approximately. Allowance must be made for the time taken to move from one tree to the next, and this has been found in practice to average out at about ten seconds. Thus, we would allow a total of 30 seconds for each tree.

3. From the above, we can calculate that the time taken to treat 200 trees is $200 \times 30 = 6{,}000$ seconds $= 100$ minutes.

This is, of course, a theoretical figure only and could vary under plantation conditions, with different planting distances, topography, etc.

APPENDIX II.

TWO NOMOGRAPHS TO ASSIST IN SOLVING PROBLEMS IN PESTICIDE CALCULATIONS.

The primary producer of today has at his disposal a large and increasing number of chemicals available as pesticides. These chemicals are often marketed at high or unusual percentages, for application at very low concentrations, confronting the user with time-consuming arithmetical problems in mixing. Introduction of concentrate and semi-concentrate applicators has added to these difficulties.

Many of the problems may be solved by the use of "nomographs" and the following series has been prepared for this purpose.

These nomographs consist of three parallel scales related to a particular type of problem.

Procedure.

It is first necessary to select the correct nomograph for the particular problem. A straight edge such as a ruler is then placed across the three scales so that it passes through known points on two of the scales. The reading on the third scale, at the point where the straight edge crosses it, is the answer to the problem.

Typical examples are given for each of the nomographs presented here.

Nomograph 1.

This chart is used for finding the quantity of a wettable powder or emulsion concentrate required to prepare for use 100 gallons of a diluted spray.

Example A (illustrated by broken line on nomograph)—

Assume that it is required to prepare a 0.1 per cent. spray from a 50 per cent.-wettable powder concentrate—

The two known points for the scales are 0.1 per cent. and 50 per cent. respectively.

Place the straight edge on the chart so that it is on the point 0.1 on the left-hand scale and 50 per cent. on the right-hand scale.

The straight edge crosses the centre scale at the point two pound.

Therefore two pound of a 50 per cent.-wettable powder is required for each 100 gallons of spray.

Example B—

To prepare 50 gallons of a 0.04 per cent. Spray from a 20 per cent. emulsion concentrate—

The two known points for the scales are 0.04 per cent. and 20 per cent.

Place the straight edge on the chart so that it passes through the point 0.04 on the left-hand scale and 20 per cent. on the right-hand scale.

The straight edge crosses the centre scale at the point 32 fluid ounces, indicating that 32 fluid ounces are required to make 100 gallons of spray ; but only 50 gallons are required, therefore half this amount (16 fluid ounces) is the quantity of concentrate to be used.

Nomograph 2.

Frequently the recommendation for application of a pesticide is given as a quantity of the active ingredient per acre and the material to be used may be available only as a water miscible solution.

Nomograph 2 is used to convert the weight of active ingredient recommended, to the equivalent volume of a solution of the pesticide.

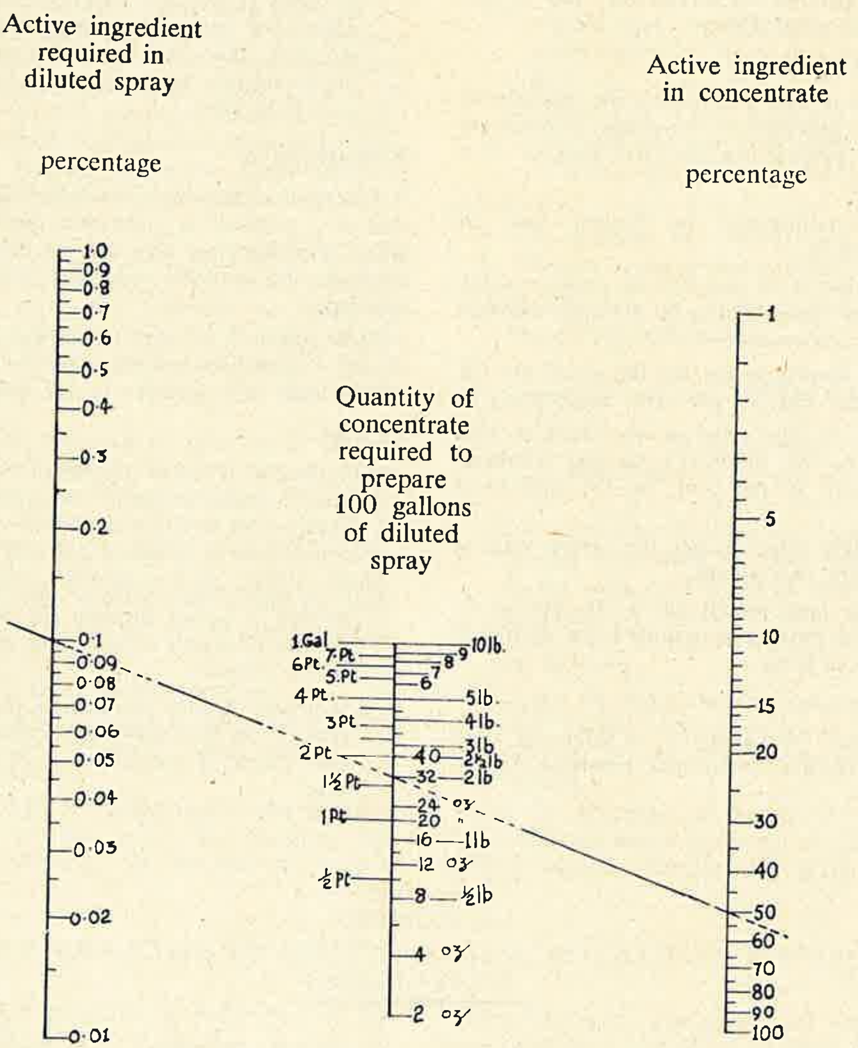
Example—

The weight of active ingredient of an 80 per cent. weight/volume concentrate to be applied per acre is 8 oz. How much of the concentrate is required per acre ?

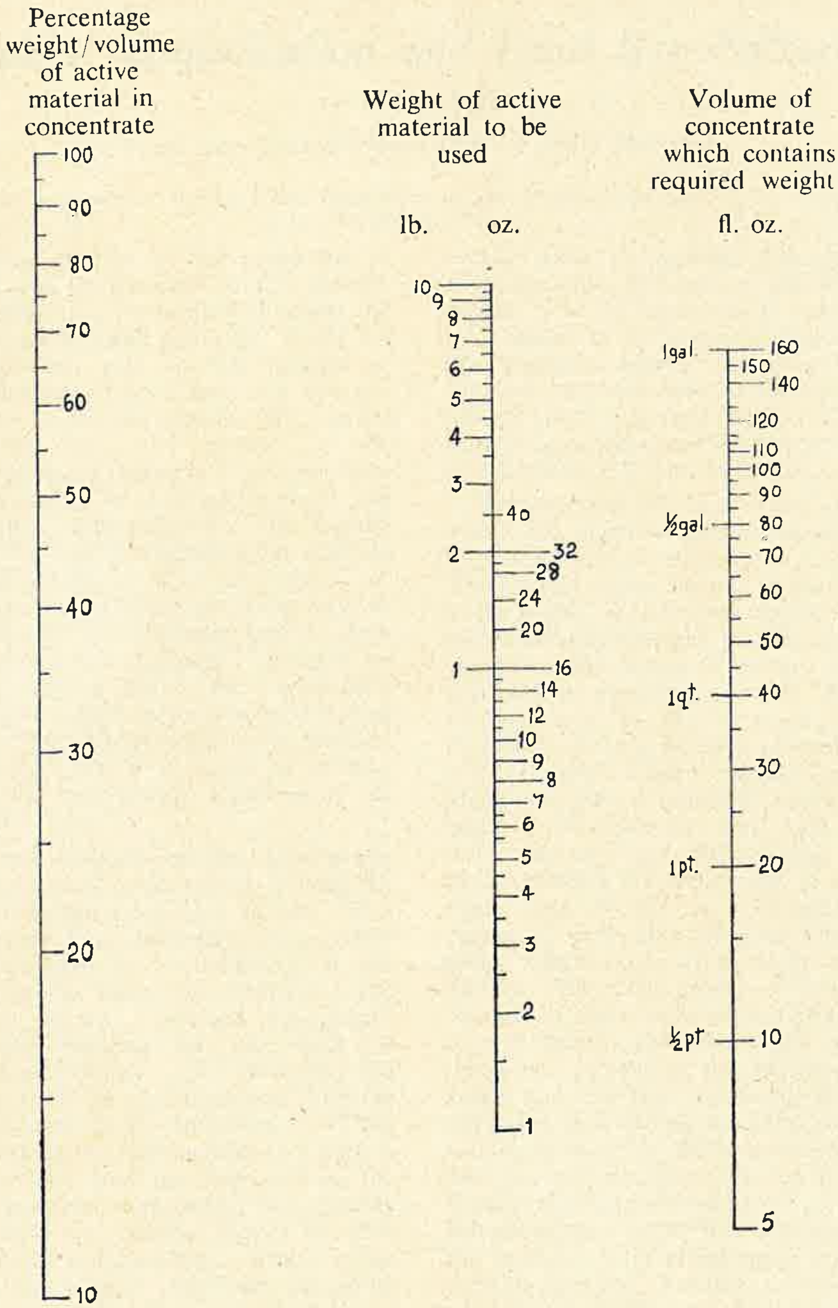
The straight edge is placed across the chart so that it passes through the 80 per cent. on the left-hand column and 8 oz. on the centre column.

It will pass through the point $\frac{1}{2}$ pint (10 fluid ounce) on the right-hand column ; this is the volume of concentrate to be applied per acre.

NOMOGRAPH 1


Active ingredient
required in
diluted spray
percentage
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·09
0·08
0·07
0·06
0·05
0·04
0·03
0·02
0·01
Quantity of
concentrate
required to
prepare
100 gallons
of diluted
spray
1.Gal
7 Pt
6 Pt.
5.Pt
4 Pt.
3 Pt
2 Pt
1½ Pt
1 Pt
½ Pt
10 lb.
9
8
7
6
5 lb.
4 lb.
3 lb
40
2½ lb
32
2 lb
24 oz
20 "
16
1 lb
12 oz
8
½ lb
4 oz
2 oz
Active ingredient
in concentrate
percentage
1
5
10
15
20
30
40
50
60
70
80
90
100

NOMOGRAPH 2


Percentage weight/volume of active material in concentrate
100
90
80
70
60
50
40
30
20
10
Weight of active material to be used
lb.
oz.
10
9
8
7
6
5
4
3
2
1
40
32
28
24
20
16
14
12
10
9
8
7
6
5
4
3
2
1
Volume of concentrate which contains required weight
fl. oz.
1gal
160
150
140
120
110
100
90
½gal
80
70
60
50
1qt.
40
30
1pt.
20
½pt
10
5