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NO.....
THE LIME-SULPHUR-SODA WASH FOR.....
ORCHARD TREATMENT.

P. J. PARROTT, S. A. BEACH AND H. O. WOODWORTH.



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THE LIME-SULPHUR-SODA WASH FOR ORCHARD TREATMENT.

P. J. PARROTT, S. A. BEACH AND H. O. WOODWORTH.

SUMMARY.

This bulletin gives the results of the first year's experiments to determine to what extent the lime-sulphur-caustic soda wash may be used in place of the bordeaux-arsenical mixtures for orchard treatment, and the value of this wash for the control of the San Jose scale.

The results are as follows :

Applications of the wash for the treatment of the scale gave somewhat variable results, which indicate that the various preparations were not always equally destructive to the scale. Some treatments gave satisfactory results, which show that an efficient spray may be prepared in the manner described. For this reason and because this method of preparing a sulphur wash is especially adapted to use by smaller orchardists, further experiments are to be made to test the wash and to devise methods by which all preparations may be made equally efficient.

In the treatment of apple trees the wash proved very efficient in preventing injuries by early spring leaf-eating caterpillars, as the bud moth and case bearer (*Tmetocera* and *Coleophora* sp.). An examination of samples of foliage shows that the average percentage of leaves from treated trees having caterpillar injuries is 13.9 per ct. and from untreated trees 71.7 per ct., proving that upon the sprayed trees there were 57.8 per ct. less worm-eaten leaves because of the treatment.

Comparative tests of the sulphur wash and the bordeaux-arsenical mixtures for the control of the codling moth demonstrated that the latter treatment is more effective. The average percentage

of wormy apples from the trees treated with the bordeaux-arsenical mixtures is 15.3 per ct., and from the trees sprayed with lime-sulphur-soda wash 36.7 per ct., showing that there were 21.4 per ct. less wormy apples upon the trees sprayed with the bordeaux-arsenical mixtures. No data were obtained upon the effects of applications of sulphur wash upon the hibernating larvæ.

Because of the absence of peach leaf curl, apple scab and other diseases in the experimental orchards no results were obtained as to the value of the sulphur wash for these diseases. Future experiments are necessary to determine the value of this treatment for these and other orchard diseases, and to what extent it may be employed in place of the usual applications of the bordeaux-arsenical mixtures.

INTRODUCTION.

One of the significant results of the lime-sulphur-salt experiments, conducted in 1902 by this Station, was that the apples upon the sprayed trees in the Stevenson ¹ orchard were practically free from scab while those of the checks were badly affected. The only satisfactory explanation for the superior condition of the fruit of the former was that the applications of the sulphur wash during the dormant season had prevented scab attack. In other experiments it had been conclusively demonstrated that similar treatment had efficiently controlled both scale and peach leaf curl.

From these results it was clearly apparent that the sulphur sprays have considerable fungicidal value and therefore have a greater range of usefulness and were more efficient in the East than had heretofore been suspected. But to what degree these sprays can be profitably used in eastern orchards, aside from the treatment of scale and leaf curl, has not been determined.

In view of this fact it was considered desirable to undertake investigations to ascertain to what extent treatment with a sulphur wash during the dormant season could be depended upon to take the place of the usual applications of bordeaux mixture and arsenical sprays for scab and other diseases, and early spring leaf-eating insects. It was also desired by Mr. V. H. Lowe to continue his investigations with his modification of the lime-sulphur-salt wash, in which caustic soda was substituted for the salt in the regular formula and used to prepare the wash, in place of external heat.

Accordingly experiments were planned jointly by Mr. Lowe and Prof. S. A. Beach, to determine to what extent the lime-sulphur-caustic soda wash could be used in place of the common sprays in orchard treatment, and its value for the control of the scale.

The execution of these plans was entrusted to Messrs. H. O. Woodworth and O. M. Taylor, who superintended the spraying

¹ Bulletin 223 of this Station p. 405.

of the orchards and made frequent observations upon the results of the treatment. Mr. V. A. Clark made the final examination of the yields in the Yorktown orchard and reported his results in Table I. Owing to the death of Mr. Lowe the writing of this bulletin largely devolved upon Mr. P. J. Parrott, his successor, who has in charge the entomological work of this investigation.

Acknowledgments are due to Messrs. White & Rice of Yorktown, and Mr. Albert Wood and Mr. Geo. Callard of Carlton Station, in whose orchards these experiments were conducted and who heartily coöperated in this work.

OUTLINE OF THE EXPERIMENT.

THE PLAN.

The experiment as planned consisted of a series of tests to determine the comparative merits of (1) one application of the sulphur wash during dormant season, (2) one application of the sulphur wash during dormant season supplemented with the remainder of the regular line of treatment with the bordeaux-arsenical mixtures, and (3) the usual applications of the bordeaux-arsenical mixtures for the treatment of common orchard pests. By the aid of abundant checks it was expected, by using this method of treatment, to obtain data upon the following points: (1) The value of the sulphur wash for scale and other insects, and for plant diseases; (2) the comparative values of the sulphur wash and bordeaux-arsenical mixtures for orchard spraying; and (3) to what extent one application of the sulphur wash could be depended upon to take the place of one or more applications of the bordeaux-arsenical mixtures.

In conducting the field work, blocks of bearing apple, peach, pear and plum, secured for the experiments, were divided into four sections, the varieties being representative of all. These sections were treated as follows: Section No. I, sprayed once with the lime-sulphur-soda wash; Section No. II, sprayed once with the sulphur wash before the opening of the buds and twice after the appearance of the leaves with the bordeaux-arsenical mixtures; Section No. III, check, no treatment; Section No. IV, sprayed three times with bordeaux mixture containing an arsenical poison,—once before and twice after the appearance of the leaves.

LOCATION OF ORCHARDS.

To carry out these plans, coöperative experiments were arranged with a number of the fruit-growers of this State. These experiments were conducted under the direct supervision of a member of the Station Staff, who directed the spraying operations and kept records of the details of the work and the results of the treatment.

The orchards in which the experiments were made are situated in Westchester County, near Yorktown; in Ontario County, near Geneva; and in Orleans County, near Carlton Station. The number of trees treated was 1440, consisting of 451 large apple, 245 plum, 338 pear, 375 peach, 26 quince and 5 cherry.

These orchards, with the exception of No. 1 at Carlton Station (which has been somewhat neglected, especially in the treatment for insects and diseases) have received careful attention, and have been given the usual sprayings with bordeaux mixture containing an arsenical poison.

The San José scale was present in all of the orchards, with the exception of No. 2 at Carlton Station. In the Geneva and Carlton Station No. 1 orchards the scale was not abundant, except upon a few trees. None of these have ever been treated for this pest. The Yorktown orchards have been known to be infested for a number of years, and have been treated in part with hydrocyanic acid gas and petroleum. The scale was well distributed among all the varieties. A goodly number of the trees were much incrustated with the scale, and many of the remaining ones were infested to a lesser degree.

The number and variety of the trees and their conditions with respect to scale furnished an excellent opportunity to work out the problems in view. In each experiment with each kind of fruit, abundant checks were reserved. In selecting these the aim was that the trees should be representative of the varieties and of similar condition with respect to scale and pest treatment as those under experiment.

THE PREPARATION OF THE SPRAYS.

THE BORDEAUX-ARSENICAL MIXTURE.

Copper sulphate.....	5 lb.
Quicklime.....	3½ to 5 lbs.
Water.....	50 gal.
Paris green.....	½ lb.

The bordeaux mixture was prepared by the common method. In the treatment of apple trees the paris green was used in the amount stated; but for peach, plum and pear, only one-quarter of a pound of the poison was used for this quantity of spraying mixture. The paris green was added to the freshly-prepared bordeaux mixture.

THE LIME-SULPHUR-CAUSTIC SODA WASH.

Lime.....	30 lb.
Sulphur.....	15 lb.
Caustic soda.....	4-6 lb.
Water.....	50 gal.

The formula used in the experiments was essentially as above, though slight changes in proportions were made in some cases.

In preparing the wash, the lime was started to slake with six gallons of water; and while it was slaking, the sulphur, which had just previously been made into a thin paste with hot water, was added and thoroughly mixed in with the slaking lime. To prolong the boiling of the wash, the caustic soda was then added, with water as needed, and the whole mixture was kept thoroughly stirred. As soon as the chemical action had ceased, the required amount of water was added, when the mixture was ready for use.

Aside from the heating of the water, the cooking of the wash was done in a tub or half barrel, and took from ten to twenty minutes. In some preparations, especially when hot water was used to start the slaking of the lime, not all of the stated amount of caustic soda was employed, but six pounds was the maximum.

CONDITIONS.

The work of applying the sulphur wash commenced Mar. 25 and continued till April 29. During the early applications the weather was bright and spring like, with light winds and occasional showers. Towards the last the weather changed and became cold and cloudy with frequent rains. Much difficulty

was experienced at this time in spraying the larger trees. Rains occurred Mar. 28, 30, 31 and April 6, 7, 8, 9, 10, 11, 14, 15, and 16. As a whole, the weather during the time of spraying was a severe test of the wash.

In applying the wash the trees were sprayed once carefully, and as soon as the application was dry, another was made, the spray being directed only upon the parts of the trees that had escaped the first treatment. Vermorel nozzles with fine apertures were employed in all of the operations.

The weather for the four weeks immediately following the last spraying with the sulphur wash was very dry. The precipitation at Geneva for May was .23 inches as compared with an average of 2.51 inches for the same month in the four preceding years.

In using the bordeaux-arsenical mixtures applications were made as follows:—(1) As the leaf buds commenced to appear green at the tips; (2) just after the blossoms fell; and (3) from ten to fourteen days after the second treatment. As previously explained, the first application was always omitted in the treatment of Section II in all orchards. In applying the spray the trees were sprayed once carefully and did not receive further treatment except as provided for in the regular order of spraying.

GENERAL RESULTS.

In planning these experiments it was the aim to obtain data upon the relative values of the sprays employed for the treatment of important insect and fungous pests of the orchard. Results of these sprays upon pests which are controlled by treatment during their dormant season were especially desired. Owing to the location of some of the orchards and the peculiar weather conditions which prevailed during the growing season the number of pests upon which an opportunity was given to make satisfactory tests was disappointingly small. This was especially true of the plant diseases, which were very little destructive this year. Very satisfactory results were obtained upon the San José scale, the codling moth, the bud moth and case bearers, especially the two latter, which are discussed under separate headings.

RESULTS ON SCALE.

The Yorktown orchard.—A careful examination of the orchards at Yorktown was made from Sept. 21 to 23, to determine the effects of the sulphur wash upon the scale. The results upon the apple trees indicate that the numbers of the scale had been greatly reduced. In comparison with the checks the treatment had apparently destroyed from 60 to 80 per ct. of the scales. On a number of the twigs and branches of three trees young live scales were quite abundant. Upon these trees the wash did not appear to be so efficient. Their condition indicated that the different preparations of the wash were not always equally effective. It was quite apparent in the course of inspection that the trees that were much incrustated with scale and had considerable rough bark were the least affected by the treatment. While these trees did not differ from others in an appreciable degree with respect to the condition of the bark, they were among the worst infested trees of the orchard. Undoubtedly the dense layers of scale, together with the rough bark, contributed to these unfavorable results. The fruit upon the sprayed trees was, as a rule, very clean, although there were individual trees that had quite a few specimens of fruit spotted with scale. The records of five trees show that from yields of 1200 to 4000 apples there were respectively from 12 to 30 infested specimens. The infestation of the foliage was very slight.

Upon the peach, plum, and pear trees the percentage of scales killed, while varying with individual trees, averaged higher than upon the apples in the same vicinity. The fruit and foliage of the peach and plum trees were unaffected, while about three to five per ct. of that on the pear trees was marked with scale. The wash was most effective upon the moderately infested trees, where a large proportion of the scales was destroyed. The trees of these varieties were small and possessed smooth bark; and for these reasons were undoubtedly better treated.

The Geneva and Carlton Station No. 1 orchards.—In these orchards the best results with the wash were obtained. As indicated before, none of these trees were much infested with scale. The scales as a rule were few and widely distributed, and were confined to twigs and small branches in the upper parts of the

trees. In no case were the scales upon the large branches where protection would be furnished by rough bark. In the Geneva orchard the scales seemed to be entirely destroyed by the treatment. Frequent examinations were made during the summer by Mr. Taylor who reports that he was unable to find a living scale upon any of the treated trees. Quite similar results were obtained in the Carlton Station No. 1 orchard. It should be stated that in preparing the wash for this orchard steam was employed for about ten minutes to heat the water to start the slaking of the lime, and to dissolve the soda. The most satisfactory demonstration of the insecticidal value of the wash was shown by the condition of one apple tree, which was the worst-infested one in the orchard. On Oct. 20 this tree was carefully examined. After considerable searching a few live scales were found on a number of branches. The treatment had cleaned the branches of most of the scales. The scales that still adhered were for the most part dead, and upon being scraped with a knife blade fell to the ground as dry, scurfy matter. Out of 7784 apples gathered from 8 trees sprayed with the wash there were only 8 infested specimens.

RESULTS ON CODLING MOTH.

The results upon the comparative values of the sulphur wash and the bordeaux-arsenical mixture upon this insect were obtained in the Yorktown and Carlton Station orchards. Owing to the differences in their conditions and past treatment, each orchard will be considered separately.

Experiments at Yorktown.—This orchard is composed of old trees, which are of a large size. These have in the past received very careful attention with respect to cultivation and spraying. The leading varieties are Baldwin, Gravenstein, Nonesuch and Roxbury. For the experiment there were reserved 276 trees which were treated as follows: 71, Section I, treated with lime-sulphur-soda wash; 60, Section II, lime-sulphur-soda wash and bordeaux mixture with arsenical poison; 64, Section III, check; and 81, Section IV, bordeaux mixture with an arsenical poison. The treatment was made upon the dates previously given. On Oct. 12 to 16, the apples from a number of trees were counted to

determine the relative amounts of sound and wormy fruit. As the Baldwins are greater in numbers and are represented in all of the treatments, the count was largely confined to this variety. The records of the yields of eighteen Baldwins are given in the accompanying table :—

TABLE NO. I.—YIELD OF SOUND, WORMY AND DISEASED APPLES, UNDER DIFFERENT TREATMENTS, AT YORKTOWN.

Number of section and tree.		Yield of picked apples.						Yield of windfalls.						
		Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Perct. wormy.	Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.	
SEC. I.	TREE 1	1485	325	135	28	1973	23.3	577	57	385	26	1045	42.3	
	2	1862	670	384	33	2949	35.7	830	63	415	21	1329	36.0	
	3	2646	627	320	50	3643	26.0	400	29	261	14	704	41.2	
	4	1663	272	241	96	2272	22.6	1410	93	330	40	1873	22.6	
	5	510	57	57	45	669	17.0	289	31	89	17	426	28.2	
		Average per ct. wormy						24.9	Average per ct. wormy					
SEC. II.	TREE 1	723	0	64	0	787	8.1	153	3	13	2	171	9.4	
	2	3598	25	151	20	3794	4.6	423	30	190	17	660	33.3	
	3	2667	19	130	88	2904	5.1	740	12	56	21	829	8.2	
	4	1114	10	94	26	1244	8.4	175	9	77	30	291	29.6	
	5	3112	114	206	87	3519	9.1	1062	28	191	37	1318	16.6	
		Average per ct. wormy						7.1	Average per ct. wormy					
SEC. III.	TREE 1	1500	136	108	36	1780	13.7							
	2	266	38	32	6	342	20.5							
	3	386	22	37	5	450	13.1							
		Average per ct. wormy						15.8						
SEC. IV.	TREE 1	1939	4	28	7	1978	1.6							
	2	569	0	7	4	580	1.2							
	3	200	0	4	2	206	1.9							
	4	2400	12	14	14	2440	1.1							
	5	1950	6	19	19	1994	1.3							
		Average per ct. wormy						1.4						

In examining this table it will be seen that the average percentage of wormy apples (picked) from Section I is 24.9; Section II, 7.1; Section III, 15.8; and from Section IV, 1.4. As the orchard has in the past been carefully sprayed the proportion of wormy fruit is low, as would be expected. The sound fruit from trees treated with bordeaux-arsenical mixture averaged 98.6 per ct. as compared with 75.1 per ct. of sound fruit from trees treated with the sulphur wash. Thus there was, upon the trees

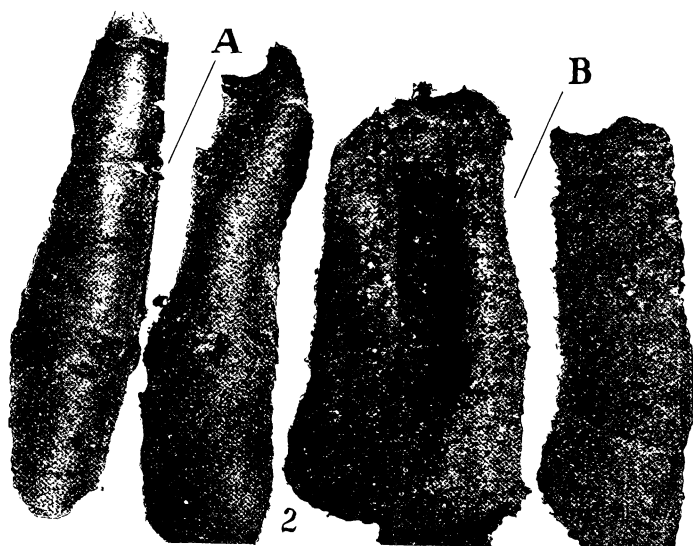


PLATE I.—EFFECT OF LIME-SULPHUR-SODA WASH ON LEAF-EATING CATERPILLARS AND ON SCALES: A, SPRAYED; B, UNSPRAYED.



PLATE II.—EFFECT OF LIME-SULPHUR-SALT WASH ON PEACH LEAF CURL
AND SCALES: 1, UNSPRAYED; 2, SPRAYED.



PLATE III —LIME-SULPHUR-SALT WASH AS A PREVENTIVE OF PEACH LEAF-CURL: 1. UNSPRAYED ELBERTAS; 2. SPRAYED ELBERTAS.

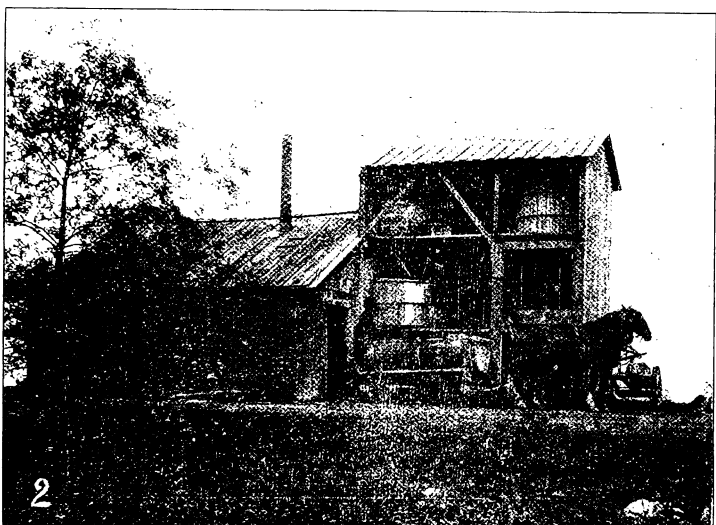


PLATE IV.—PREPARATION OF LIME-SULPHUR-SALT WASH : 1. OVER WOOD FIRE ; 2. IN POPULAR STEAM OUTFIT.

treated with the bordeaux-arsenical mixture, 23.5 per ct. less wormy apples than upon the trees sprayed with the sulphur wash. The percentage of wormy apples from trees sprayed with the sulphur wash is higher than that of the checks. This difference is undoubtedly due to the variation of individual trees in the amount of infestation, irrespective of the treatment; for it is clearly evident from the results obtained with the sulphur wash in this and other orchards that this treatment gives no protection to the fruit from the codling moth. The same explanation may be given for the results obtained from the trees in Section II, which were treated once with the sulphur wash and twice with the bordeaux arsenical mixtures, in comparison with Section III, treated entirely with the bordeaux-arsenical mixtures. The difference in the results of these two sections seems to be due to the variation of individual trees in the amount of the infestation of the fruit rather than to differences in treatment.

The superior results from the bordeaux-arsenical mixture are not surprising, when one considers the habits of the codling moth. If the infestation had been greater, more marked contrasts in the results of the two sprays would have been expected. It seems to be clearly indicated by the experiments that an arsenical spray must be depended upon for the control of the codling moth. The effects of applications of a sulphur wash upon the hibernating larvæ were not determined.

Experiments at Carlton Station.—This orchard consists almost entirely of the variety Baldwin. The trees are about thirty years of age, and have been somewhat neglected with respect to treatment with spraying mixtures. In this experiment 165 trees were used. With the exception of five trees reserved for checks, this number was divided evenly for treatment as outlined in the preceding experiment. On Oct. 20–22 a count was made to determine the effects of the treatments upon the codling moth. The examination was confined entirely to the fruit of Section I, treated with the lime-sulphur-soda wash, and Section IV, treated with the bordeaux-arsenical mixtures. The results of the examination are given in the following table:

TABLE NO. II.—YIELD OF SOUND, WORMY AND DISEASED APPLES UNDER DIFFERENT TREATMENTS, AT CARLTON STATION, ORCHARD I.

Number of section and tree.		Yield of picked apples.						Yield of windfalls.						
		Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.	Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.	
		No.	No.	No.	No.	No.		No.	No.	No.	No.	No.		
SEC. I. One application of the lime-sul- phur soda wash.	TREE 1	286	140	11	0	437	34.6	39	112	3	0	154	74.7	
	2	40	28	5	0	73	45.2	13	18	0	0	31	58.1	
	3	198	262	42	0	502	60.6	81	136	8	0	225	64.0	
	4	76	93	0	0	169	55.0	36	182	13	0	231	84.4	
	Average per ct. wormy						48.8	Average per ct. wormy						70.3
	5	10	68	9	0	87	88.5	78	142	13	0	233	66.5	
	6	862	312	42	0	1216	29.1	45	96	20	0	161	72.1	
	7	312	349	5	0	666	53.2	59	362	85	0	506	88.4	
	8	1873	496	66	8	2443	23.0	114	486	50	0	650	82.5	
	Average per ct. wormy						48.4	Average per ct. wormy						77.3
SEC. IV. Three applications of the bordeaux-ar- senical mixture.	TREE 1	59	15	4	0	78	24.4	52	48	7	0	107	51.4	
	2	412	161	23	0	596	30.9	41	112	18	0	171	76.0	
	3	895	417	51	2	1365	34.3	119	296	15	0	430	72.3	
	4	1780	452	18	0	2250	20.9	205	305	42	1	553	62.8	
	5	268	148	3	0	419	36.0	129	116	24	0	269	52.1	
	Average per ct. wormy						29.3	Average per ct. wormy						62.9

The wormy apples (picked) from Section I averaged 48.6 per ct. and from Section IV, 29.3 per ct. The sound fruit from trees treated with the bordeaux-arsenical spray is 70.7 per ct. and from trees sprayed with the sulphur wash 51.4 per ct.. Thus there was upon the trees sprayed with the bordeaux-arsenical mixture 19.3 per ct. less wormy apples than upon the trees sprayed with the sulphur wash. The results of this experiment agree very closely with those obtained in the Yorktown orchard, and further emphasize the superiority of the bordeaux-arsenical mixture for this pest.

RESULTS ON EARLY LEAF-EATING CATERPILLARS.

An examination of the Carlton Station (No. 1) orchard on May 5, showed that there was a marked contrast in the appearance of the foliage of the checks and of the trees treated with the sulphur wash. The leaves of the treated trees appeared to be more healthy and abundant. Upon close inspection it was found that the principal cause of this difference was that the early spring

leaf-eating caterpillars had been much more destructive to the foliage of the check trees.

In the past this orchard had been somewhat neglected, and these insects seemed to have had full sway as indicated by their work upon the untreated trees. These results were entirely unexpected, and were a great surprise to the observers. To those on the ground there was forced the conclusion that the treatment with the sulphur wash had greatly reduced the numbers of these insects. To obtain data upon the condition of the foliage at that time Mr. Taylor collected samples of leaves which were representative of the sprayed and unsprayed trees, and after a careful examination reported the results given in the following table :

TABLE NO. III.—A RECORD OF THE CONDITIONS OF FOLIAGE UPON SPRAYED AND UNSPRAYED TREES.

Treatment of trees.	Leaves.	Leaves not injured.	Leaves injured.	Leaves not injured.	Leaves injured.	Larvæ of bud moth on leaves.	Case bearers on leaves.
	No.	No.	No.	Per ct.	Per ct.	No.	No.
Sprayed. . . .	96	84	12	87.5	12.5	0	6
Check	120	31	89	25.8	74.2	8	35

On June 9, Prof. Beach and Mr. Taylor again visited the orchards to make further observations. The condition of the trees was much the same except that the foliage of the unsprayed trees did not appear to be so completely worm-eaten as before, because of the appearance of new leaves which at this time were not much affected by the insects. The uninjured leaves were as a rule of recent appearance. Representative clusters of leaves and fruits were gathered from treated and untreated trees and examined as before. The results of the examination are given in the accompanying tables :

TABLE NO. IV.—A RECORD OF THE CONDITIONS OF THE FOLIAGE OF
SPRAYED¹ AND UNSPRAYED² TREES.

Tree sprayed with lime-sulphur-salt wash.				Tree not sprayed.			
Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.	Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.
No.	No.	No.	Per ct.	No.	No.	No.	Per ct.
9	7	2	22.2	3	0	3	100.0
9	9	0	0.0	4	2	2	50.0
9	9	0	0.0	5	0	5	100.0
10	10	0	0.0	5	3	2	40.0
6	6	0	0.0	3	0	3	100.0
8	8	0	0.0	6	3	3	50.0
7	7	0	0.0	4	4	0	0.0
9	9	0	0.0	5	4	1	20.0
7	7	0	0.0	6	6	0	0.0
9	8	1	11.1	7	6	1	14.3
6	5	1	16.7	4	1	3	75.0
6	6	0	0.	4	2	2	50.0
9	7	2	22.2	6	2	4	66.7
6	6	0	0.0	4	1	3	75.0
5	5	0	0.0	3	0	3	100.0
5	5	0	0.0	6	2	4	66.7
7	5	2	28.6	7	1	6	85.7
7	7	0	0.0	7	6	1	14.3
6	6	0	0.0	8	1	7	87.5
5	2	3	60.0	5	1	4	80.0
7	6	1	14.3	8	5	3	37.5
5	4	1	20.0	11	1	10	90.9
11	8	3	27.3	7	2	5	71.4
Average percentage of leaves eaten.			9.7	Average percentage of leaves eaten.			59.8

¹ Tree 4, Section I. ² Tree 3, Section IV.

TABLE NO. V.—A RECORD OF THE CONDITIONS OF THE FOLIAGE OF
SPRAYED¹ AND UNSPRAYED² TREES.

Tree sprayed with lime-sulphur-soda wash.				Tree not sprayed.			
Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.	Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.
No.	No.	No.	Per ct.	No.	No.	No.	Per ct.
5	1	4	80.0	8	2	6	75.0
6	6	0	0.0	6	1	5	83.3
6	6	0	0.0	7	0	7	100.0
9	9	0	0.0	3	0	3	100.0
6	6	0	0.0	7	2	5	71.4
8	8	0	0.0	6	0	6	100.0
7	7	0	0.0	7	1	6	85.7
8	4	4	50.0	6	3	3	50.0
8	7	1	12.5	9	0	9	100.0
7	6	1	14.3	7	0	7	100.0
7	5	2	28.6	9	6	3	33.3
8	2	6	75.0	8	3	5	62.5
7	4	3	42.9	9	1	8	88.9
5	4	1	20.0	6	0	6	100.0
10	7	3	30.0	8	3	5	62.5
7	7	0	0.0	7	0	7	100.0
7	7	0	0.0	4	1	3	75.0
4	4	0	0.0	9	0	9	100.0
5	5	0	0.0	8	2	6	75.0
5	3	2	40.0	7	0	7	100.0
7	6	1	14.3	7	4	3	42.9
Average percentage of leaves eaten.			19.4	Average percentage of leaves eaten.			81.2

¹ Tree 6, Section I. ² Tree 2, Section IV.

TABLE VI.—A RECORD OF THE CONDITIONS OF THE FRUIT OF SPRAYED¹ AND UNSPRAYED² TREES.

Tree sprayed with lime-sulphur-soda wash.				Tree not sprayed.			
Fruits in cluster.	Fruits free.	Fruits eaten.	Proportion eaten.	Fruits in cluster.	Fruits free.	Fruits eaten.	Proportion eaten.
No.	No.	No.	Per ct.	No.	No.	No.	Per ct.
1	1	0	0.0	2	0	2	100.0
2	2	0	0.0	2	2	0	0.0
4	4	0	0.0	2	2	0	0.0
1	1	0	0.0	3	0	3	100.0
1	1	0	0.0	1	0	1	100.0
3	3	0	0.0	1	1	0	0.0
2	2	0	0.0	4	3	1	25.0
4	4	0	0.0	1	1	0	0.0
3	0	3	100.0	4	1	3	75.0
3	3	0	0.0	1	0	1	100.0
1	1	0	0.0	2	1	1	50.0
Average per ct. of fruit eaten 9.				Average per ct. of fruit eaten 50.			

¹ Tree 4, Section I. ² Tree 3, Section III.

The total number of leaves examined is 802, of which 406 were from trees treated with the sulphur wash and 396 from untreated trees. The number of fruits examined is 48, of which 25 were taken from sprayed and 23 from unsprayed trees. The worm-injured leaves from the sprayed trees averaged 13.9 per ct. and from the unsprayed trees 71.7 per ct. The worm-injured fruit from the sprayed trees averaged 9 per ct. and from unsprayed trees 50 per ct. Thus of the number examined there were 57.8 per ct. less worm-eaten leaves and 41 per ct. less worm-eaten apples from the sprayed lot than from the unsprayed. Judging from the appearance of the foliage at the time of the examinations it is believed that these figures closely represent the conditions of the leaves of the sprayed and unsprayed trees.

In the Carlton Station No. 2 orchard, which belongs to Mr. Albert Wood, 74 apple trees, consisting of the varieties Twenty-Ounce and Roxbury Russet, were used for the experiment. These trees were old and of a very large size. During the past ten years they have been thoroughly sprayed for insects and fungous pests. Because of this careful treatment, the case-bearer and bud-moth were not numerous enough to be injurious. For this reason no results were obtained upon the value of the sulphur wash for these pests. There were no evidences of the work of the codling moth upon any of the trees. Because of this no count was made of the fruit. The weather conditions prevailing during the growing season were very unfavorable for the apple scab. For this reason there was no evidence of this disease in the orchard, and consequently no opportunity was given to determine the comparative values of the sulphur wash and the bordeaux mixture for the treatment of this trouble.

RESULTS ON PLANT DISEASES.

The season was remarkable for the absence of important fruit diseases. During the early part of the growing season there was a protracted drouth, which was succeeded on June 7 by cold, wet weather. These conditions were unfavorable for the development of orchard diseases. For this reason the experiments undertaken to determine the comparative merits of the sulphur wash and bordeaux mixture as fungicides gave no satisfactory

results. Apple scab, which was so destructive the year before, was not sufficiently abundant to give conclusive evidence upon the merits of the different sprays. Likewise the work undertaken for the peach leaf curl, sooty blotch, brown rot, etc., gave inconclusive results. It is intended to continue these experiments until conclusive results are obtained.

DISCUSSION OF RESULTS AND CONCLUSIONS.

The experiments recorded in this bulletin represent the first season's work to determine to what extent the lime-sulphur-caustic soda wash may be used in the place of the usual applications of the bordeaux-arsenical mixture for orchard treatment and its value for scale control. It will be remembered that extensive tests conducted by this Station in 1902 demonstrated that the lime-sulphur-salt wash was a safe and reliable remedy for the scale. Likewise experiments conducted in this and other states have shown that this wash may to some degree prevent apple scab, pear psylla, and peach and pear mites. But its value for these latter and other important orchard pests has not been sufficiently determined to warrant its recommendation in place of recognized remedies.

In view of the fact that the scale is becoming more widely distributed, and sulphur sprays are being more generally used, there is need of more data as regards to the efficiency of sulphur washes for other pests than the scale and its range as a combined insecticide and fungicide. It was for this purpose that the present experiment was planned. In this year's work considerable progress has been made in the knowledge of the limits of the profitable use of sulphur sprays in the East. Because of the demand for information upon the use of lime-sulphur-soda wash, the present bulletin, which contains the important results of the investigation and directions for the preparation of sulphur washes has been published as a preliminary report of the progress of the work to date.

The conclusions drawn from the year's work are as follows :—

The experiments with the lime-sulphur-caustic soda wash indicate that the wash prepared in this manner may not give as uniform results for scale treatment as the common lime-sulphur-salt

wash, prepared by external heat. The difficulty of preparing an unvarying wash by this method seems to be due to variations in the quality of lime and caustic soda, and the quantity of water employed in the slaking of the lime. As some applications have proven very efficient and as this method of preparing a sulphur spray is a convenient one for small orchardists, further experiments are to be carried on to test this wash and to devise methods by which all preparations of it may be uniformly destructive to the scale.

One application of the lime-sulphur-soda wash to apple trees during the dormant season greatly reduced injuries by early spring leaf-eating caterpillars (*Tmetocera* and *Coleophora* sp.). Upon the sprayed trees 13.9 per ct. of the leaves and 9 per ct. of the apples were worm-injured; while upon the unsprayed trees 71.7 per ct. of the leaves and 50.0 per ct. of the fruits were worm-injured.

In the comparative tests with one application of the sulphur wash during dormant season and the usual treatment with the bordeaux-arsenical mixtures for the control of the codling moth it was shown that the latter treatment was much more effective. The average percentage of wormy apples from trees sprayed with the bordeaux-arsenical mixtures is 15.3 and from trees sprayed with the lime-sulphur-soda wash 36.7. The results indicate that the sulphur wash has no effect in preventing injuries to the fruit by this pest. The effects of the wash upon the hibernating larvæ were not determined.

Owing to the absence of apple scab in the experimental orchards no opportunity was given to determine the value of the sulphur wash for this disease. As it is desirable to obtain more data of the value of this treatment for this disease the experiment is to be continued until conclusive results are obtained. For the same reason as for the scab the results of the sulphur wash upon other plant diseases were inconclusive. Aside from peach leaf curl, the value of sulphur sprays for orchard plant diseases remains undetermined and requires further investigation.

To what extent it is advisable to use a sulphur spray in place of the bordeaux-arsenical mixtures remains undetermined.

Before any satisfactory conclusion can be drawn upon the desirability of a change of sprays in the first spring treatment of the apple, cherry, pear and plum, data are needed upon the value of the sulphur wash for apple scab, fruit rot and pear scab.

In case of the peach one application of the sulphur wash during dormant season may be used in place of the usual treatment with bordeaux mixture for the control of scale and leaf curl.

THE LIME-SULPHUR-SALT WASH.

The formula and directions for preparing the lime-sulphur-salt wash are as follows :

FORMULA.

Lump lime.....	15 lbs.
Flowers of sulphur.....	15 "
Salt.....	15 "
Water.....	50 gals.

Place the lime in a kettle, or in a vat if steam is used, and slake it with hot water so that it forms an even white paste. Now add enough water to reduce the lime paste to a thin whitewash. The sulphur and salt are then added and should be thoroughly stirred in. If the mixture is not already boiling, bring it to this point and allow it to boil for one hour. If the wash is prepared in an iron kettle it will be necessary to add a bucket of water now and then to replace that lost in the boiling process, and to stir the mixture frequently to prevent the burning and caking of the materials upon the sides of the vessel. After one hour's boiling, enough hot water should be added to make the required amount of mixture, or if cold water is used the proper proportion should be added and the wash again brought to the boiling point. The wash is now ready for use. It should then be emptied into a spraying barrel, being strained through common wire screening, and if possible, applied while hot to the trees. Applications should be made during dormant season.

The salt may be omitted. Experiments conducted this past summer indicate that washes prepared without the salt have given as satisfactory results as preparations containing it. Some think that it makes the wash more adhesive, and others believe that

preparations containing it are more likely to injure the buds. These are points that are not satisfactorily determined. If preparations without it are equally efficient there seems no necessity for using the salt. Some orchardists add the dry sulphur and salt before the slaking of the lime or sift it in dry, or add it as a paste during the slaking process. The mixture made by either of these methods seems to give satisfactory results, but it is believed that prepared as directed above there is less coarse sediment. Recent experiments indicate that one-half hour's boiling is sufficient but till more extensive tests have been made the full amount of time is advised. The mixture should be boiled till it is of a brick red color, and when allowed to settle appears as a brownish or yellowish-green liquid.

Use good fresh stone lime, which when slaked forms an even paste free from grit and dirt. The Ohio white lump lime makes a first class wash, and some grades of local lump lime have been found satisfactory. Flowers of sulphur, and light and heavy flour of sulphur may be used. The stock salt is the grade used.

THE LIME-SULPHUR-CAUSTIC SODA WASH.

FORMULA.

Lump lime.....	30 lbs.
Flowers of sulphur.	15 lbs.
Commercial caustic soda	4-6 lbs.
Water	50 gal.

Place the full quantity of lime in the kettle or barrel, or whatever the receptacle may be, and start it to slake with water, using enough to prevent the lime from being air-slaked, and not enough to drown it. As soon as the boiling action commences, add the sulphur, which has just previously been made into a paste with water. Stir this in thoroughly and pour in water in small quantities, to keep the mixture in the form of a rather thin paste. After the slaking of the lime, then add the caustic soda, in lots of about two pounds, at short intervals, and stir till the soda is dissolved. As soon as the chemical action has ceased, dilute the mixture with cold water to make the required amount. The time of cooking will be shortened by using warm water in slaking

the lime, and in making the sulphur into a paste. This wash is advised for experimental purposes, or when it is not possible to use the sulphur wash prepared by external heat.

Use the same grades of lime and sulphur, flowers of sulphur preferably, as for the lime-sulphur-salt wash. For extensive spraying, purchase from wholesale druggists the commercial caustic soda, put up in fifty pound cans. Upon exposure to the air, the caustic soda absorbs moisture and greatly increases in weight. Odd amounts of the soda may be kept dry in covered Mason jars. To prepare small quantities of the wash one may use any of the common soda lye brands, as sold by grocers.