CIRCULAR NO. 111. Issued September 29, 1909.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

PREPARATIONS FOR WINTER FUMIGATION FOR THE CITRUS WHITE FLY.

By A. W. MORRILL and W. W. YOTHERS.

INTRODUCTION.

As a result of investigations conducted by the Bureau of Entomology during the past three years, fumigation for the citrus white fly has been placed upon a practical basis, and the process has been so simplified that any citrus grower can undertake the treatment of his grove without depending upon experienced fumigators to conduct the operations. Under present conditions fumigation is the most satisfactory and profitable method of controlling the white fly in hundreds of infested groves in the Gulf coast citrus-growing regions, and its usefulness will be extended to nearly all infested groves when the practical recommendations in a forthcoming bulletin on the white fly have been put into effect. The superior quality of Florida citrus fruits when grown in groves free from injury from insect pests and the awakening of progressive growers to the necessity for organizations for combating insect pests and for marketing the fruit point to the general adoption of the control measures to be recommended in the publication referred to.

At the present time the authors would recommend fumigation for the white fly under the following circumstances: In groves isolated by a distance of at least 200 yards [a] from all other infested groves, in citrus groves or in citrus-growing sections where the white fly has recently appeared and is still of limited distribution, and in sections where cooperation can be secured among growers in naturally isolated groups. In many cases the owner of an extensive and valuable grove which is isolated except for a small grove of a few acres from other infested groves can well afford to loan his equipment, or, if necessary, fumigate the neighboring grove entirely at his own expense,

[a] Experience so far has shown that as a rule in cases of isolation of much less extent fumigation can be practiced without its being rendered unprofitable through the migration of adults.

rather than to permit the presence of such grove to interfere with his results.

Full directions concerning equipment, chemicals, and methods of procedure in fumigating for the citrus white fly have been published in a bulletin of this Bureau.[a] This bulletin is based upon results obtained in January and February, 1907. Extensive field experiments have been conducted during the last two seasons and the additional results obtained will be embodied in a supplementary report now in preparation by the authors of this circular. It is hoped that before the beginning of the next fumigating season, extending from December 1 to March 1, a publication in the Farmers' Bulletin series of this Department will be available. This bulletin will contain only such advice and directions as are of practical importance in fumigation work against the white fly, omitting the details of experiments published elsewhere as the necessary basis for establishing practical conclusions. The present circular aims to call attention to the desirability and in most cases necessity for early preparations where fumigation work is planned for the coming winter season; also to give full directions for such preparations.

EQUIPMENT.

TENTS.

Orders for tents should be placed as soon as possible after it is decided to fumigate a grove. Tent makers do not always have on hand a sufficient quantity of desirable grades of canvas to fill large orders. Delays in filling the order may necessitate shipment by express, at a cost several times the expense of shipment by freight.

The first step is the determining of the sizes of tents required. It is a more common mistake to underestimate the size of a tent required than to overestimate it. Some allowance should be made for the growth of trees, in consideration of the future use of the tents. If the trees are nearly uniform in size, the largest trees should be selected for measuring. A tape measure attached to a reel is used in measuring trees to determine the size of tent required. Standing a few feet from the outside branches of the tree to be measured, enough of the tape is unreeled to extend over the top of the tree and about half way to the ground on the other side, the free end of the tape is held in one hand and the reel is thrown over the center of the tree and unreels the tape by its own weight until it reaches the ground. Two or three attempts may be necessary in order to have the tape pass over the center of the tree. It should be borne in mind that the weight of the tent will reduce the extreme height of the tree and that

[a] Bul. 76, Bur. Ent., U. S. Dept. Agr., Fumigation for the Citrus White Fly as adapted to Florida conditions. By A. W. Morrill.

it is therefore unnecessary for the tape to pass over the highest twigs. For large trees 6 to 8 feet should be added to the number of feet over the top of the tree, as shown by the measurement, and for small trees 4 to 6 feet should be added. In general, trees from 10 to 15 feet high require tents between 32 and 44 feet in size[a]; trees from 16 to 20 feet high require tents 44 to 58 feet in size; trees 21 to 25 feet high require tents 60 to 70 feet in size; and trees 25 to 30 feet high require tents 70 to 76 feet in size.

In regard to the number of tents required, it is safe to estimate that with one tent for each 100 trees the work of fumigation could be completed in ten to fourteen nights' work. One crew can handle from twenty to twenty-five small tents, 45 feet in size and smaller, and from eight to fifteen tents, 50 feet in size and larger. Much depends upon the trees being so spaced as to obviate interference with the work of shifting the tents.

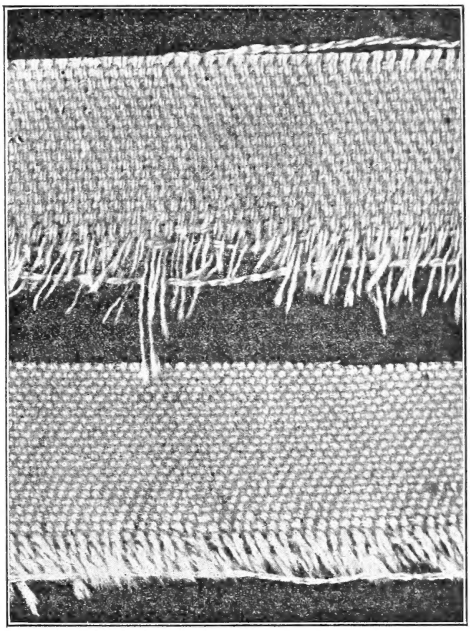

FIG. 1.—An undesirable and a desirable type of 8-oz. cotton duck for fumigating tents. (Original.)

Having decided upon the number and sizes of tents required, orders should be placed as soon as possible. Samples of 8-ounce army duck should be obtained from tent and awning makers who are in a position to furnish the tents. The selection of tent material is a matter of great importance. Samples of duck can be classified roughly in regard to tightness by the general texture and by the degree of imperviousness to direct rays of light when held between the eye and the sun, or any bright light. Neither of these methods is entirely satisfactory, however, in selecting material for fumigating tents. With a simple arrangement devised by the authors for testing the tightness of material submitted to the laboratory at Orlando, Fla., for examination, it has been found that samples of duck vary nearly 50 per cent in their comparative tightness.

Figure 1 illustrates two extreme samples of 8-ounce duck which differ to the extent of 47 per cent in this respect. As a result of

[a] The size of tents is expressed in terms of the distance between parallel sides of the octagonal sheet of canvas of which the tent is composed.

the examinations made so far, the authors strongly advise against the use of drills of any kind. The appearance of these is much more misleading than that of ducks, and it seems impossible to estimate their comparative tightness except by tests with special apparatus. Our experience up to the present time leads us to recommend closely woven duck weighing 8 ounces per yard, when 28½ or 29 inches wide, or about 10 ounces per yard when the material is 36 inches wide. The more expensive grades of cloth are not always the most nearly gastight. In the case of two leading concerns which have supplied large orders of tents for use in Florida, the medium grades of material, as shown by the prices quoted, have been found to be superior in gas-holding qualities to either the cheapest or the most expensive of the three grades upon which prices were quoted.

The form of cover which is at present almost exclusively employed is the flat octagon. Frequently those who have never seen a tent of this kind fail to realize its simplicity. A square piece of canvas would answer the purpose as well as the octagon, but to save material and the handling of extra cloth the corners of the square are left off. A perfectly circular cover would be more economical in respect to the amount of cloth required, but the saving would not cover the extra expense of construction in this form.

For specifications tentmakers may be referred to Bulletin 76 of this bureau.[a] In general these specifications are simply that the form is approximately octagonal, of any desired size, made of parallel strips of goods overlapped three-eighths or one-half inch, double stitched, and all raw edges hemmed. In the case of tents 50 feet or more in size a reinforcement is desirable across the middle section near each end, as described in the bulletin referred to. It is desirable that allowances be made for shrinkage, otherwise a tent after becoming wet and later drying may not be sufficiently large to cover trees of the size for which it was intended. The following published statement by the senior author is of importance in this connection and is quoted in full:[b]

> Shrinkage of the goods after being thoroughly wet is an important consideration in the economical construction of fumigating tents. In order that the tents approximate a regular octagon, after having been used for fumigating purposes, it is necessary either to have the goods thoroughly shrunk before cutting or to make allowance for subsequent shrinkage by cutting the strips longer. A test made with a brand of 8-ounce duck commonly used in California for fumigating tents showed that the shrinkage lengthwise of the goods amounted to 7.5 per cent and crosswise 0.9 per cent. This means that in a 50-foot tent the shrinkage would result in the full-length strips shortening 3¾ feet, while the tent would shrink less than 6 inches crosswise of the strips. Such irregularities might be remedied by a skirt of 6½-ounce drill, but it is simpler to

---

[a] For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 15 cents.

[b] Bul. 76, Bur. Ent., U. S. Dept. Agr., pp. 17–18.

plan to have each strip cut longer by a given amount for each 1 per cent of difference in the lengthwise and crosswise shrinkage. In the case referred to above this difference is 6.6 per cent, and each per cent represents an actual difference of 6 inches. A 50-foot tent constructed in this manner would therefore measure before shrinkage 52¼ feet (49 feet 10½ inches + 3 feet 4 inches) lengthwise of the strips through the middle section, and 49 feet 10½ inches crosswise of the strips. After shrinking, the dimensions would be approximately 49 feet 4½ inches in each direction.

On account of the variation in the shrinkage of different brands of duck it is necessary to test the crosswise and lengthwise shrinkage in the sample selected. This may be done by marking, with a lead pencil, lines 1 foot or more in length, both crosswise and lengthwise of the strip of goods. The sample should be shrunken twice, each time wetting by submerging in water for two or three hours and drying in the sun. The amount of the shrinkage can then be determined by measuring the pencil lines just referred to.

The marking of the tents with graduated stripes, which is a part of the process of determining dosage requirements originated by the senior author,[a] requires less than an hour for each tent. The necessary preparations for this, therefore, consist in procuring suitable paint and arranging for a patch of open field where the tents may be spread flat to become saturated with rain or dew, thus producing the desired shrinkage. The importance of the tents being thoroughly shrunken before the measuring for the graduations is obvious.

Directions for "mildew-proofing" the tents will be given in publications now in preparation and it is not necessary to include them in this connection. Tents should be thoroughly dried in the sun before being folded for storage, and in preparing them for field use they should not be exposed to rains or dews any more than is necessary to shrink as advised above.

POLES AND DERRICKS.

In the Gulf States, seasoned cypress is probably the best material available for the manufacture of poles and derricks used in shifting tents. These serve practically the same purpose, the former being used in handling tents up to 50 feet in size and the latter in handling tents 50 feet in size and larger. The poles have no other attachment than a rope, while the derricks each consist of a pole with a crosspiece and braces at the base and eye-bolt attachment for pulley and tackle at the small end. These poles and derricks can be prepared for use in a short time, but it is very important that the poles be cut and peeled long enough before they are needed for use to permit them to become well seasoned. Poles should be carefully selected in order to have them as straight and free from knots as possible. While only two poles or two derricks are needed for use at one time, an extra supply of both should always be in readiness,

[a] Loc. cit., pp. 32-33.

so that in case of breakage the work can be continued with little interruption. The length of the shifting poles should be about 2 feet more than the height of the average trees, and the small end should be about 1½ inches in diameter. The poles for derricks should be about 3 or 4 feet more in length than the height of the average tree, and when ready for use should be between 3 and 4 inches in diameter at the base and between 2 and 3 inches in diameter at the top. The method of attaching the crosspieces and braces is described and illustrated in Bulletin 76 of this Bureau. If ordinary three-eighths or one-half inch bolts are at hand, a pair of derricks can be prepared for use in less than half an hour, and this need not therefore be considered a necessary part of the early perparations for fumigation. Cypress poles should be seasoned in a barn or packing house, or if out of doors they should be in the shade. Straight poles, while being seasoned, should be so supported as to prevent bending or warping. If, after cutting, a pole is found to be crooked, it may perhaps be made practically straight by the proper arrangement of the supports when seasoning.

GENERATORS OR CROCKS.

In generating the gas earthenware crocks are used. In general, trees 5 to 8 feet high will require crocks of 1½ gallons capacity; trees 9 to 12 feet high, crocks of 2 gallons capacity; trees 13 to 16 feet high, crocks of 4 gallons capacity; trees 17 to 20 feet high, crocks of 4 or 5 gallons capacity; and trees 21 to 30 feet high, crocks of 5 or 6 gallons capacity. For trees up to about 18 feet in height one crock will be needed for each tent, but for larger trees two crocks should be used, dividing the dosage into two equal parts. Crocks with straight sides can be used with more cyanid for each gallon of capacity than crocks which narrow at the top, and it is to the former style rather than to the latter that the preceding statements refer.

The foregoing directions should enable anyone preparing to fumigate to determine the actual number and sizes which will be needed. It is always advisable to have several extra crocks at hand, so that delays will be avoided in case of breakage.

Crocks of more than 2 gallons capacity can not be readily obtained as a rule and frequently even the smaller sizes can not be obtained of local dealers in sufficient numbers to equip a large outfit. It is important, therefore, that orders for crocks be placed as soon as possible when preparing to fumigate. As the tops or covers are not needed, dealers should take this into consideration in quoting prices. When not purchased of local dealers and no allowance is made in the price on account of the covers of the crocks, instructions should be given not to include the covers in the shipment, in order to avoid unnecessary freight or express charges.

Convenient handles for the crocks can be made of a large size[a] of wire. If properly arranged the ends of the handle will be held in position on opposite sides of the crock, otherwise they may cause considerable annoyance.

MISCELLANEOUS REQUIREMENTS.

Of the numerous articles of minor importance which sometimes are not easily obtained and should therefore be arranged for as early as possible are rubber gloves and glass graduates. Two or three pairs of rubber gloves should be obtained for a large outfit. One pair is needed for the one who measures the acid and generates the gas, and one pair should be available for use by the helper who empties the contents of the crocks after fumigating. The third pair should be on hand in case one of the pairs in use is lost or destroyed by any means. Rubber gloves can be purchased of or ordered through electrical supply houses or electric-light companies. Black rubber gloves with cloth lining are preferable to the red rubber gloves without lining which are sometimes used. The latter are not easily removed from the hands, especially after they become wet on the inside, and are on this account very troublesome. One should avoid gloves which are so thick that a wet glass graduate can not be easily handled when wearing them.

A glass graduate of 16 ounces capacity is needed for each outfit, and if not obtainable of local dealers one or two extra ones should be always on hand. They can be purchased through local druggists or directly of wholesale drug houses. It is important that the numbers on the graduate be plain and easily readable.

Torches are preferable to lanterns, and if possible three or four of the former should be obtained.

Balances, stoneware pitchers, dippers, water buckets, ropes, pulleys, and other articles can usually be obtained of local merchants.

CHEMICALS.

The chemicals required in fumigation with hydrocyanic-acid gas are potassium cyanid (KCN) and sulphuric acid (H_2SO_4).

POTASSIUM CYANID.

The cyanid ordinarily used in fumigating citrus trees is put up in 200-pound cases and costs between 21 and 23 cents a pound in ton lots. It should be guaranteed to be 98 to 99 per cent pure. In calculating the amount of cyanid required, a tree should be selected which represents as nearly as can be estimated the average size of the trees in the grove. The distance over the top can be obtained by the tape measure in the same manner as described in connection with estimating the sizes of tents required. In addition to this measurement the circumference of the tree should be measured with the

[a] No. 9 has been used by the authors for this purpose.

tape line. This can be done by attaching the free end of the tape to a twig and passing around the tree, hanging the tape on the outer twigs as it is unreeled. If the grove consists of two sizes of trees, as, for example, large seedling and medium-sized budded trees, an average specimen of both kinds should be measured. The amount of cyanid required for these average specimens can be determined from the dosage table given herein. The following examples illustrate the method of using the table after the distance over and the circumference of the tree have been obtained:

Example No.	Distance over tree.	Circumference of tree.	Amount of potassium cyanid required.
	Feet.	*Feet.*	*Ounces.*
1	24	40	9
2	38	55	26
3	52	72	58
4	66	79	96

The amount of cyanid in ounces having been obtained for the average tree in the grove, this amount is multiplied by the total number of trees to be treated and divided by 16 to reduce to pounds. It is advisable to obtain from 5 to 10 per cent more cyanid than the amount estimated, in order to avoid delays in case of underestimation. The cyanid, being put up in air-tight tin cases inclosed in stout wooden boxes, may be stored for months without deterioration. Excess cyanid can usually be disposed of without difficulty.

SULPHURIC ACID.

Sulphuric acid can be purchased in iron drums containing about 1,500 pounds at about $1\frac{1}{10}$ cents a pound. One drum of acid is required for about 4 cases of cyanid. The acid should be guaranteed 66° Baumé or 93 per cent pure. It is advisable to have a sample tested with an acid hydrometer, an inexpensive instrument which can be obtained through any druggist. Acid should not be stored for more than two or three weeks in the drum. Unless it is to be used at once the entire contents should be emptied into carboys, the mouths of which should be closed with wooden plugs, strips of burlap, and plaster of Paris. Empty carboys can be purchased for $1.50 or $1.75 each, and 9 are required to contain the contents of an acid drum. Only carboys in good condition should be used, since the container is made of thin glass and breaks easily if the bottom of the wooden case becomes weakened and fails to support the contents. Great care should be used in handling the acid. Probably the quickest and safest way of emptying acid from the large drum into carboys is a method which has been used on several occasions by the authors. The drum is mounted on two heavy planks resting on the ground and is arranged so that it can be rolled forward and backward easily. At one end of

the planks a pit about 3 feet deep is dug. This should be large enough for two men to stand in and place the empty carboy in position and lift it out when filled. A large-mouthed funnel made of sheet lead is placed in the mouth of the carboy. A piece of cast-iron piping about 6 or 8 inches long and properly threaded is a convenience, but not a requirement. This, if available, is screwed into the opening in the drum, which is arranged so that the acid will pour into the funnel leading to the carboy. A piece of heavy plank or other suitable lumber should be strongly spiked across the ends of the two plank supports of the drum to prevent its being rolled too far forward. Whenever there is a suitable platform available, or timber is available for making a rough one, the trouble of digging the pit can be obviated. It is not

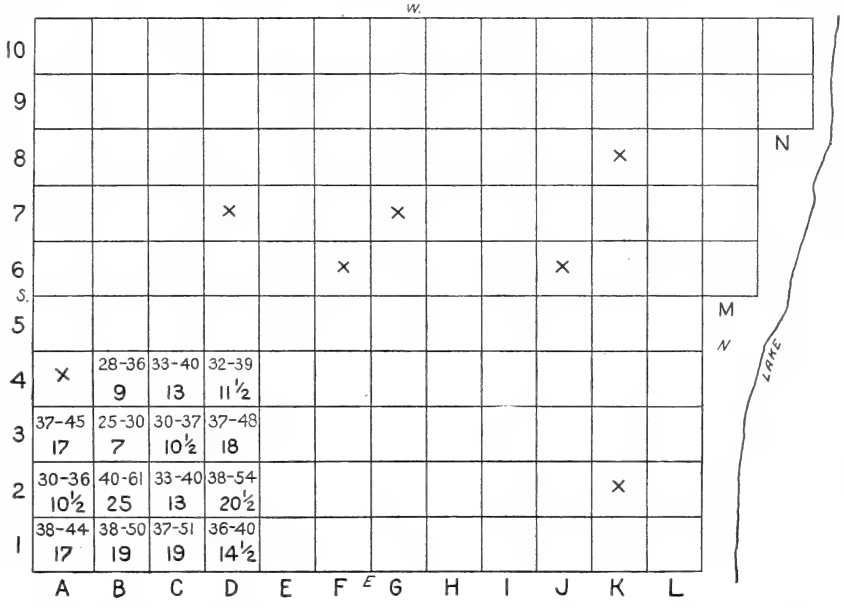

FIG. 2.—Diagram of regularly set grove in process of fumigation with an outfit of four tents: X, X, trees missing. (From Morrill.)

advisable to empty drums from railroad stations or packing-house platforms, as more or less acid is usually spilled. No one should stand near the carboy when the acid is being poured, and care should be taken to prevent any spattering of the acid from reaching the face. When handling acid it is always well to have water at hand for use in case of accident. With proper care sulphuric acid can be handled without danger of any kind.

DIAGRAMS OF GROVES, AND DOSAGE TABLES.

While it is not always necessary that diagrams of groves be made, it is always advisable as a matter of record and to prevent errors. Figures 2 and 3 illustrate methods of making diagrams when trees

are set in the square and in the alternate system, respectively. The figures in the squares represent the records of the trees fumigated, the two upper figures separated by a dash representing the dimensions of the tented tree and the lower figure the amount of cyanid given.[a] These records are made at the time each tree is fumigated.

In presenting the dosage table recommended in Bulletin 76 it was stated that the amounts of cyanid could be increased from 10 to 25 per cent with advantage under certain conditions. At the present time the authors advise for general use a table (fig. 4) representing

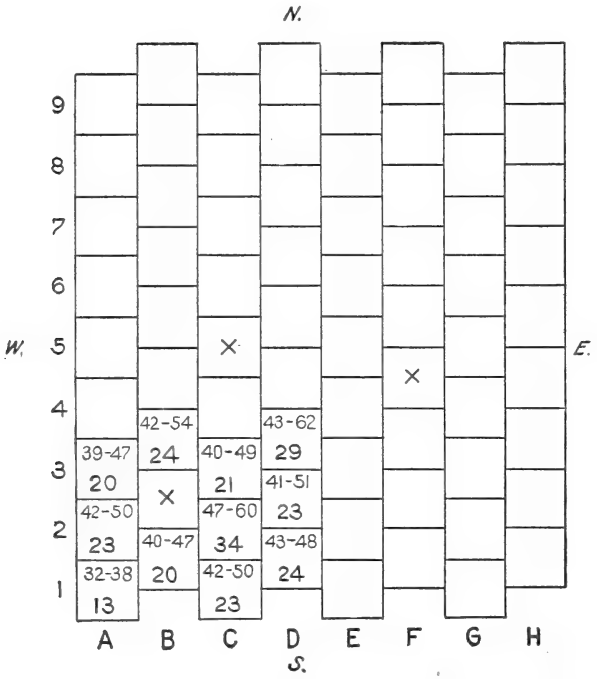

FIG. 3.—Diagram of grove with alternating trees; first four rows in process of fumigation with four tents; three sets of trees fumigated, the tents being moved from south to north: X, X, X, trees missing. (From Morrill.)

an increase of 25 per cent over the minimum requirements previously given in tabular form. This seems desirable, owing to the wide variations in the weave of various tenting materials and to the frequency with which slight winds might interfere with the results.

MISCELLANEOUS SUGGESTIONS.

With the gradual extension of the process of fumigation in the control of the white fly in Florida and other citrus-growing sections of the Gulf coast, the value of a citrus grove will be considerably

[a] The amount is according to the dosage table given in Bulletin 76 of this Bureau, page 68.

affected by the difficulties in fumigation presented by excessive height of trees, closeness of planting, unevenness of ground, and other conditions. The systematic treatment of groves to overcome these difficulties, so that the trees may be easily fumigated, will not only be of value in this respect, but will constitute a good cultural practice. Trees planted too closely for fumigation to be practicable are too close for best results in productiveness. Limiting the height of trees by pruning not only lessens the expense of fumigation, but reduces the expense of picking the fruit without reducing the quantity.

DISTANCE OVER	CIRCUMFERENCE.																											DISTANCE OVER
	10	15	20	25	30	35	40	45	50	52²	55	57²	60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
10	2	2	2																							10	
12	3	3	3																							12	
1 14	3²	3²	3²	3²																						14	1
16	4	4	4	4	4																					16	
18		5	5	5	5	5																				18	
	10	15	20	25	30	35	40	45	50	52²	55	57²	60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
20		5²	5²	5²	5²	5²																				20	
22			5²	6²	6²	6²	7																			22	
2 24			6²	7²	7²	8	9	9²																		24	2
26				9	9	9²	10	11																		26	
28				10	11	11	12	13	13																	28	
	10	15	20	25	30	35	40	45	50	52²	55	57²	60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
30					12	13	13	14	15																	30	
32					13	14	15	16	18	19																32	
3 34					15	15	16	18	19	21	23															34	3
36						17	18	19	21	22	23	25														36	
38						19	20	21	23	24	26	27	28													38	
					30	35	40	45	50	52²	55	57²	60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
40							22	23	26	27	28	30	31	32												40	
42							23	26	28	30	31	32	33	35	36											42	
4 44								28	30	31	33	35	36	37	39	40	42									44	4
46									33	34	36	37	39	40	42	43	45	47	49							46	
48									35	37	38	39	42	43	45	47	48	50	51	53						48	
							40	45	50	52²	55	57²	60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
50										39	41	43	45	46	49	51	53	55	57	58	60					50	
52											43	45	47	49	51	53	56	58	60	62	64	66				52	
5 54											46	48	50	53	55	58	60	62	64	66	68	70	73			54	5
56												51	53	56	58	61	63	66	68	71	73	75	77	79		56	
58												53	56	59	61	64	67	70	72	75	78	80	82	84		58	
									50	52²	55	57²	60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
60													60	63	65	68	70	73	76	79	82	85	88	91	94	60	
62													62	65	68	72	75	78	80	83	86	89	91	94	97	62	
6 64													66	69	72	76	79	82	85	89	92	95	98	101	104	64	6
66													69	73	76	80	84	87	89	93	97	101	104	107	111	66	
68													73	77	80	84	87	90	93	97	101	105	109	113	116	68	
													60	62²	65	67²	70	72²	75	77²	80	82²	85	87²	90		
70													77	80	83	87	90	94	98	102	106	110	114	118	123	70	
72													80	83	86	90	94	98	103	107	111	115	119	123	127	72	
7 74													84	87	89	94	98	103	107	112	116	120	124	128	133	74	7
76													87	90	94	98	102	107	112	117	121	125	129	134	139	76	

FIG. 4.—Dosage schedule for use in fumigating for the citrus white fly. (Original.)

In preparing for the fumigation of a grove, if the branches interlock to any extent, either pruning of branches or transplanting of alternate trees or rows of trees is advisable. Deadwood on the outer parts of the trees should be thoroughly removed in all cases to avoid the tearing of tents. Watershoots should be thoroughly removed at the same time, since about 1 per cent of the white fly pupæ present during the winter months survive fumigation and the resistance of the insects on watershoot leaves is much greater than elsewhere on the trees.

If possible, the cultivating and fertilizing of groves to be fumigated should follow fumigation. It is much more difficult to handle the fumigating tents on newly cultivated ground, and the dust arising in the shifting of the tents is sometimes a matter of considerable discomfort to the men engaged in the work.

Approved:

W. M. HAYS,

Acting Secretary of Agriculture.

WASHINGTON, D. C., *August 10, 1909.*

[Cir. 111]

O