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DOSAGE TABLES

By C. W. WOODWORTH

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DOSAGE TABLES.

By C. W. WOODWORTH.

The study of the leakage of fumigation tents has now reached the point where it becomes possible to present tables of dosage so calculated that there may be approximately equal killing power under tents of varying degrees of leakage.

A recent publication¹ states "Most of the ducks and drills now used in California are about equally gas-tight," but actual measurements of the leakage of the fumigation tents operating in the orchards in Orange and Los Angeles counties have shown wide variation in this respect and the same tent is much tighter moist nights than on dry nights, indeed, practical fumigators have long realized that it was impossible to secure a good killing of scale on dry nights.

If it were possible to figure on the tent always maintaining the same degree of leakage, a single dosage schedule would be sufficient, though different tents might not require the same schedule. The fact is, however, that variation in leakage proves to be the most important factor to be considered, and as long as it is neglected will result in errors in dosage several times greater than those that are liable to occur through mistakes in guessing the size of a tree, which heretofore has been supposed to be the most important cause of irregularity in results secured.

Only the very wide margin of safety, permitting the use of gas very much stronger than necessary to kill the scale insect, has enabled fumigators to obtain fairly uniform results, notwithstanding the variation in loss of gas through the tent. When trees are dosed according to leakage it will probably be found safe to materially economize in the amount of chemicals used. In these tables, however, the full strength of chemicals now commonly used is indicated, since there must be considerable more data secured before it will be safe to recommend a material reduction. The use of these tables, therefore, simply insures greater uniformity in results.

The true basis for any system of dosage is the volume of the spaces enclosed by the tent, that is, the cubic contents. All the older tables

The early studies of this series are as follows:

1. Bulletin 122, Orchard Fumigation.
2. Bulletin 152, Fumigation Dosage, 1903.
3. Circular 11, Fumigation Practice, 1904.
4. Circular 50, Fumigation Scheduling, 1910.

¹Bulletin 90, U. S. Division of Entomology, "Fumigation of Citrus Trees," R. S. Woglum, p. 53.

of dosage² are based solely upon the volume. Eight years ago we suggested (Bulletin 152) the use of the surface area of the tent as a basis for dosage, showing that this corresponds very much nearer with the actual practice of fumigators. It was understood at the time that such a calculation was fundamentally wrong, but since the data was not at hand for determining the leakage factor; that is, the amount the dose must be increased to allow for the leakage, it was suggested as a rough approximation.

The area basis has been adopted by all subsequent writers on fumigation and has been generally supposed to correctly allow for leakage³. If this were true differences of leakage could be provided for by simply making a proportionate increase or decrease of dose. On a volume basis one tent twice as large in each dimension as another would require eight times the dose, while on an area basis it would require only four times. Now any amount of proportionate increase of dose for a tighter tent would still retain the ratio 1 to 4 instead of approaching 1 to 8, as it should.

From these considerations one will readily appreciate that an area basis of calculation will not produce an accurate table of dosage for any degree of leakage whatever, and can be an approximation for only one definite degree of leakage.

The full explanation of the method of calculation of the leakage factor and the detail of the experiments, upon which it is based will be given in another bulletin. For the present purpose it will only be necessary to explain enough to permit intelligent use of the tables.

LEAKAGE.

In the experimental work the tents were tested double thick, that is, a fold of the cloth was placed in the apparatus. The reason for this was that by doing so a test could be made at any point over the surface as easily as at the edge. The average of over 5,000 determinations of the leakage of tents in operation was, when calculated for a single thickness of the cloth, approximately .25 per cent. With this leakage the gas will escape through a square foot of the average tent material at the same rate it would through a hole about $\frac{1}{3}$ of a square inch in size. Some tents were found in operation with more than twice this leakage and others were less than half as leaky. The common range was from .10 to .40 per cent. The tables below have been calculated for .10 per cent,

²Morse, Bulletin 71, Calif. Agr. Exp. Station, 1887.

Coquillett, Report for 1887, U. S. Dept. of Agr. pp. 123-142, 1888.

Coquillett, Insect Life, Vol. II, pp. 202-207, 1889.

Woodworth, Bulletin 115, Calif. Agr. Exp. Station, 1896.

Johnson, Bulletin 57, Maryland Agr. Exp. Station, pp. 72-95, 1898.

Woodworth, Bulletin 122, Calif. Agr. Exp. Station, 1899.

³Woglum, Bulletin 79, U. S. Division of Entomology, 1909, p. 47, determined "leakage surface" by dividing the area by the volume and the dose by multiplying this by the volume; the product is, of course, only the area.

.15 per cent, .20 per cent, .25 per cent, .30 per cent, .35 per cent, and .40 per cent, and the leakage meters designated for determining the leakage are graduated into these degrees. A full account of the construction and use of leakage meters is given in another bulletin.

The determination of the leakage of the tent must come to be a very important part of the process of fumigation. There seems to be no way of estimating the leakage with sufficient accuracy except by actually measuring it. We may know that one tent is tighter than another, and that any tent holds the gas best when the air is damp, but the only way to make full use of this knowledge is to have it in a definite form so as to choose the correct system of dosage. With the new apparatus now available the measuring of leakage is a very simple and rapid process, and there is no reason why every fumigating outfit should not be provided with a leakage meter.

A result sure to follow the adoption of the rational basis for dosage now advocated will be the elimination of the more leaky tents. Such tents will either be made tight by treatment or discarded altogether, because the doses by this system will be so large that the economy of so doing will be very evident.

In the selection of new tents the saving that will follow the adoption of the tighter material will be capable of being accurately estimated and the question of its economy readily determined.

THE DOSE.

After measuring the leakage of the tent, the next question will be determining the dose which will correspond with the degree of leakage. Evidently there are three factors in this problem. First, the insect to be killed; second, the size of the tent, and third, the leakage of the tent.

The insect, as far as our present knowledge goes, has a constant effect on the dose, that is, if the dose is determined for the purple scale, that for the black scale is always a certain fraction of the purple scale dose. This relationship has never been accurately tested out, but is probably true, and has been uniformly accepted as true by all who have had to do with fumigation. In the tables given below the relationship assumed as the correct ratio of dosage for the black, red and purple scales, respectively, is $4:5\frac{3}{4}:7\frac{1}{2}$.

The size of the tree, as pointed out above, affects the dosage differently according to the leakage. With an absolutely tight tent the dose should correspond strictly with the size, but as tents average in the field, the universal practice is to vary the dose very much less rapidly than the size or volume basis of calculation would provide. This factor is, therefore, incapable of adequate treatment without a knowledge of the leakage.

FIG. 1.—Fumigator's rule, leakage basis.

The determination of the size is very fully discussed in Circular 50 and a new rapid method described below.

The leakage is very easily determined, but to determine its relationship to the dose requires a very complicated mathematical formula. This much, however, can be readily appreciated, that given trees of equal leakage and different size will differ in dose, and if equal in size but different in leakage they also differ in dose, it is evident that the same dose may apply to two trees of different sizes, provided they have a certain definite difference of leakage.

FUMIGATION RULE.

The impossibility of briefly describing the effect of the leakage upon the dose is shown by Fig. 1, where the doses corresponding with trees of different sizes and with different degrees of leakage are given.

The effect of the leakage upon the dose in the case of any particular size is shown by the numbers read crosswise of the rule. The smaller the tree the greater the effect of the leakage upon the dose. This is due to the larger amount of leakage surface as compared with the volume enclosed by the tent.

The effect of the size on the dose is shown by following the lines of figures lengthwise along the rule. The greater the leakage the less the effect of the size of the dose, since a decrease in size is affected by the increase in amount of leakage due to the larger relative leakage surface in the case of small trees.

By the use of this rule one may read the dose for black scale corresponding with any size and leakage. By increasing it in the proportion of $4:5\frac{3}{4}$ one obtains the dose for red scale and by the ratio of $4:7\frac{1}{2}$ that for purple.

The doses given on the rule are for the common average shaped trees in which height and width are equal and these dimensions may be read on the scale marked "diameter." To obtain the dose for trees of a different shape than this find both dimensions on this scale and the correct dose will be found at a point about two fifths way from the diameter towards the height. Or find the diameter and increase or decrease by an amount equal to two fifths of the difference between the two dimensions. Opposite this point on the scale will be found the dosage.

If one has the dimensions of a tree in circumference and distance around, the rule is not as convenient as the tables

that follow, but it is still possible to read the dose by noting the diameter on one edge of the rule which corresponds with the given circumference on the other, increasing this one fifteenth and then decreasing by an amount equal to one fifth the number of feet in the difference between the two measurements, circumference and distance over.

This rule contains the complete system of dosage based on leakage, and besides, may be used as a measure for trees according to the method given on the concluding pages of this bulletin.

THE MINIMUM DOSE.

This rule shows a fact not hitherto noted, that there is a point for each degree of leakage where the tree requires a minimum dose. With no leakage the minimum point is approximately at zero, and as the leakage increases so does the minimum dose till, as shown on the rule, 8 ounces is the least amount that will do effective work with .40 per cent leakage, which is the dose for a seven and a half foot tree. Smaller trees would require more cyanide, so much, indeed, that the danger to foliage would probably render the method impractical. The reason for increase of dose for smaller trees is the fact that the leakage surface is so large relatively to the volume of gas contained within the tent in such cases, that the percentage of gas present drops very rapidly, and must be made very strong in order that enough remain to the end of the killing period to insure the death of the insects treated. It is probably not wise to attempt to use a tent for a tree much smaller than indicated on the rule. The theoretical minima are as follows:

Leakage.	Minimum size of tree.	Dose.		
		Black Scale.	Red Scale.	Purple.
.10 per cent -----	2 feet.	$\frac{1}{8}$ ounce.	$\frac{1}{8}$ ounce.	$\frac{1}{4}$ ounce.
.15 per cent -----	3 feet.	$\frac{1}{2}$ ounce.	$\frac{1}{3}$ ounce.	1 ounce.
.20 per cent -----	4 feet.	1 ounce.	$1\frac{1}{3}$ ounces.	2 ounces.
.25 per cent -----	5 feet.	2 ounces.	3 ounces.	4 ounces.
.30 per cent -----	5½ feet.	3½ ounces.	5 ounces.	7 ounces.
.35 per cent -----	6½ feet.	5½ ounces.	8 ounces.	11 ounces.
.40 per cent -----	7½ feet.	8 ounces.	12 ounces.	15 ounces.

LEAKAGE BASIS AND ACTUAL PRACTICE.

The dosage system calculated on the leakage basis must be shown to accord with the dosages given by practical fumigators in order to be accepted with any degree of confidence, since on the whole the results of their work has been very satisfactory. For this purpose the dosage scheme for the twenty-six fumigators, as presented in Bulletin 152,

have been compared with the tables given below with the following results:

.40 per cent	none
.35 per cent	3
.30 per cent	5
.25 per cent	7
.20 per cent	8
.15 per cent	3
.10 per cent	none

In the above table each fumigator is placed in the class corresponding most closely with the record we have of his actual work.

Classifying, again, the same 26 fumigators according to the size of dose, which is quite a different thing from the rate of increase of size shown in the table above, we have

Above	5
Purple scale dose	1
Red scale dose	10
Black scale dose	5
Below	5

In both these particulars the leakage basis is thus seen to be in remarkable agreement with the practice of fumigators, simply supplying the means of determining when the system of one fumigator is to be followed and when that of another.

FIG. 2.—Method of scheduling with a chart.

correct dosage for the average tent and for those better than the average.

The directions accompanying the charts are revised to include these determinations, as follows:

DIRECTIONS FOR USING THE SCHEDULING CHARTS.

To use these charts one should first determine the dose for the average sized tree in the orchard to be scheduled by means of the fumigator's rule, after determining the leakage with a leakage meter.

SCHEDULING CHARTS.

The study upon which this bulletin is based was undertaken largely in fulfilment of a promise made in Circular 50, where it was pointed out that while differences of leakage required the use of different bases of calculation it was impossible to specify what chart to use in any particular case. We are now able to give this very necessary information, and we, therefore, reproduce the two charts which give approximately cor-

FUMIGATOR'S SCHEDULING CHART.
 of Experiment Station - University of California.

Location of Plot

Scheduled 191 by

FUMIGATOR'S SCHEDULING CHART.

DESIGNED BY C. W. WOODWORTH.

Dose for 10 foot tree ounces. Agricultural Experiment Station—University of California.

AREA BASIS.

Total Cyanide prescribed

Amount used

Fumigated 191 by Location of Plot

Scheduled 191 by FUMIGATOR'S SCHEDULING CHART.
Dose for 10 foot tree ounces. Agricultural Experiment Station—University of California.

DESIGNED BY C. W. WOODWORTH.
VOLUME BASIS.

Total Cyanide prescribed

Amount used

Fumigated 191 by Location of Plot

Total Cyanide prescribed

Amount used

The charts provide for leakages from 0 to .25 per cent, as follows:

Leakage.	
0-----	Heavy lines on volume chart.
.05%-----	Light lines on volume chart.
.10%-----	Dotted lines on volume chart.
.15%-----	Dotted lines on area chart.
.20%-----	Light lines on area chart.
.25%-----	Heavy lines on area chart.

For tents with greater leakage or for trees either very large or very small, use the rule instead of the charts for determining dosage.

The method of using the chart is as follows:

First—Place this chart in a holder provided with a loop of flat wire. This should project from the upper right-hand corner of the chart and extend exactly $14\frac{3}{4}$ inches.

Second—In using the chart one should always stand at a uniform distance from the tree to be measured. In most cases the most convenient point is midway between four trees (or between three trees in case the orchard is planted in oblique rows); by looking down between the rows of trees one can locate oneself quite accurately. Do not attempt to measure the nearest trees, but those just beyond. This will make the distance between thirty and forty feet, according to the way the trees are planted.

Third—The distance between the chart and the eye must also be maintained constant. Before beginning to schedule an orchard, fasten a light flexible wire around the hatband, allowing the end to project forward 8 or 10 inches, then standing opposite an average tree at the distance which you find best to measure the tree, move the slide and slip the flat wire loop till the end of the wire touches the dose line at the dose determined for the size and leakage by means of the rule. Then move the chart to or from the face till the distance across the loop corresponds with the size of the tree. Now bend the end of the wire around the hatband into a hook into which the flat wire loop will lie, holding it at the desired distance.

Fourth—Having thus adjusted the apparatus, one can proceed to measure the trees by moving the slide and slipping the wire loop until the outline of the tree exactly corresponds with the loop (the fringe of slender twigs are disregarded in day scheduling, since these will always be bent down by the tent). See that the wire lies straight across the chart, and where the end of the wire comes one may read off at once the proper dose; and should write the amount in the appropriate square. One may readily schedule four rows of trees at a time by this method for daytime work.

Fifth—When scheduling very large trees adjust the apparatus for half the dose desired and double all readings. By having hooks at each end of the wire around the hatband one hook may be set for ordinary sized trees and the other for large trees when extremes occur in the same orchard.

Sixth—Where one desires extreme accuracy in measuring, attach the transparent diagram described in the same bulletin and use a specially graduated tape, instead of the wire loop and graduations on the chart, for determining the dose. With the aid of a boy to handle one end of the tape, two rows may be scheduled about as rapidly as four rows by the former method.

Seventh—This chart may be also used for calculating the dose when direct measurements are made if one first graduates an oblique line to correspond with dimensions. Hold a card square with the sides of the diagram and in such a position that the two dimensions are indicated by the adjacent edges of the card and the corner between will indicate the dose. This will give determinations accurate to a small fraction of an ounce.

NOTE (a).—Some fumigators increase or decrease the dose a half ounce or more for badly infested trees, for especially dense trees, or for irregularly shaped trees. Where this is done it may be indicated on the chart by placing a dot in a corner of the appropriate square. If the dose is increased, put the dot in an upper corner; if reduced, below; and if on account of the character of the tree place the dot to the left; if because of the abundance of the scale place it in one of the right-hand corners.

DIRECT MEASUREMENTS.

Many may prefer to use direct measurements for determining the size. The most accurate method of measuring is to determine the distance around the tent or circumference, and the distance over the top. This plan was first suggested in 1899 in Bulletin 122 of this Station, and a dosage table based on volume was presented for use with such measurements. The data secured for Bulletin 152 was obtained by the use of such measurements. This method of measuring is now largely known as the Morrill or Woglum system, since these two investigators have particularly urged its adoption. The most convenient plan is to mark the tents so as to readily determine the distance over the top and use a tape line around the side for the circumference.

Such measurements give the dimensions very accurately, but must be used with properly calculated tables or the dose may be far from correct. The original table published in Bulletin 122 is accurate only for tents without leakage. No such tents are in use, but if such tents were provided the dose would be much stronger than necessary. The marking suggested in Bulletin 152 and the tables given by Morrill, Woglum, and Quayle are all based on area and are approximately right for a .25 per cent leakage, except at the two extremes, where they are all defective, particularly at the lower end and where the dose is only half large enough as compared with the center of the table. For any other degree of leakage they are incorrect throughout, though the dose recommended is high enough to be effective in most cases, notwithstanding the inaccuracy of the tables.

EXPLANATION OF THE NEW TABLES.

The tables given below are arranged in a new form which will be found very convenient in practice. In each table at the top is given the *dosage*, below the corresponding *dimensions*.

The *dosage* is given for all the ingredients instead of only for the cyanide as has been the practice in all tables heretofore offered. This will avoid the error that sometimes results from the mental calculation heretofore required to determine the amount of water (or acid in the case of sodium cyanide) to use. The amounts given are simply 3, $2\frac{1}{2}$, 2, and $1\frac{1}{2}$ times the cyanide dose. The formula recommended for sodium cyanide is $1-\frac{2}{3}-1\frac{1}{3}$, that is, 1 ounce of the acid, $\frac{2}{3}$ of an ounce of the cyanide to $1\frac{1}{3}$ ounces of water. The formula longest used for potassium cyanide is 1-1-2. If accurately measured this is sufficient water to keep the all-acid sulfate formed in solution. When the water is slightly less than this amount or the acid slightly more there is danger of the crystallization of the salt and the generator is said to "freeze." To avoid this many fumigators use 1-1-3, though with an appreciable loss of gas. The use of 1-1- $2\frac{1}{2}$ gives ample water to offset inaccurate meas-

urements and by the use of these tables is as convenient as the former, though it would not be so practical if it had to be calculated mentally.

The dimensions given at the beginning of each line are the circumference, and when the distance over is the same as in high trees the dose will be read in the column above this figure. The remaining figures on each line represent the distance over the tent. To obtain the dosage of a tree, therefore, first find the circumference at the left end of a line and follow along that line till the distance over is found, and then follow up the column and read the dose.

If one decides to use the formula $1-1-2\frac{1}{2}$, a line of red ink should be run through the lines beginning x3, x2, x1 $\frac{1}{3}$, and x $\frac{2}{3}$, and if he does not wish to dose to the half ounce, red ink may be run through the alternate columns. The use of these red ink lines will avoid the danger of using the wrong figures.

If the dimension is smaller than any given in the table, a tighter tent should be used since it has passed below the point of minimum dose described above and effective treatment is not to be expected.

	Water, ounces.																								Sodium Cyanide, ounces.																								Acid and Potassium Cyanide, ounces.																								Dimensions—Distance around and over tent, feet.																							
x3	108	102	96	90	84	78	72	66	60	57	54	51	48	45	42	39	36	33	30	28	27	25	24	22	21	19	18	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
x2	90	85	80	75	70	65	60	55	50	47	45	42	40	37	35	32	30	27	25	23	22	21	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																							
x2	72	68	64	60	56	52	48	44	40	38	36	34	32	30	28	26	24	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																										
x1	48	45	42	40	37	34	32	29	26	25	24	22	21	20	18	17	16	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1																																																							
x	24	22	21	20	18	17	16	14	13	12	12	11	10	9	8	8	7	6	6	5	5	4	4	3	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1																																																							
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					54	52	49	46	44	42	41	39	38	36	35	33	31	29	27	26	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2																																																					
						50	47	45	43	42	40	38	37	35	34	32	30	28	26	25	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
							48	45	44	42	40	39	37	36	34	32	30	28	27	25	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
								46	45	44	42	41	39	38	36	34	33	31	29	27	26	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2																																																				
									44	43	41	40	38	37	35	33	31	29	28	26	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
										44	43	41	40	38	37	35	33	31	29	28	26	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																				
											42	40	39	37	35	33	32	30	28	26	25	23	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
												38	36	34	32	30	28	27	25	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																						
													36	35	33	31	29	27	26	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																						
														36	34	32	30	28	27	25	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
															34	32	30	28	27	25	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
																34	32	30	28	27	25	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																				
																	32	30	28	27	25	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																				
																		30	29	28	26	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																				
																			28	26	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
																				26	25	23	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
																					24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
																						22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																					
																							22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																				
																								22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																			
																									22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																		
																										22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																	
																											22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																																
																												22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																															
																													22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																														
																														22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																													
																															22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																												
																																22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																											
																																	22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																										
																																		22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																									
																																			22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																								
																																				22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																							
																																					22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																						
																																						22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																					
																																							22	22	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1																																				

RED SCALE TABLE—35 PER CENT LEAKAGE.

Water, ounces.																							
x3	114	108	102	96	90	84	78	72	66	60	57	54	51	48	45	42	39	36	33	30	28½	27	25½
x2½	95	90	85	80	75	70	65	60	55	50	47½	45	42½	40	37½	35	32½	30	27½	25	23½	22½	21½
x2	76	72	68	64	60	56	52	48	44	40	38	36	34	32	30	28	26	24	22	20	19	18	17
x1½	50½	48	45½	42½	40	37½	34½	32	29½	26½	25½	24	22½	21½	20	18½	17½	16	14½	13½	12½	12	11½
Sodium Cyanide, ounces.																							
x½	25½	24	22½	21½	20	18½	17½	16	14½	13½	12½	12	11½	10½	10	9½	8½	8	7½	6½	6	5½	
Acid and Potassium Cyanide, ounces.																							
	38	36	34	32	30	28	26	24	22	20	19	18	17	16	15	14	13	12	11	10	9½	9	8½
Dimensions—Distance around and over tent, feet.																							
62	59	57	55	52	50	47	44	41	39	37	35	34	32	30	29	27	25						
60	58	55	53	51	48	44	42	39	37	35	34	32	30	29	27	25							
58		55	53	51	48	45	42	40	38	36	34	33	31	30	28	26							
56	54	52	49	45	43	40	38	36	35	33	31	30	28	26	24	22							
54	52	49	46	43	40	39	37	35	33	32	30	29	27	25	22								
52		49	46	43	41	39	37	36	34	32	31	29	27	25	22								
	50	47	44	41	39	37	36	34	33	31	29	27	25	23	21	19							
48	47	44	41	40	38	36	35	33	32	30	27	25	23	21	19								
46		45	42	40	38	37	35	33	32	30	28	26	23	21	19								
	44	42	40	39	37	35	34	32	30	28	26	24	22	20	18								
	42	41	39	38	36	34	33	31	29	27	24	22	20	18									
	40	39	38	36	35	33	31	29	27	24	22	20	18										
		38	36	35	33	32	30	28	25	23	21	19											
			36	34	32	30	28	25	23	21	19												
				34	32	30	28	26	24	22	20												
					32	30	28	26	24	22	20												
						30	28	26	24	22	20												
							28	26	24	22	20												
								26	24	22	20												
									24	22	20												
										22	20												
											20												
												18											

PURPLE SCALE TABLE—25 PER CENT LEAKAGE.

		Water, ounces.																																
x ³	114	108	102	96	90	84	78	72	66	60	57	54	51	48	45	42	39	36	33	30	28	27	25	24	22	21	19	18	16	15	13	12		
x ² ₁	95	90	85	80	75	70	65	60	55	50	47	45	42	40	37	35	32	30	27	25	23	22	21	20	18	17	16	15	13	12	11	10		
x ²	76	72	68	64	60	56	52	48	44	40	38	36	34	32	30	28	26	24	22	20	19	18	17	16	15	14	13	12	11	10	9	8		
x ¹ ₁	50	48	45	42	40	37	34	32	29	26	25	24	22	21	20	18	17	16	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
x ¹	25	24	22	21	20	18	17	16	14	13	12	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	
		Sodium Cyanide, ounces.																																
		11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1		
		Acid and Potassium Cyanide, ounces.																																
		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	
		Dimensions—Distance around and over tent, feet.																																
		43	40	39	38	36	35	34	33	31	30	28	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7		
		56	54	53	52	50	49	47	45	43	41	39	38	37	35	34	33	32	30	28	26	25	24	23	22	21	20	19	18	17	16	15		
		56	55	54	52	51	49	47	45	43	41	39	38	37	36	35	34	33	32	30	28	26	25	24	23	22	21	20	19	18	17	16	15	
		57	55	54	53	51	50	48	46	44	41	40	38	37	36	35	34	33	32	31	29	27	25	24	23	22	21	20	19	18	17	16	15	
		56	55	53	51	50	48	46	44	41	40	39	38	36	35	34	33	32	31	29	27	25	24	23	22	21	20	19	18	17	16	15	14	
		54	52	50	49	46	44	42	40	39	38	36	35	34	33	32	30	28	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	
		52	51	49	47	45	42	41	40	39	37	36	35	34	32	30	28	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	
		50	48	46	43	42	41	39	38	37	36	34	33	31	29	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	
		48	46	44	42	41	40	38	37	36	35	33	31	29	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	
		46	44	42	41	40	38	37	36	35	33	31	29	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	
		44	42	41	40	39	38	37	36	35	33	31	29	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	
		42	41	40	39	38	37	36	35	33	31	29	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	
		40	38	37	36	35	34	32	30	28	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	
		38	37	36	35	34	32	30	28	27	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	
		36	35	34	32	30	28	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	
		34	32	30	28	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	
		32	30	28	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	
		30	28	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	
		28	26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4
		26	25	24	23	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3
		24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2
		22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10
		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8
		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6
		16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4
		14	13	12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2
		12	11	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10
		10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8
		8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6
		6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4
		4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2
		2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10
		1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9
		10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8
		9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7
		8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6
		6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4
		4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2
		2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10
		1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9
		10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8
		9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7
		8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6
		6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4
		4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2
		2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10
		1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9
		10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8	7	6	5	4	3	2	1	10	9	8
		9	8	7	6	5	4</																											

PURPLE SCALE TABLE—30 PER CENT LEAKAGE.

Water, ounces.																																																																																																																																																																																																																																																																																																																																																																																																																																																									
x3-----	168	156	144	132	120	114	108	102	96	90	84	78	72	66	60	57	54	51	48	45	42	39	36	33	30	28½	27	25½	24	22½	21	19½																																																																																																																																																																																																																																																																																																																																																																																																																									
x2½-----	140	130	120	110	100	95	90	85	80	75	70	65	60	55	50	47½	45	42½	40	37½	35	32½	30	27½	25	23½	22½	21½	20	18½	17½	16½																																																																																																																																																																																																																																																																																																																																																																																																																									
x2-----	112	104	96	88	80	76	72	68	64	60	56	52	48	44	40	38	36	34	32	30	28	26	24	22	20	19	18	17	16	15	14	13																																																																																																																																																																																																																																																																																																																																																																																																																									
x1½-----	74½	69½	64	58½	53½	50½	48	45½	42½	40	37½	34½	32	29½	26½	25½	24	22½	21½	20	18½	17½	16	14½	13½	12½	12	11½	10½	10	9½	8½																																																																																																																																																																																																																																																																																																																																																																																																																									
Sodium Cyanide, ounces.																																																																																																																																																																																																																																																																																																																																																																																																																																																									
x3-----	37½	34½	32	29½	26½	25½	24	22½	21½	20	18½	17½	16	14½	13½	12½	12	11½	10½	10	9½	8½	8	7½	6½	6	5½	5½	5	4½	4½																																																																																																																																																																																																																																																																																																																																																																																																																										
Acid and Potassium Cyanide, ounces.																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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PURPLE SCALE TABLE—.35 PER CENT LEAKAGE.

		Water, ounces.																								
x ³	192	180	168	156	144	132	120	114	108	102	96	90	84	78	72	66	60	57	54	51	48	45	42	39	36	33
x ^{2½}	160	150	140	130	120	110	100	95	90	85	80	75	70	65	60	55	50	47½	45	42½	40	37½	35	32½	30	27½
x ²	128	120	112	104	96	88	80	76	72	68	64	60	56	52	48	44	40	38	36	34	32	30	28	26	24	22
x ^{1½}	85½	80	74½	69½	64	58½	53½	50½	48	45½	42½	40	37½	34½	32	29½	26½	25½	24	22½	21½	20	18½	17½	16	14½
		Sodium Cyanide, ounces.																								
x ^½	42½	40	37½	34½	32	29½	26½	25½	24	22½	21½	20	18½	17½	16	14½	13½	12½	12	11½	10½	10	9½	8½	8	7½
		Acid and Potassium Cyanide, ounces.																								
64	60	56	52	48	44	40	38	36	34	32	30	28	26	24	22	20	19	18	17	16	15	14	13	12	11	
		Dimensions—Distance around and over tent, feet.																								
62	59	57	54	52	50	49	47	46	44	43	41	39	37	34	32	30	29	27	26	25	24	23	21	20		
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	58	57	55	53	50	49	48	46	45	43	42	40	38	35	33	31	30	28	27	25	24	23	21	20		
	56	55	53	51	50	49	47	46	44	42	40	38	36	33	31	30	29	27	26	24	23	21	20			
		54	51	50	49	47	46	44	42	41	39	36	34	32	31	29	28	26	25	23	21	20				
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		48	47	45	43	42	40	37	35	33	32	30	29	27	26	24	22	20								
		46	44	42	40	38	35	34	32	31	29	28	26	24	22	20										
			43	40	38	35	34	33	31	30	28	27	25	23	21	20										
			42	41	38	36	34	33	31	30	29	27	26	24	22	20										
				40	39	36	35	33	32	30	29	27	26	24	22	20										
					40	38	36	35	34	32	31	29	28	26	24	22	20									
						44	42	40	38	35	34	32	31	29	28	26	24	22	20							
							43	40	38	35	34	33	31	30	28	27	25	23	21	20						
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									40	39	36	35	33	32	30	29	27	26	24	22	20					
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													40	38	35	34	32	31	29	28	26	24	22	20		
														36	34	33	32	31	29	27	26	24	22	20		
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NEW METHOD OF MEASURING TREES.

The use of tables of any kind always introduces the possibility of an error in reading that it would be very desirable to avoid. The fumigator's rule may be used to measure the tree and gives either the dimensions in feet or indicates directly the dose. The method of using the rule for this purpose is shown in figure 3.

This figure is almost self-explanatory—one stands in any position in the orchard, preferably equidistant from two trees, one of which he desires to schedule; holding the rule in the left hand, as shown in position A, bringing it towards the face until the two ends correspond to the trunks of the two trees, then holding the hand perfectly steady, rotate the body slightly till the rule is brought into position B, then grasp it with the right hand in such a way that the thumb will mark off the apparent diameter of the trees; then keeping the rule at exactly the same distance from the eye, turn the hand into position C; one can read at once on the rule the proper dose corresponding with each degree of leakage. In the figure the circumference of the tree is shown to be 46 feet, the height about $13\frac{1}{2}$ feet; the row of figures between these two points gives the correct dosage for the different degrees of leakage, that is, 4, 5, 6, 7, 9, 11, 13 ounces, according to the different degrees of leakage.

This tree, therefore, represents a seven-ounce dose with average leakage, but may only need four ounces with a tighter tent, or should receive thirteen ounces with the most leaky tent.

The dose is found approximately midway between the two dimensions, or more accurately two fifths of the way from the diameter towards the height.

In case the distance between the trees is more or less than 20 feet the length of the rule should be increased or decreased proportionately since this rule reads to a 20 feet, as shown on the scale on the edge marked diameter.

The rule illustrated is graduated for black scale, the dose for purple scale is approximately twice as large. We propose to produce similar rules for red and purple scale.

This method of measuring trees is sufficiently accurate for practical purposes, and is rapid and convenient and not liable to the errors incident to the use of tables, and may be found better in practice than previous methods.

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FIG. 3.—Method of scheduling by the use of the fumigator's rule.

RÉSUMÉ.

Recent studies now make possible the proper allowance in the dose for leakage.

Tents differ very greatly in leakage.

Present dosage tables fundamentally wrong.

More uniformity and economy will result from leakage determination.

Excessive dosage now necessary to cover errors in the tables.

Average leakage as determined with doubled tents is .25 per cent.

The common range of leakage was found to be from .10 per cent to .40 per cent.

The dose for black, red, and purple scale for ten-foot tree and with tent having .25 per cent leakage is 4, $5\frac{3}{4}$, and 7 ounces, respectively.

The dose should be always in this proportion.

Large size or great leakage both require an increased dose.

The proper adjustment to leakage is a complicated problem.

The amount of increase given in the form of a rule showing the whole dosage system.

Small trees require very tight tents.

The limits of effective fumigation are given for all leakages.

This system of dosage agrees with the actual practice of fumigators.

Scheduling charts may be used under this system.

The errors of previous dosage tables are pointed out and a full set of new tables given.

Dosage tables are given for using direct measurements.

A new method is presented which may supersede all other methods of estimating the dose.

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69. The Extermination of Morning-glory.
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