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SPRAYING FOR SCALE INSECTS

By H. J. QUAYLE.

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SPRAYING FOR SCALE INSECTS.

By H. J. QUAYLE.

Introduction.—The experiments recorded in this bulletin were conducted by the Experiment Station in coöperation with the Kings County Board of Horticulture and with the fruit-growers in the neighborhood of Hanford. The work included spraying operations against the two most important scale insects of the county, namely, the brown apricot and San José scales.

The brown apricot scale (*Eulecanium armeniacum*, Craw) has been known to occur in California since 1891, but it is said to have been unknown as a pest in Kings County until within the last three or four years. It is now, however, widely distributed throughout the county, and is the most important scale insect with which the orchardist has to deal. While the popular name of this insect is the *brown apricot scale*, it is not upon the apricot tree that it thrives best, but instead shows a decided preference for the prune, and it is upon this tree that it does the most serious injury.

Next in importance to the brown apricot scale is the well-known San José scale. This insect is not so uniformly distributed over the county, and occurs in serious numbers only in limited areas, seldom an entire orchard being completely infested. While the San José scale attacks a great variety of trees, it particularly delights in the apple and pear in that section, and there are few old apple or pear trees in the county, which have escaped treatment, that are free from infestation of this scale.

Heretofore the remedies applied for the brown apricot scale seemed to have been inadequate to keep it under proper control, and it was the purpose of these experiments to determine upon an effective remedy for this insect, as well as to decide upon a satisfactory formula for the lime-sulfur-salt wash, which is the standard remedy for the San José scale. The work was done in Kings County in the upper San Joaquin Valley in the immediate vicinity of Hanford, and included the spraying of about one thousand acres of trees, of which the greater number were prune, and the balance consisted chiefly of peach and apricot.

THE LIME-SULFUR-SALT WASH.

History in California.—The lime-sulfur-salt wash is of California origin, and in the East it is sometimes known as the California wash. The above ingredients with water originally constituted a sheep dip, and

when horticultural interests began to be menaced by the ravages of the San José scale it was one of the first mixtures that proved effective as a remedy. The value of this solution as a spray was first demonstrated in 1886 by Mr. F. Dusey, a resident of Fresno, who experimented with a sheep dip prepared by Mr. A. T. Covell. The mixture, with some modification, quickly came into favor, and is now considered the standard remedy for the San José scale, not only in California but in most of the Eastern States.

The proportion of materials used in the original experiment was: lime 80 pounds, sulfur 100 pounds, sugar 20 pounds, salt 10 pounds, and water 160 gallons, the whole being boiled for a half hour. This was originally prepared, as stated above, for a sheep dip, and a small quantity was applied to some trees near by that were infested with the San José scale. In subsequent experiments the amounts of materials were changed considerably, and the first formulas recorded for a tree spray are those recommended by Mr. I. H. Thomas and Mr. A. T. Covell in the report of the California State Board of Horticulture for 1887–88. A few years later, in 1890, Mr. Thomas advocated the strengthening of his first formula by the increase of five pounds each of lime and sulfur. In the following year the amount of lime was increased and the amount of sulfur decreased, as shown in the formula which appeared in Mr. Lelong's report, as Secretary of the State Board of Horticulture, for 1891. At about the same time the Horticultural Commissioners of Sutter County did some further work with the wash, but finally adopted the same formula as that given in the report for 1891. This formula, up to the present time, has been considered the standard in this State.

The following tabulation shows the evolution of the wash in California:

	Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Sugar, lbs.	Water, gals.
1886, Original formula (sheep dip)	80	100	10	20	160
1887, I. H. Thomas	25	20	15	--	60
1887, A. T. Covell	50	20	15	--	60
1890, I. H. Thomas	30	25	15	--	60
1891, Lelong's report	40	20	15	--	60
Hort. Com. Sutter County	40	20	15	--	60
1904, Recommended in this bulletin	30	15	10	--	60

History in the East.—The lime-sulfur-salt wash was slow in getting a place among the standard remedies in the East. In 1895 Marlatt and Coquillett gave the wash a practical test under Eastern conditions, and the results were so unsatisfactory that its use was abandoned until it was again tried by Marlatt in 1900. The second attempt proved more successful than the first, and in fact gave gratifying results, and it is from this date that the lime-sulfur-salt wash rapidly came into use in the East. The failure of the first experiment under Eastern con-

ditions is attributed to the fact that the application was followed by a period of drenching rains, a condition which has not entered so largely into the California experience; while in the second case a period of dry weather followed the application of the spray, and the results proved more favorable.

This wash was further tested during the winter of 1901–02 by Professor Forbes, of Illinois, with the result that it was satisfactory, even if the application was followed by a reasonable amount of rainfall. During the past two or three years extensive experiments have been carried on with the wash in many of the Eastern States, prominent among which are the stations of New York, New Jersey, Connecticut, Delaware, Virginia, Georgia, Ohio, Kentucky, and Illinois. The general verdict of these experiments has been the adoption of the lime-sulfur-salt wash as a remedy for the San José scale.

The formula recommended by the different States at the East is shown in the following table:

	Lime. lbs.	Sulfur, lbs.	Salt, lbs.	Water, gals.	Time Cooked.
U. S. Dept., Washington	40	20	15	60	2 hrs.
New Jersey	50	50	50	150	1½ hrs.
Maryland	40	20	15	60	2 hrs.
Georgia	30	20	15	60	2½–3 hrs.
Illinois	15	15	15	50	1¼ hrs.
New York (Geneva)	40	20	15	60	2–2½ hrs.
Kentucky	20	14	10	40	1¼ hrs.
Connecticut	20	14	10	40	1¼ hrs.
Virginia	30	30	10	100	30–40 min.
Ohio	15	15	15	50	1¼ hrs.
Delaware	5	5	5	15	1½ hrs.

KINGS COUNTY EXPERIMENTS.

While the formula adopted in 1891 has proved to be satisfactory from the point of view of results, yet there lacked work of an experimental character to determine whether or not the materials were used in the proper proportion consistent with the best results and at the least cost. It was with a view, primarily, to determine this that the following experiments were undertaken.

The field of operations included several hundred acres, the main work, however, being done on a single orchard of 240 acres. This orchard included about 200 acres of prune trees and 40 acres of peach trees. The San José scale was unevenly distributed over the orchard, varying from badly infested localities to places that were entirely free. The spraying was done mostly during February and March, a period during which but little rain fell.

Experiments in Dilutions.—Since the old formula 40, 20, 15, 60, of lime, sulfur, salt, and water respectively, when properly prepared and applied, gave favorable results, the first work done was with dilutions

of this formula with a view to cheapening the cost if possible. With the above formula as a standard, the amount of water was increased by 10 gallons at a time until double the amount of water, or 120 gallons, was used. A considerable number of trees, varying from 100 to 700, were sprayed with each of the dilutions, so that the results might be judged from a practical test rather than from laboratory experiments. While the results of such large-scale tests can not be stated by a definite number of scales killed, or not killed, yet it is believed that this method is preferable as a basis for recommendation to the practical orchardist. As supplementary to these tests, laboratory experiments on a few twigs were carried on as a check to the larger experiments. The results of these experiments are given in the tables which follow:

TABLE No. 1.

No. of Trees.	Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Water, gals.	Result.
700	40	20	15	60	No scales alive.
300	40	20	15	70	No scales alive.
700	40	20	15	80	No scales alive.
300	40	20	15	90	No scales alive.
200	40	20	15	100	An occasional live scale found.
100	40	20	15	120	Several alive.

TABLE No. 2.

Scales on Twigs.	Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Water, gals.	Result.
400	40	20	15	60	All killed.
250	40	20	15	70	Two alive.
320	40	20	15	80	All killed.
290	40	20	15	90	All killed.
210	40	20	15	100	All killed.
200	40	20	15	120	Eleven alive.

During the experiments recorded in Table No. 1, there were no drenching rains and nothing to disturb the wash upon the trees beyond a few gentle showers. Of course, the examination on such a large scale was not searching enough in the case of each tree to examine every scale, but simply a careful examination of the entire lot.

In Table No. 2 the twigs were examined beforehand to determine the per cent of scales already dead, and this was found to average 60 per cent for the entire number. The twigs were then thoroughly sprayed, or in some cases a marked-off portion of the trunk, or large limb, and the final examination made five weeks later.

From these tests it would appear that the old formula may be reduced somewhat, with no serious difference in the results. While the formula including 100 gallons of water gave good results, yet it was due in part probably to the thoroughness of application, so that it had the effect of a stronger solution. In ordinary work, therefore, it would not be safe to recommend a greater dilution than 80 gallons.

Difference in Amount of Lime.—Various amounts of lime were used, ranging from 20 to 50 pounds, as given in the formulas below:

Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Water, gals.	Effect.
50	20	15	60	All killed.
45	20	15	60	All killed.
40	20	15	60	All killed.
35	20	15	60	All killed.
30	20	15	60	All killed.
20	20	15	60	All killed.

The amount of lime necessary to combine with the sulfur has been found by practical tests to be about equal parts by weight, and for this reason equal amounts only are recommended by some stations, some going so far as to say that an excess of lime amounts to mere whitewash. The combination effected between the lime and sulfur is not a simple one, however, and it may be that the different compounds produced, when different proportions of lime are present, may make an essential difference in the effectiveness of the wash. These experiments were not full enough to give any very definite data upon this point, but that there is some effect, apparently due to the mere presence of uncombined lime, is shown by the difference noted during the application of a single tankful, due to its settling from lack of proper agitation. It was found that the live scales, if any, were more abundant where there had been a scarcity of lime. Particularly is this true where heavy rains will readily wash away the clear liquid and reduce the period of effectiveness. A comparative experiment showing the effect of the clear liquid, and one in which there was a considerable excess of lime, follows. The clear liquid was that which remained at the top after the wash was allowed to settle for twenty-four hours.

	No. Scales Counted.	Number Dead.	Number Alive.	Dead, per cent.	Alive, per cent.
Clear liquid	512	482	30	94.1	5.9
Excess of lime	340	340	0	100.0	0.0

It is a common opinion now that the less easily soluble compounds remain effective for some time, and these are better retained in the coating formed by the lime.* On the other hand, too much lime is unnecessary, especially when it is applied by a hand pump with no

*According to the analysis made by Mr. Fuller of the New York station, the following lime compounds are formed: Calcium sulfid (CaS), some of the polysulfids of calcium (CaS_3 and CaS_5), calcium sulfate ($CaSO_4$), a large quantity of calcium thiosulfate (CaS_2O_3), and some calcium sulfite ($CaSO_3$). If equal amounts of these different compounds were formed, then according to the atomic weights there would be a greater amount of sulfur than of lime (1 part of lime to 2.285 parts of sulfur); but since the relative amounts of these compounds have not been determined, we can not say whether the sulfur and lime combine equally by weight or whether there is not an excess of one over the other. It was not the purpose of these experiments to study the wash from a chemical standpoint, but much might be done along this line.

apparatus to keep the lime in suspension, since the lime quickly settles to the bottom, where it is taken up by the pump and applied on the first few trees.

Variation in Amount of Sulfur.—We may consider sulfur as the important ingredient of the wash, since it is the compounds formed by the union with the lime that gives it its principal insecticidal value. All the sulfur will enter into combination so long as there is, approximately, an equal amount of lime to combine with it. The sulfur, therefore, may be called the basic ingredient of the wash, and the proportion of this substance present determines the strength of the wash, providing there is the necessary amount of lime present.

Different amounts of sulfur were tried, the quantities varying from 40 to 50 pounds to each 60 gallons of water. A material reduction in the amount of sulfur changed the character of the wash both as to color and specific gravity. The effect of the solutions containing a small amount of sulfur on the scales was a falling off in efficiency.

Lime, lbs.	Sulfur, lbs.	Salt, lbs.	Water, gals.	Effect on Scales.
40	40	15	60	Good.
40	35	15	60	Good.
40	30	15	60	Good.
40	20	15	60	Good.
40	10	15	60	Not satisfactory.
40	5	15	60	Not satisfactory.

Difference in Amount of Salt.—The use of salt in the lime-sulfur-salt wash is still a mooted question, some advocating the doing away with the salt entirely, while others still use it, with its exact function a questionable point. While in these experiments several hundred trees sprayed without the salt gave no difference in the results that was discernible, yet we are not ready to recommend its disuse.

What has been claimed for the salt is:

(1) That it raises the boiling point of the wash, and thus insures a better union between the lime and sulfur.

(2) That it adds to the adhesive qualities of the wash.

(3) That it renders the precipitate more flocculent, that is, the heavier materials remain in suspension better, and occupy more space in the lighter liquid.

In addition to this the hygroscopic behavior of the salt, or power to absorb water, may insure the gradual solution of the less easily soluble compounds. It is probable also, that the salt adds to the penetrating power of the wash, if this may be separated from the hygroscopic action, and makes the solution more effective on badly incrusted trees.

Bluestone instead of Salt.—The experiments with bluestone consisted in the treatment of but 200 trees, and on account of a high wind at the

time the wash was prepared, the application was delayed until the following day, and consequently the wash was applied cold. There was a very heavy precipitate, and it required constant stirring to keep it in suspension. The trees were examined two months later, with the result that live scales were not uncommon. The bluestone was effective in cleaning the moss from the tree, but beyond this its advantages in the wash were not apparent.

Making a Lime-Sulfur-Salt Wash without Boiling.—The trouble and expense of boiling have been the chief objections to the use of this wash, and it was with a view to overcoming this difficulty that the New York station originated a method of cooking the wash without the use of fire. To do this, caustic soda was added to dissolve the sulfur, and the same combination with the lime is supposed to take place. The amount of caustic soda (76 per cent) required is 1 pound to every 2 or 3 pounds of sulfur. One pound to more than three of sulfur did not give satisfactory results.

To prepare the wash according to this method, the sulfur was sifted through mosquito wire-netting into two or three inches of water in the boiler, and stirred in thoroughly, when the lime was added, about one fourth of the total amount at a time. When the lime was well slaked the caustic soda was added, a portion at a time, in the same way in which the lime was added. The mixture was kept well stirred and was ready for use in about twenty minutes. Hot water was added by preference.

About 500 trees, which were but very slightly infested with the San José scale, were treated with the wash prepared in this way. The few scales that were present seemed to be killed. The effect on the brown apricot scale was the same as that of the regular wash, namely, that a large number remained unharmed.

The wash prepared in this way, however, has not, according to the present experience, overcome the objections for which the method was proposed.

A comparison in the cost of the two methods as involved in a day's work with a power outfit, applying a total of 2,000 gallons, is as follows:

TABLE SHOWING DIFFERENCE IN COST OF THE TWO METHODS.

Boiling by Fire.		*Caustic Soda Method.*	
1,000 lbs. lime, at 2 cents	$20 00	1,000 lbs. lime, at 2 cents	$20 00
500 lbs. sulfur, at 2¾ cents	13 75	500 lbs. sulfur, at 2¾ cents	13 75
330 lbs. salt, at ½ cent	1 65	200 lbs. caustic soda, at 6 cents	12 00
Total	$35 40	Total	$45 75

This leaves a balance of $10 at the end of each day in favor of the old method. Granting that it requires an extra man, the wages and fuel together should not go above $5, which still leaves a balance of $5

in favor of the old method. This does not take into consideration the fact that the recommendations for the soda method call for hot water, which likewise requires fuel as well as labor.

This wash is still in the experimental stage, so far as the effect on the insects is concerned, it proving effective in some cases and ineffective in others. The conditions governing this difference in results have not yet been determined.

If, by further experimentation, the results can be made more uniform, this method of preparing the wash will prove useful on a small scale and where apparatus for boiling is not at hand.

The Effect the Wash Has on the Scales.—The wash evidently kills the scales by contact, and this is supposed to be due to its caustic effect. The easily soluble compounds act upon the scales immediately, while the less soluble compounds remain effective for some little time. In addition to this, the mechanical effect due to the coating of the lime may possibly prevent the escape of the young.

Effect on the Tree.—The wash has no appreciable injurious effect on the tree; that is, unless applied late in the season when the trees are in full bloom. Even then, certain trees do not appear to suffer, as shown in the case of a number of peach trees that were sprayed at this period with apparently no ill effect. A number of prune trees were also sprayed while in full bloom, and while the petals were considerably browned, the fruit suffered no serious injury. Spraying at this season, however, is not to be recommended, since work against scale insects on deciduous trees can be accomplished while the tree is still dormant.

SUGGESTIONS FOR LIME-SULFUR-SALT WASH.

The Formula.—The formula determined upon as a result of these experiments which seemed most satisfactory from the point of view of cost and effectiveness is as follows:

Lime	30 pounds.
Sulfur	20 pounds.
Salt	10 pounds.
Water	60 gallons.

Preparation.—For preparing the wash two vats or boilers are necessary, and if the spraying is to be done on a large scale, one of these at least should hold a couple of hundred gallons. If but a small number of trees are to be treated, ordinary iron kettles will answer the purpose. Of course, the preferable way of cooking the wash is by means of live steam.

Many ways have been suggested for mixing the materials, but the results are the same in every case, so long as the mixture has been subjected to the required amount of boiling. It is largely a matter of con-

venience, then, that determines the particular method, and the one found in these experiments to best answer this requirement is as follows:

First place two or three inches of water in the boiler, and to this add the sulfur, which has previously been made into a paste by mixing with hot water in order to remove the lumps, or sift the dry sulfur through a mosquito wire-netting and stir in thoroughly. Then add about one fourth of the lime, and when the violent boiling has ceased add another fourth, and so on until the required amount of lime has been added. Hot water should be added with the lime as needed, so as to make the mixture of a creamy consistency. Too much water will

FIG. 1. Preparing the wash on a small scale.

"drown" the lime, while on the other hand too little will cause incomplete slaking of the lime. In this way the heat generated by the slaking of the lime is taken advantage of, and by adding the sulfur first plenty of time is given for removing the lumps.

By the time the lime is thoroughly slaked the fire should continue the boiling, so that the time of boiling begins with the addition of the lime. The salt and about one fourth of the water should now be added, and the whole boiled from one to two hours, keeping it frequently stirred in the meantime. At the end of this period screen into the spray tank and add the necessary amount of hot water and apply to the trees hot.

The wash when properly made is a heavy reddish-brown liquid, very

caustic and having a strong sulfur odor. The heavier materials settle upon standing, leaving a lighter liquid both in color and weight.

In order to save fuel, a stock solution is recommended. This stock solution should not be made too concentrated, on account of the difficulty in handling the heavy materials in the boiler; but an amount sufficient to fill the spray tank two or three times may be made without difficulty. To do this, say for two tankfuls, double the amounts of materials used for one, and put half of the stock solution in the spray tank and fill up with hot water as before. The stock solution should be well stirred while being added to the spray tank, in order that the next tankful will be of the same strength. In this way a considerable

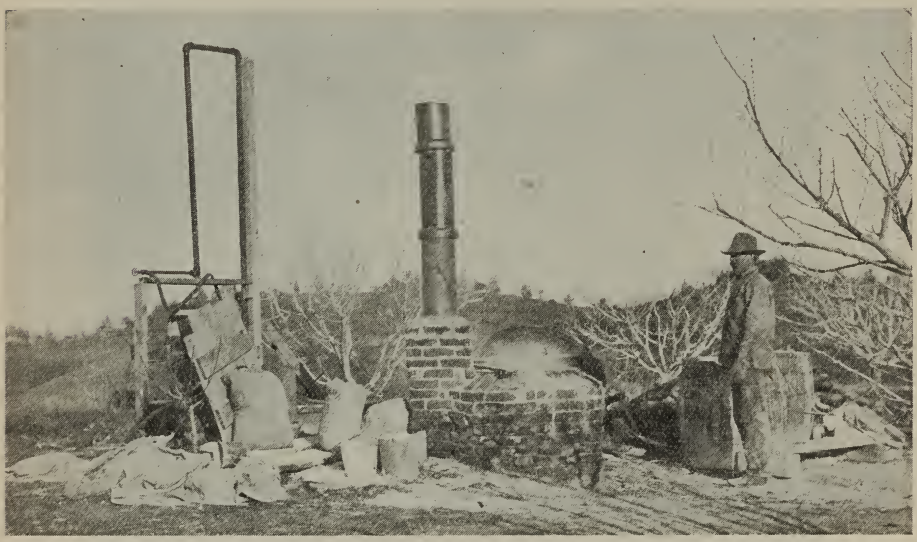

FIG. 2. A common outfit in California for cooking the wash.

amount of boiling is saved, and this is an important item if the spraying work is extensive.

Application.—On account of the heavier ingredients of the wash quickly settling to the bottom, means should be provided for agitating the mixture in the spray tank. This is best done, of course, by the power outfit. In the absence of this, a gearing may be attached to the wheel of the wagon and the mixture agitated while going from one tree to another. A still simpler way is to stir frequently by means of a hoe or paddle.

The nozzle should be of the stopcock type, which will permit of ready cleaning. The type of spray should be a rather coarse one which will thoroughly wet the insects, and not a fine mist as used in paris green work. Thoroughness of application can not be too strongly urged, and no part of the tree should escape treatment.

REMEDIES FOR THE BROWN APRICOT SCALE.

Inefficiency of the Lime-Sulfur-Salt Wash.—It was the general opinion among the growers of Kings County, as elsewhere, that the lime-sulfur-salt wash was not an effective remedy for the brown apricot scale, and this opinion was verified during the experiments there this season.

Since this wash has been so often demonstrated as being efficient for the control of the San José scale, it seemed natural to infer that it would be equally satisfactory as a remedy for a naked scale, such as the brown apricot. In consequence, it is continually being tried as a remedy for this insect. While the apricot scale lacks the protective, waxy covering with which the San José scale is provided, yet because of the hard, leathery texture of the body of the adult insect, it is almost entirely resistant to the lime-sulfur-salt mixture. In the case of the young insect, while it has not yet attained the firm body-covering characteristic of the adult, it is, even in this stage, fairly resistant to insecticides, evidently because of the oily nature of the body surface. It was not uncommon to find the young insects in the midst of a heavy coating of the wash, but none of it adhered to the insect itself. Very often it was observed that the scales were covered over with the wash directly after the application, but that they had the power, later, of throwing off this covering or loosening it to such an extent that rains or other causes finally removed it, leaving the insect free.

From these observations it became evident at once that the spray could be only partially effective against the apricot scale, and this conclusion was further verified by the following experiment. Twigs were sprayed February 15th and examined March 12th:

TABLE SHOWING EFFECT OF LIME-SULFUR-SALT WASH ON BROWN APRICOT SCALE.

Twig.	No. Scales.	Alive.	Dead.	Alive, per cent.	Dead, per cent.
1	30	12	18	40	60
2	52	18	34	35—	65+
3	38	8	30	21+	79—
4	44	14	30	31+	69+
5	63	28	35	44—	56+
6	62	16	46	25+	75—
Totals	289	96	193	33+	67+

THE RESIN COMPOUND.

The failure of the lime-sulfur-salt wash to control the brown apricot scale led to the use of the resin compound as a remedy for this insect.

The resin compound was first used by Mr. Albert Koebele in 1886, and was first applied in the southern part of this State as a remedy for the cottony cushion scale. It came into quite general favor, and has been used more or less since as a remedy for scale insects in California.

In the Eastern States, however, it has never come into very general use, and this is possibly due to the climatic conditions prevailing there which might make it less likely to adhere to the tree long enough to be effective.

In the present experiments the compound was applied to about 6,000 prune trees that were thoroughly infested with the brown apricot scale, and some of these were also slightly attacked by the San José scale. The spraying was started on the 17th of February and continued until the 21st of March, when the trees were almost in full bloom. The time of application was delayed longer than our present experience would warrant, since spraying so late as the middle of March, at least in the upper San Joaquin Valley, is not only less effective on the apricot scale, but, in the case of such a strong wash as the resin compound, it is also likely to do injury to the tree.

Experiments in Dilutions.—The formula for the resin compound which has been generally recommended for winter use on deciduous trees in this State was:

Resin	12 pounds.
Caustic soda (76%)	3 pounds.
Fish oil	1½ pounds.
Water	40 gallons.

The work had not progressed far until it was found that the resin compound killed the brown apricot scale very effectively, so the first experiments were along the line of dilution, in order to determine if a weaker mixture would not give the same results. In the first experiment the water was increased to 50 gallons, instead of 40, as given in the standard formula. This solution was applied very thoroughly to 200 trees, and seemed just as effective as the normal solution. The water was then increased to 60 gallons, and a considerable number of trees sprayed with this strength. Here, too, the results were quite satisfactory, but there was a noticeable difference in the character of the wash, it being a much lighter liquid and having a consistency not unlike that of ordinary water. The dilutions were continued with 80 and 100 gallons of water, but with these amounts the solution was weakened to such an extent that the effect on the scales was not satisfactory.

Difference in Amount of Caustic Soda.—The amount of caustic soda in the wash determines quite largely its effect upon the scale, since it is this ingredient that furnishes the causticity of the wash. When the caustic soda was increased there was a more marked shriveling effect produced on the scale, and this could be detected with the stronger solution, even on the following day, while with a mixture containing a small amount of caustic soda two or three days elapsed before the same

effect was produced. An experiment was undertaken to establish this observation, with the following result:

Twigs Sprayed March 1st.	Number of Scales.	Examined March 3d. Per Cent Dead.	Examined March 7th. Per Cent Dead.
With solution containing excess of soda	184	73.9	100.0
With solution containing small amount of soda	214	51.0	87.1

The following table gives the results of experiments with different amounts of caustic soda. The twigs were sprayed March 2d and examined March 10th:

Amount of Caustic Soda to 5 gals. Water—	No. Scales.	No. Dead.	Per Cent Dead.	No. Alive.	Per Cent Alive.
4 pounds	226	226	100.0	0	0
3 pounds	180	175	97.2	5	1.8
2 pounds	308	302	98.0	6	2.0
1 pound	240	220	91.7	20	8.3
½ pound	160	132	82.5	28	17.5

The Use of the Resin.—While the caustic soda is an important ingredient of the resin compound, the resin itself also plays an important part in making the wash effective. It does this in two ways: first, in causing the wash to adhere to the tree, and second, in the impervious coating formed by the resin itself. The efficiency of this wash as a remedy for the apricot scale depends to a large degree on its ability to adhere to the smaller twigs where the scales are found. But the effect of the resin itself is also to kill a number of the scales, as was shown in an experiment where the resin alone was used.

The Use of the Fish Oil.—The use of the fish oil may be compared to the use of the salt in the lime-sulfur-salt wash, in that it is difficult to demonstrate just what its function is. No doubt the oil itself acts directly upon the scales to a certain extent. This is certainly true if a sufficient quantity is used, as was shown in the case of twigs that were sprayed with a solution of oil and water. In addition to this direct effect on the scales, it is also useful in softening the resinous coating on the tree, and thus preventing the hard, varnish-like covering which would be formed by the resin itself.

Several substitutes were tried for the fish oil, and the most promising of these was a distillate. This was a 28° gravity oil, and it mixed with the other materials even better than the fish oil. However, since the effect of the oil on the resinous coating is probably its most important function, this is better brought about by the heavier and less volatile fish oil. Crude oil was also substituted for the fish oil, but the product was too coarse. It did not mix well, and consequently separated out in the spray tank, and was also injurious to the tree, unless but a small amount was used.

Addition of Arsenic.—Experiments in the addition of arsenic to the kerosene emulsion and resin compound, carried on by Mr. Koebele several years ago, suggested the use of arsenic in these experiments, but since the resin compound itself proved satisfactory, only a single spray-tankful of the mixture was prepared. A pound of arsenic was used to 200 gallons of the spray. The arsenic was prepared according to the Kedzie formula, as follows: The arsenic and 4 pounds of sal soda were boiled in one gallon of water for twenty minutes. This, together with 3 or 4 pounds of lime, was then added to the resin solution. A flocculent precipitate was at once formed, which was later partly dissolved, but much sediment still remained in the bottom of the spray tank. The trees treated with this mixture had the appearance of being dusted over with a white powder. No difference was observed in the effect on the scale, but the trees which were just bursting into bloom appeared to show the effects of the spray less than that of the normal solution, which would indicate that the wash was slightly weakened, or at least made more neutral in its behavior toward the petals.

Effect of the Wash on the Scales.—The value of the wash lies in its caustic effect due to the caustic soda, which acts immediately, and also to the smothering coating formed by the resin and the oil. The apricot scale which has been treated with this wash first begins to wrinkle up and turn pale in color along the margin of the body, leaving a longitudinal ridge, which retains the body fluids for some little time, but finally this also shrivels up and the entire scale becomes pale brown in color. This wash was very effective against the apricot scale, and it was rare that a live scale was found where the spray struck it.

On the other hand, the resin wash did not prove satisfactory against the San José scale. A pear tree that was completely infested with healthy scales was thoroughly sprayed, and on examination a month later quite a number of live scales were found. A laboratory experiment gave somewhat better results. Scales were sprayed March 18th and examined March 23d:

Number of scales examined	860
Number dead	830
Number alive	30
Per cent dead	96.5
Per cent alive	3.5

Effect on the Tree.—The formula recommended in this bulletin is for winter use on dormant trees only, and should not be applied after the buds have begun to burst in the spring. There seems to be a period in the early spring when the prune tree is very susceptible to the wash. Trees sprayed between February 17th and March 1st, were not materially

affected, while for about two weeks following March 1st, when the fruit buds had begun to swell perceptibly, but no green had yet appeared, the wash kept the trees back almost two weeks, and many fruit buds were killed outright. From that time on, when the buds began to unfold and until the trees were in full bloom, the wash had but little effect on the tree.

Preparation of the Wash without Boiling.—We are also indebted to the New York station for a method of preparing the wash without boiling by fire, but the method in the present experience was found to be rather unsatisfactory. The method employed was as follows: Two pounds of resin and one half pound of caustic soda were placed in half a gallon of cold water. To this was added one quart of ammonia (26°), and the whole stirred for half an hour. The resin was only partly dissolved, probably because there was not a sufficient quantity of ammonia; but since the cost was $1.50 a gallon, the supply was naturally limited. More ammonia would probably dissolve the resin, but the cost and the fact that hot water is needed for dilution anyway, since the cold solution does not work well in the nozzles, make the method impracticable on a commercial scale, when one half hour's boiling will bring about the same results.

SUGGESTIONS FOR RESIN SPRAY.

The Formula.—The formula recommended in this bulletin, and which was used on the greater part of the work this season, differs from the old formula in having a greater amount of water and a less amount of resin. It is as follows:

Resin	10 pounds.
Caustic soda (76%)	3 pounds.
Fish oil	1½ pounds.
Water	50 gallons.

This old formula seemed stronger than necessary to kill the scales well, and besides its action on the tree was not so neutral as it might be, so that the solution was weakened by the addition of water, which also effects a saving in the cost. The effect of the wash on the tree was largely due to the resin, and for this reason the amount was reduced somewhat.

Preparation.—This wash is more easily prepared than the lime-sulfur-salt wash, requiring less boiling and also less attention to stirring. The directions heretofore given for preparing the wash call for two hours' boiling, but it was found that there was no advantage in boiling more than half an hour. About one half hour's boiling is necessary to dissolve the resin, and this is the object sought for, so that further boiling is a mere waste of fuel.

The resin is broken up into small lumps, and together with the caustic soda is placed in the boiler with three or four inches of water. The mixture should be stirred occasionally until the resin is dissolved. About one fourth of the water should be added, and at the end of a half hour after it has begun to boil it is ready for the spray tank, when the rest of the water is added. The same apparatus is required as that used in the lime-sulfur-salt work. A stock solution may also be made, as suggested for this latter wash.

Character of Wash.—The wash when ready for use is a black-looking liquid, resembling strong coffee in appearance. There is no grit or heavy materials present, and it sprays very readily through any sort of nozzle. It does not require stirring in the tank, unless a portion of the oil comes to the surface. Usually this amount is very small, but if there is a quantity it should be mixed in well with the other materials. It is soapy in character, but apparently not so caustic as the lime-sulfur-salt wash, and gives rise to no inconvenience to the hands and face, except to cover them over with a sticky coating. The wash when applied warm gives no trouble in the nozzles; but the precaution should be taken, when through using at night, to run hot water through them in order to prevent the resin from remaining in the parts of the nozzle and hardening.

Ingredients and Cost.—The resin comes in 500-pound barrels, providing a quantity is purchased, and costs 2¾ cents a pound. The caustic soda is the commercial (76%) soda used in soap factories, and is sold in 100-pound kegs or larger drums. Its cost is from 4 to 6 cents per pound, depending upon the distance of transportation. The ordinary fish oil is used, and this is put up in 5-gallon cans, and costs 40 cents a gallon.

The cost of the mixture, according to the formula recommended, is:

10 pounds resin, at 2¾ cents	$0.27½
3 pounds caustic soda, at 5 cents	.15
1½ pounds fish oil, at 5 cents	.07½
50 gallons cost	$0.50
1 gallon costs	0.01

Application.—Since the brown apricot scale is situated on the under side of the smaller twigs, the spray should be applied from below, that is, the under-shot spray should be used. From their situation it is almost impossible to reach every scale, but spraying to the very tips of the twigs can not be too strongly insisted upon. It is unnecessary to spray the trunk and larger branches for this scale, hence the bulk of the spray should be directed to the smaller twigs. In order to reach the scales on the lower branches, the spray should be thrown at an angle with the axis of the rod, an angle of about 45 degrees being found to be the most satisfactory.

THE DISTILLATE SPRAY.

The distillate spray, a 28° gravity oil, which finds a place among the remedies for scale insects in southern California, has not been used to any extent on the deciduous trees of the north. Through the courtesy of a manufacturer of spray pumps, who placed a power outfit in the field, we were able to test in a commercial way the value of this spray as a remedy for the brown apricot scale. The amount ordinarily used on dormant trees in southern California is a 3 per cent solution. This has been used there with fairly good results against the black scale, which is similar in structure and habits to the brown apricot scale. Working on this basis we started the experiment with a 3 per cent solution, and this was applied to ten acres of prune trees that were badly infested with the scale. The result of this work did not come up to expectations, and an examination of several hundred scales gave the amount killed as 40 per cent. It was at once evident that if satisfactory work was to be done by this spray, the strength of the solution must be increased, or some other ingredient added that would have the required insecticidal value.

Increase in Amount of Oil.—The first test was made with a 5 per cent solution, and the result of this experiment was a great improvement over the first, as shown in the following table:

Solution.	Total Number Scales Examined.	Number Alive.	Number Dead.	Per Cent Alive.	Per Cent Dead.
3 per cent	1,820	1,092	728	60	40
5 per cent	950	95	855	10	90

The result of this experiment seemed to indicate that if the distillate was used strong enough it would prove effective in destroying the insects. This 5 per cent solution had no ill effect whatever upon the tree, and we were only prevented from using a still stronger solution because of the lateness of the season and the fear of doing injury to the tree, which by this time was bursting into bloom.

Addition of Potash.—The next series of experiments included the addition of potash in order to strengthen the distillate solution. For this purpose ordinary lye was added to a 3 per cent solution of the oil. Different amounts of lye were tried, varying from 3 to 8 pounds of the concentrated 98 per cent product to 200 gallons of the 3 per cent distillate. Each of these mixtures was applied to a number of different trees, and at the same time a small experiment was carried on with a definite number of scales. The result of these experiments was that the solution containing the greatest amount of potash proved very effective on the brown apricot scale, and, indeed, gave promise of being a very satisfactory remedy for this insect. The check experiment carried on in addition to the field work gave, for the total number of scales

examined, 94 per cent killed. As stated under the resin wash, the caustic effect seemed to be an important factor in control, and the same is true here. Both the potash and caustic soda were used with the same result.

Effect of the Distillate Spray.—The action of this spray on the scales is to cause them to loosen their hold on the twig, and after a few days they may be seen hanging by their beaks for a time, when they finally drop off entirely. In addition to this, the shriveling effect was also noticed, and this was particularly true on trees that were treated with the potash-distillate spray.

These sprays had no injurious effect on the tree up to the time the bloom was well out. About forty acres of trees were sprayed with the 5 per cent distillate when the trees were in full bloom, and they were not seriously injured, although the petals were badly browned. No spray, however, should be applied as late as this for the apricot scale. This insect begins to grow rapidly after the sap begins to come up in the tree in the spring, and by the time the tree is in full bloom the scale is of considerable size, and its firm body-covering renders it less susceptible to the wash. No opportunity was given for trying this spray on the San José scale, and its effect on this scale remains to be demonstrated.

SUGGESTIONS FOR THE DISTILLATE SPRAY.

While these experiments carried on with the distillate sprays may be considered as only a beginning, yet the results seem to indicate that there is considerable promise of these solutions becoming useful as remedies for the brown apricot scale and others of a similar character. The advantage of these sprays lies in the fact that they are less expensive than most other sprays, and also in the fact that they require no preparation in the way of boiling. They do, however, require a power outfit to apply them, since the oil and water must be made into a mechanical mixture by violent agitation.

The Formulas.—While both the 5 per cent distillate and the potash-distillate gave quite satisfactory results, the preference so far is in favor of the potash-distillate spray. The formulas given below are those which, according to the above experiments, give the most promise of being satisfactory. They are given on the basis of an amount sufficient to fill the tank of the power outfits in most general use in the State:

Potash Distillate.

Oil	6 gallons.
Potash, or caustic soda	12 pounds.
Water	200 gallons.

Straight Distillate.

Oil	10 gallons.
Water	200 gallons.

The oil found to be most satisfactory in southern California is a 28° gravity oil, specially refined for tree use. Its cost in Los Angeles is 6 cents a gallon. To this, of course, must be added the freight, if bought in other towns. The freight from Los Angeles to Hanford is about 7 cents per gallon, making the cost of the oil 13 cents as delivered at Hanford.

The water and oil after being made into a mechanical mixture have the appearance of a milky fluid. It sprays very readily, and a nozzle should be used that will break up the spray into a fine mist.

PATENT COMPOUNDS.

The following proprietary compounds were tried: I X L, Fruitolin, and the Carbolic spray. The last, which consists of pine tar and carbolic acid, is not a strictly proprietary mixture, but will be treated under this head.

The I X L Compound.—Opportunity was afforded for observing the effect of the I X L compound on a large scale, as well as for judging of its results on definite experiments. The conclusion from both of these sources is that the mixture has little insecticidal value, at least so far as the brown apricot scale is concerned.

Marked twigs thoroughly sprayed with the I X L compound on March 1st and examined on March 10th gave the following result:

No. Scales Examined.	Number Dead.	Number Alive.	Per Cent Dead.	Per Cent Alive.
350	80	275	22.8	77.2
420	102	318	24.3	75.7

I X L and Resin Compound Compared.—A practical test of the resin wash and the I X L compound was made, as follows: Fifty trees were selected at random from two different orchards where no special efforts were made at applying the wash thoroughly, and twigs from these were taken from various parts of the tree and examined for number of scales killed. The trees were sprayed three weeks before the examination was made, and the result was as follows:

Compound.	No. Scales Counted.	Number Dead.	Number Alive.	Per Cent Dead.	Per Cent Alive.
I X L	490	90	400	18.3	81.7
Resin	700	596	104	85.2	14.8

Most of the twigs sprayed with the resin compound showed 100 per cent killed, while a few showed from 90 to 100 per cent alive, indicating that the twigs were not hit with the spray. On the other hand, the live scales on most of the twigs treated with the I X L compound were uniformly distributed, while some showed 100 per cent alive, indicating that the wash was not effective.

Fruitolin.—The compound known as Fruitolin is a South American product, and was introduced into this State for the first time during the

present season. This mixture proved to be quite effective on the apricot scale, and it acts quickly. Branches sprayed with Fruitolin March 14th and examined March 16th gave the following result:

Number of scales counted	250
Number dead	225
Number alive	25
Per cent dead	90
Per cent alive	10

This wash is of a soapy consistency, and leaves a marked greasy effect upon the tree. While the wash appears to kill the scales, yet its cost, which is 20 cents a gallon as applied to the tree, makes it entirely beyond use as a commercial spray.

The Carbolic Spray.—This spray, which consists of pine tar and carbolic acid, has been used in the State to some extent, and some reports claim it is fairly satisfactory as a remedy for the San José scale. The present experience does not bear this out fully, since a number of San José scales were found alive on trees treated with this wash. The results of the carbolic spray on the apricot scale gave but 39 per cent killed. This application was made a month later than the other compounds, and the scales had attained considerable size, so that the wash may be somewhat more effective than the present results indicate.

RESUMÉ.

The *lime-sulfur-salt wash* is an effective remedy for the San José scale. It is not satisfactory for the control of the brown apricot scale. The old formula may be reduced about one fourth without affecting the results. The wash is for winter use on dormant trees, and while some trees do not suffer, even if applied when in full bloom, it is not recommended to be used at this time. The method of boiling without fire, while not reducing the cost, will prove useful under certain conditions.

The *resin compound* is a satisfactory remedy for the brown apricot scale. It is only partially effective on the San José scale. It should not be used on trees after the fruit buds begin to burst. The time of application for the brown apricot scale is during the months of January and February, when the scales are all small and will most readily succumb to treatment. The ammonia method of dissolving the resin is not practicable.

The standard *3 per cent distillate* failed to kill a satisfactory percentage of the apricot scales. A 5 per cent solution, and a 3 per cent solution with potash give promise of good results, with the advantage in favor of the latter.

The *patent compounds* have no advantage over remedies that are considered as standard.