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*Cecididae - San Jose Scale
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UNIVERSITY OF ARKANSAS

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

SPRAYING FOR SAN JOSE SCALE

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SPRAYING FOR SAN JOSE SCALE

W. J. BAERG

INTRODUCTION

The purpose in taking up the project of Dormant Spraying was to determine the results that could be expected from the application of such insecticides as Dry Lime Sulfur, Soluble Sulfur, Barium Tetrasulfide, and "Scalecide." Since Commercial Concentrated Lime Sulfur solution has many times proved an effective insecticide, for the control of San Jose scale, it seemed well to use this as a standard for comparison.

The account of the work and observations presented in this bulletin is intended to be a preliminary paper. Although the work has been carried on for a period of three years; 1919, 1920, and 1921, yet in the light of recent observations on the heavy toll that San Jose scale has taken in orchards, apparently well sprayed, there doubtless remains something in regard to the control work that we need to learn.

The first two seasons the spray applications were made in the spring, just as the buds began to show green. In 1921 the applications were made when the buds were separating. As will be discussed later, the spring dormant spraying is known to be more effective than the fall, and the later the spring application the more effective it is.

The orchards used in this project were:—one five-acre orchard consisting of 6-8 year old trees, belonging to James Nichols, near Springdale; a small terrace orchard consisting of 4-year old trees belonging to the Experiment Station; and a three-acre variety orchard of 10-15 year old trees, on the new Experiment Station farm. In the Nichols orchard and the Terrace orchard the work and the observations cover a period of three years, and during all this time the same arrangement of plats was maintained, and the same materials were applied in the same way. The variety orchard has been sprayed but once, and the observations are for one season.

The arrangement of the plats and the materials used: The Nichols orchard, as is seen in fig. 1 was divided into four plats, one for each of the following materials:—Commercial Concentrated Lime Sulfur solution (made by the Kimmons-Walker Company, Springdale, Arkansas), at the rate of 1 gallon to 8 gallons of water; Scalecide* (made by B. G. Pratt & Company, New York City,) at the rate of 1 gallon to 15 gallons of water; Barium Tetrasulfide (made by the General Chemical Company,

*"Scalecide" is one of a number of well-known forms of miscible oil.

FIG. 1—NICHOLS ORCHARD

W															
T	T	T	T	T	T	T	T	T	T	T	T	T	T		
Soluble			Barium Tetrasul-			"Scalecide"			Commerci-						
T	T	T	T	T	T	T	T	T	T	T	T	T	T		
Sulfur, 14			fide, 14 pounds to						al Lime						
\	(15)		(14)			1:15					(6)				
T	fT	T	T	T	T	T	T	T	T	T	T	fhT	T		
pounds to			50 gallons						Sulfur						
(16)			(13)			(7)					1:8				
H	T	T	T	T	T	T	T	fhT	T	T	(5)	T	fT	T	
50 gallons															
T	T	T	H	T	T	T	T	T	T	T	T	fT	T		
											(4)				
T	T	T	T	T	T	T	T	T	T	T	T	T	T		
(17)			(12)												
fh	T	T	T	T	T	fhT	T	T	T	T	T	T	T		
			(11)			(8)									
T	T	T	T	T	T	T	H	T	T	T	T	T	T		
(18)															
T	T	fhT	T	T	T	T	T	T	T	T	T	T	T		
							(9)				(3)				
T	T	T	T	T	T	T	fT	T	T	T	T	H	T	T	
							(10)								
T	T	T	T	T	T	T	T	T	fhT	T	T	T	T		
											(2)				
T	T	T	T	T	T	T	T	T	T	T	T	C	T	C	T
											(1)				
T	T	T	T	T	T	T	T	T	T	T	T	C	T	C	T
E															

C—Checks.

H—Heavily infested, bark covered.

f. h.—Fairly heavy infestation.

f.—Fairly infested, scales easily found.

FIG. 2. TERRACE ORCHARD

W

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

Dry Lime Sulfur, 14 pounds to 50 gallons

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

"Scalecide", 1 gallon to

T T T T T T T T

15 gallons of water.

T T T T T T T T

T T T T T T T T

T T T T T T T T

T T T T T T T T

E

FIG. 3.—VARIETY ORCHARD

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

New York City), at the rate of 14 pounds to 50 gallons of water; and Soluble Sulfur (made by the Niagara Sprayer Company, Middleport, New York), at the rate of 14 pounds to 50 gallons of water. Four check trees were left in the southeast corner.

The Terrace orchard, see fig. 2, was divided into two plats, one for "Scalecide" and the other for Dry Lime Sulfur (made by the Shermin-Williams Company, Cleveland, Ohio).

The Variety orchard was divided into four plats, see fig. 3. Two for different strengths of dry lime sulfur, one for commercial lime sulfur solution, and the remainder for "Scalecide."

Spraying in the Nichols, and the Variety orchard was done with a Hardy Duplex Sprayer equipped with 10-foot poles, and four angle nozzles. In the Terrace orchard a Demming Barrel Sprayed was used. All the spraying was done through discs of 1/16 inch opening.

SEASON OF 1919

With a view of obtaining definite figures in regard to relative merit of the various insecticides, a count of live scale insects was made before and after treatment. For this purpose four trees that showed either a heavy or fair infestation of scale were selected in each plat, and from these and from two of the

four check trees, five pieces of twigs were removed for examination. These were terminal twigs about eighteen inches long and taken from various portions of the trees. The examination was made under a binocular microscope, and only the live scale insects were counted.

On twigs that were heavily infested, the insects were counted over a distance of one or two centimeters, and from the figures thus obtained the total was estimated.

The number of scale insects taken from the different trees, as is seen in the table below, varied between wide limits. This is mostly due to the fact that the twigs were taken at random from various parts of the tree, without any effort to get a certain degree of infestation. The examination was made on February 19.

The number of insects found on the trees labelled are as follows, five 18-inch twigs were taken from each tree:

Tree No. 1.	54 scale insects.	Tree No. 10.	316 scale insects.
Tree No. 2.	48 scale insects.	Tree No. 11.	10 scale insects.
Tree No. 3.	2452 scale insects	Tree No. 12.	258 scale insects.
Tree No. 4.	45 scale insects.	Tree No. 13.	994 scale insects.
Tree No. 5.	131 scale insects.	Tree No. 14.	111 scale insects.
Tree No. 6.	54 scale insects.	Tree No. 15.	477 scale insects.
Tree No. 7.	220 scale insects.	Tree No. 16.	864 scale insects.
Tree No. 8.	2883 scale insects.	Tree No. 17.	285 scale insects.
Tree No. 9.	92 scale insects.	Tree No. 18.	2205 scale insects.

The selection of the check trees was somewhat unfortunate. The infestation on these trees was rather slight, and this was later nearly destroyed by the lime sulfur that was carried over by a moderate wind.

The Nichols orchard was sprayed on March 14, using the following materials: (see fig. 1). Commercial Lime Sulfur solution; "Scalecide"; B. T. S.; and Soluble Sulfur. The Terrace orchard was sprayed on March 15, using "Scalecide," and Dry Lime Sulfur. (See fig. 2). Weather conditions were favorable. The maximum temperature for the two weeks following the spraying ranged between 57-76° F. The buds at the time of spraying were just beginning to show green.

Results. On April 14, a month after the spraying, twigs were again taken from the same trees and in the same manner as was done before the spraying. These twigs were examined in the same manner as described above. The results of the examination were as follows:

Twigs from Mr. Nichols' Orchard,*

Cut on April 14, 1919.

Examined on April 15, 1919.

Material Used	Tree No.	No. of Live Scale	Degree of Infestation Before Spraying.
Check	1	19	Light
	2	15	Light
Lime Sulfur	3	1	Very Heavy
	4	1	Light
	5	1	Medium
	6	0	Light
Scalecide	7	0	Medium
	8	1	Very Heavy
	9	2	Light
	10	0	Medium
B T S	11	2	Light
	12	49	Medium
	13	137	Heavy
	14	4	Medium
Soluble Sulfur	15	41	Medium
	16	50	Heavy
	17	12	Medium
	18	40	Very Heavy

*See preceding table.

Checks do not afford as striking a contrast as would be desirable, as the twigs unfortunately had but few scales. Nearly all of those that had reached the proper stage of development, had wintered well, and were about full-grown. The males were about to emerge or had already done so.

The twigs of Lime Sulfur and "Scalecide" plats showed results very definitely, numerous scales in the right stage, and practically all dead.

Comparing these figures with those obtained in the first count, it is seen that the Commercial Lime Sulfur and the "Scalecide" showed fairly definite and good results. Barium Tetrasulfide, and soluble Sulfur were not as effective. Of these two the Soluble Sulfur seems to be slightly more effective. The check

trees were disappointing. The fatalities among the insects were apparently due to the lime sulfur that was carried over by a moderate south wind.

On November 11, 1919, the various plats were examined again, and live scale was found on many of the trees. At this time the twigs were selected with a view of getting the largest possible number of scale insects. Ten terminal twigs about 18-20 inches long were taken from five different trees in each plat. An examination of these twigs gave the following figures:

Lime Sulfur Plat	-106 live scale insects.
Scalecide Plat	-100 live scale insects.
Barium Tetrasulfide Plat	-158 live scale insects.
Soluble Sulfur Plat	-352 live scale insects.

These figures do not indicate the relative merits of the various insecticide materials, for the reason that in the Lime Sulfur and the "Scalecide" plats it required considerable searching to find twigs with live scale insects. This was not necessary in the Barium Tetrasulfide and the Soluble Sulfur plats.

Comparing the Barium Tetrasulfide and the Soluble Sulfur at this time it is seen by the figures that the Barium Tetrasulfide has the advantage over the Soluble Sulfur. This was confirmed by a careful examination of the other trees in the two plats. The examination made April 14 seemed to show the opposite. The change came during the summer when it was observed that the young insects were establishing themselves much faster in the Soluble Sulfur plat than they were in the Barium Tetrasulfide plat.

The check trees showed a few live scale insects, but not enough to warrant the counting.

In the Terrace orchard, since the trees were small and thus easily examined, it was considered unnecessary to bring twigs into the laboratory. Accordingly a number of general examinations were made during the summer and fall which showed that "Scalecide" and Dry Lime Sulfur were about equally effective. A few live scale insects were found in the Dry Lime Sulfur plat, late in the fall. The object in using the "Scalecide" here was mainly, to determine whether or not it would injure the young trees when used each year for 3-4 years.*

SEASON OF 1920

The Nichols and the Terrace orchards were sprayed on March 22 and 23 respectively, using the same materials and maintaining the same plats as in 1919. Weather conditions

*Anderson—Ill. Hort. Soc. Rpt., 1920, p. 87-88.

Glenn—Ill. Cir. 180, p. 22.

were favorable. The maximum temperatures for the two weeks following the spraying ranged between 50 and 78° F. The buds had begun to swell and were showing green at the time of spraying. The check trees were abandoned, partly because the drifting lime sulfur in the previous season made them almost valueless, and partly because the owner fairly begged to have them sprayed. While this is contrary to usage in experimental work, yet considering that San Jose scale was very common and in several orchards had killed many trees, it was believed that the use of the check trees could be dispensed with.

Results

The observations in regard to the results of the second year's work were made on November 13. At this time all the trees were carefully examined for live scale insects, but no material was taken to be examined under the microscope.

Commercial Lime Sulfur. In this plat a few, 5 or 6, trees were found with live scale insects. These infestations, however, were distinctly restricted to small regions in the tree. Obviously they originated from a few overwintering scales that were missed when we sprayed.

"Scalecide." The results in this plat were contrary to what was expected. Live scale insects could be found on practically every tree, and with but little difficulty. On some of the trees the infestation was becoming rather marked. What this striking difference in the results of the two seasons is due to is problematical. For the first season's work the material was sent directly from the headquarters of the manufacturer; this year the material was purchased from a local dealer.

Barium Tetrasulfide. The trees in this plat had nearly the same degree of infestation as was found in the "Scalecide" plat. Live scale insects could be found on many of the trees; but the infestation was nowhere as conspicuous. The infestation was markedly less than at the end of the previous season.

Soluble Sulfur. A number of the trees had scale insects. Since the trees in this plat are much smaller than those of the other three plats, the results cannot reasonably be ascribed to a failure in covering the entire tree with the spray material.

The results in this plat were very much like those in the Barium Tetrasulfide plat, although live scale insects could be found on many of the trees; yet it showed a decided decrease from the condition of last year.

Terrace Orchard. The observations here were made at various times during the summer and fall. Late in the fall a number of the trees in the Dry Lime Sulfur plat showed a slight infesta-

tion. The results in the "Scalecide" plat were markedly better, practically no live scale insects could be found. The "Scalecide" used here was taken from the supply of the previous year, which was shipped directly from headquarters of the manufacturers.

SEASON OF 1921

This year the work was extended to cover the 3-acre Variety orchard in addition to the Nichols and Terrace orchards. These orchards were sprayed on March 8, 9, and 10 respectively. In the Nichols and the Terrace orchards the same plats were maintained and the same materials were applied as in the previous seasons. In the Nichols orchard a spray gun was used in the place of one of the rods. The gun was kept on the same hose all the time so that in case any infestations would appear they could properly be traced. Special care was taken with the gun, spraying the trees from all sides, and using a generous amount of material.

The Variety orchard was sprayed with Dry Lime Sulfur (two different strengths), Liquid Lime Sulfur solution, and "Scalecide." (See fig. 3.)

Weather conditions this year were more favorable than any other year. The maximum temperature for the two weeks following the spraying ranged between 48 and 84° F. On several days the temperature went to 80° or above.

Results

On June 9 all the trees in the Nichols orchard were examined. In the Soluble Sulfur plat a large number of trees showed dead scale insects, but no live insects, either old or young, could be found. The Barium Tetrasulfide plat also showed dead scale insects on a few trees, no live scale could be found. In the "Scalecide" plat there were a few traces of scale, no live insects could be found. In the Commercial Lime Sulfur plat all traces of scale insects had disappeared.

On August 1 the trees in this orchard were again examined and the observations given above were confirmed, with the additional feature that many of the dead scales had dropped off. There could not be found any live scale insects.

On June 10 all the trees in the Terrace orchard were examined, dead scales were found on a number of trees, but no live scale insects were in evidence.

On August 2 the orchard was again examined and the observations given above were confirmed.

The Variety orchard was examined on June 11. Dead scales were fairly common, and could be found on nearly all the trees. There was no evidence of live scale insects, either old or young.

On August 2 the trees in this orchard were again examined

as before and the same results were obtained.

The results of this season are strikingly better on control work than those of the seasons of 1919 and 1920, in that all materials used appeared to be entirely effective. The high temperature at the time of spraying was probably responsible for this.

DISCUSSION OF RESULTS

Commercial Lime Sulfur Solution. Judging from the results just discussed, covering three year's work, it appears that Lime Sulfur stands first in effectiveness among the materials that have been tested. Infested trees examined thirty days after spraying, gave definite results. Wherever the material had been applied all the insects were dead. There were no indefinite cases. This cannot be said of any of the other sulfur compounds.

Comparing Lime Sulfur with "Scalecide" the former is preferable because it spreads better, or putting it in another way, it wets up the tree quicker. "Scalecide" has a tendency to collect on the bark and then run down. My experience is that the use of "Scalecide" involves more care, in order to make a thoro application, and it likewise involves at least as much material. In so far as I know this is contrary to all published statements, excepting one made by Mr. Leroy Childs* of the Oregon Experiment Station.

"Scalecide." According to the results of these experiments "Scalecide" would come second in efficiency, judging solely by the effect it had on San Jose scale. It has decided advantages over Lime Sulfur in that it has no very noticeable unpleasant effects on the human skin. It does not corrode the pumps and presents no difficulties in mixing. Its disadvantages compared with lime sulfur solution have already been discussed.

There is a claim made in advertisements that the application of "Scalecide" for a period of three years has a "stimulating" effect, so that the trees sprayed will be "in every way better" than the trees sprayed with lime sulfur. I can find no evidence for the claim in all the work that has been done. On the other hand there are certain publications* which state that "Scalecide" when applied for 3-4 years in succession will injure, and in some instances kill the trees. I have been unable to find any evidence of injury caused by the use of "Scalecide," either in the Nichols orchard (trees 8-10 years old) or the Terrace orchard (trees 4-5 years old.) In both of these orchards "Scalecide" was used for three successive seasons.

Barium Tetrasulfide. This material would stand third in

*Oregon Hort. Rept. 1920, p 122.

*Anderson, Ill. Hort. Soc. Rpt. 1920, p 94.

Glenn, Ill. Cir., 180, p 22.

efficiency for dormant spraying. In the work of 1919 and 1920 the material came in a coarse crystalline form. These crystals were rather slow in going into solution, hence much time was lost in making up the mixture. In 1921 the material was in the form of a dull black powder, which when sifted slowly into the tank, already filled, and the agitator going, dissolved quite readily. Whether this material will be more effective against the San Jose scale than was the crystalline form, remains to be shown.

As can be seen from the foregoing pages, the *combined* effect of the three season's spraying with this material is entirely satisfactory; but the results of the one or even two year's spraying are clearly below those of the Commercial Lime Sulfur solution, and of "Scalecide" also.

Attention has already been called to the fact that when trees that had been sprayed were examined a month later, there were many dead insects, but there were many that were indefinite. In other words, although the insects gave no clear evidence of being alive, yet they were plump and full of liquid, while the results in the "Scalecide" and the Liquid Lime Sulfur plats were clear and definite.

Soluble Sulfur. This material would come fourth in efficiency for the control of San Jose scale. An examination of the sprayed twigs gave practically the same results that are given for Barium Tetrasulfide. However, after a number of observations made at intervals of about a month, I have observed that Barium Tetrasulfide has an inhibiting effect on San Jose Scale, (i. e., prevents young scale from settling) which lasts decidedly longer than it does in Soluble Sulfur.

Soluble Sulfur apparently passes very rapidly into solution, and causes no trouble in nozzles.

Dry Lime Sulfur. Owing to the fact that this material was not at hand when the work on the Nichols orchard was begun, it was not included in that test. The test in the Terrace orchard and the Station orchard indicates that Dry Lime Sulfur is fairly effective in killing San Jose scale. However, since it was tried under different conditions than the former materials, given above, one cannot draw any definite conclusions as to where it would stand in regard to the other materials tried. However, apparently it is preferable to Barium Tetrasulfide and Soluble Sulfur, in so far as its efficiency as an insecticide is concerned.

The Dry Materials. B. T. S., Dry Lime Sulfur, and Soluble Sulfur, while highly effective in the season of 1921, were not so satisfactory during the two previous years, and cannot yet be given as strong a recommendation as Lime Sulfur. They have the advantage that they can be hauled more readily over rough roads.

There is no trouble with leaking containers. These materials are purchased in substantial tin containers in which they can be kept almost indefinitely, provided the cans are in a fairly dry place.

CONTROLLING SAN JOSE SCALE

A considerable number of failures to control San Jose scale have been reported. As a rule the trouble was attributed to a poor quality of lime sulfur solution. Various attempts have been made to substantiate this claim, but in most cases these have failed.

It is well known that only such equipment as will make the most thorough work possible, that is, a sprayer equipped with rods and the type of nozzles that throw a fine mist, can be relied on in cases of severe infestation of scale. The spray gun, although it is still held very much in favor by many growers, has without a doubt given rise to a number of failures in dormant spraying. In my opinion the spray gun cannot be used successfully for this purpose unless the trees are small and the grower is willing to waste about half of his spray material. The spray gun will not wet the upper surface of the twigs, unless the spraying is done from above or the material is allowed to drop down on the twigs. This will not do in the form of a fine mist. Furthermore, in a moderate wind, it is almost impossible to make a thoro application with a spray gun. By the use of angle nozzles on rods the spray can be directed at the twigs from all different angles so that no place remains uncovered.

Proper pruning obviously is essential for successful dormant spraying. Trees from 12-15 years old that have been allowed to grow in their own way for many years, and then develop a severe infestation of scale, cannot be sprayed with any degree of success. Such trees should be severely pruned so that the tops are well thinned out.

THE SEASON FOR SPRAYING

It has long been known that spraying for scale in spring, just before the buds show green, is about twenty per cent more effective* than spraying in the fall after the leaves have fallen. However, there are other features to be considered. Dormant spraying is relatively slow work. One ordinary power sprayer equipped with a 3-5 H. P. engine should not be expected to cover more than six acres of average-sized trees a day.

Furthermore, the weather is very uncertain during the time of spring dormant spraying. It is well to allow at least three days time for one day of spraying. And, in addition, in some

*Forbes, Ill. Bull. 180, p 555, 561.

years the development of the buds comes much earlier than in others, and proceeds at a very rapid rate. The season of 1921 is a good illustration of this. Many growers had only just started with the work when the buds began to separate. At this time all dormant spraying must be discontinued, or severe burning may be the result.

For these reasons, if the orchard is large and with a fair infestation of scale, and the spraying equipment limited, the grower will do better to apply at least a part of the dormant spray in the fall. Very heavily infested trees should be sprayed in the fall, and again in the spring.

If the orchard is small, involving only 2-3 days work, or the spraying equipment sufficient to make the entire application in a week or less time, then the spring application is to be preferred, provided, as already indicated, the trees are not heavily infested.

DOSAGE OF LIME SULFUR

In the experiments recorded in this paper, Lime Sulfur solution was used at the rate of 1 gallon to 8 gallons of water. All the spraying was done in spring, and moreover, at the particular time (when the buds were beginning to swell) when spraying is most effective.

The United States Bureau of Entomology recommends for dormant spraying, 1 gallon of Lime Sulfur solution to 7 gallons of water*. The recommendation is based on many years experimentation, and is doubtless intended for spraying to be effective in fall as well as in spring.

In the fall when the temperature is going down, when cold weather often sets in during the spraying, or soon after it, it will probably be necessary to use the dosage recommended by the United States Bureau of Entomology.

SUMMARY

The results of the work in Dormant Spraying may be summed up as follows:

Lime Sulfur is the most effective of all the materials tested.

The others may be arranged, relative to efficiency and advantages, as follows:

"Scalecide," Dry Lime Sulfur, Barium Tetrasulfide, Soluble Sulfur.

Dormant Spraying, in order to be effective, must be done thoroly, every portion of the infested tree must be covered with the spray material.

The spring application of the dormant spray is the most

*Farmers' Bulletin 650.

effective. This must be finished before the buds begin to separate. If spraying is to be done in spring, ample time should be allowed for unfavorable weather and unexpected progress in the development of the buds.

DESCRIPTION OF SAN JOSE SCALE

San Jose scale is a small oval-shaped insect, of a yellowish color. It lives underneath a black or grayish scale which consists partly of wax secreted by the insect and partly of the cast-off skins of the insect.

The following description of San Jose scale as it appears on the trees refers to the scales and not to the insects proper. These can be examined only under the microscope.

During the fall and winter, when the trees are dormant, the scales may be found on the bark of the trees. In a slight infestation the scales will appear as small, round, black and grayish spots. (See Plate I.) Many of them, especially on the last year's growth will be surrounded by reddish discoloration in the bark. When fully developed, they are about $1/16$ of an inch in diameter, or the size of a pin head. The black spots represent half-grown scale insects, and are therefore smaller.

In the summer and fall the scales may be found not only on the bark, but also on the leaves and the fruit. In fact a rather light infestation may often be located best when the apple crop is nearly mature. The scale insects on the fruit cause a bright red discoloration before the remainder of the apple develops this color.

The accompanying plates represent a heavy infestation of San Jose scale, enlarged about eight times, and also as it would appear in natural size.

PRICES OF THE VARIOUS MATERIALS

These quotations were received between August 15 and 23, 1921:

Liquid Lime Sulfur, 14 cents a gallon in barrel lots (or \$7.00 for a 50-gallon barrel).

"Scalecide," \$38.44 for a 50-gallon barrel.

Dry Lime Sulfur, \$25.00 for 200 pounds.

Barium Tetrasulfide, \$30.00 for 300 pounds.

Soluble Sulfur, \$12.00 for 100 pounds.

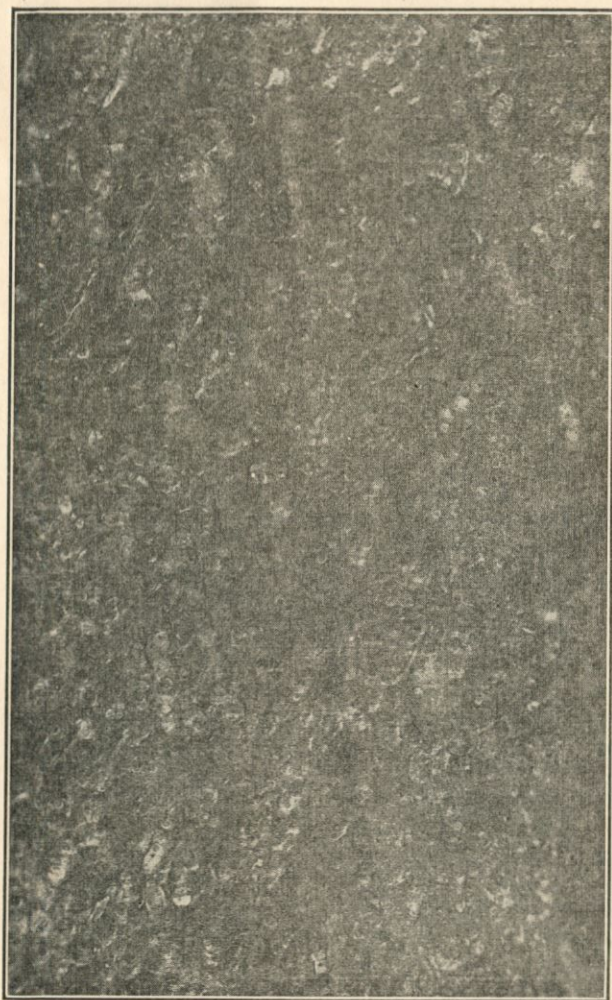


PLATE I

San Jose scale, enlarged about 8 times. Notice the small round bodies with white nipples in the center.

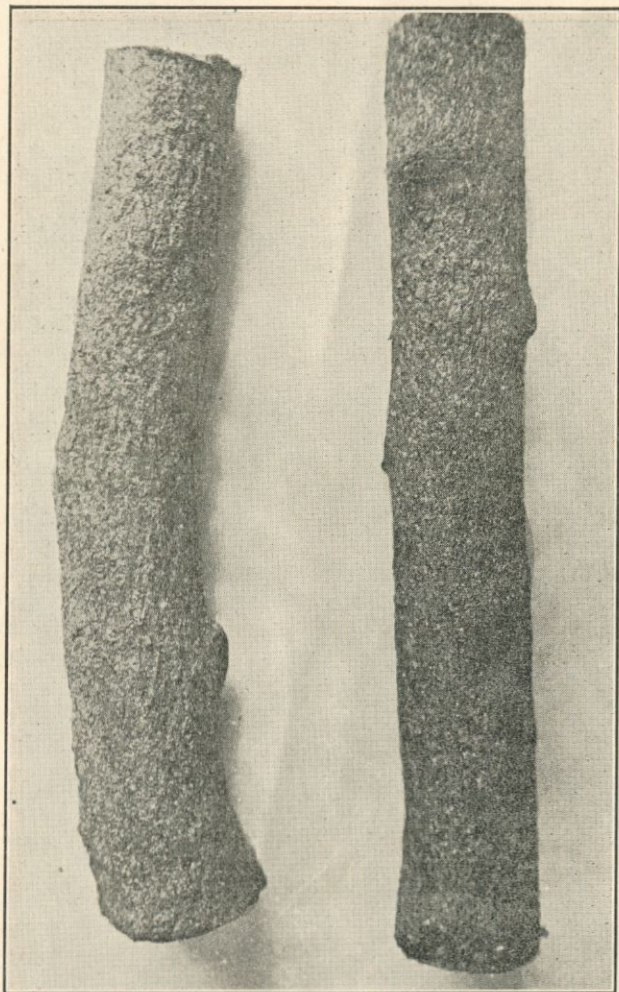


PLATE II

San Jose scale, about natural size. Notice the grayish-white appearance of the bark.

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