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THE SULPHIDE SULPHUR CONTENT AS A BASIS FOR DILUTING LIME-SULPHUR FOR SPRAYING

BY GEO. M. LIST

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THE SULPHIDE SULPHUR CONTENT AS A BASIS FOR DILUTING LIME-SULPHUR FOR SPRAYING

By Geo. M. List

While lime-sulphur is being replaced to some extent by other contact sprays in the control of certain pests, it remains one of our very important insecticides. The proper dilution of the concentrated forms is of prime importance and errors in this connection may explain some failures to get satisfactory results.

Dilutions for spraying have been based upon work at the New York (Geneva) Agricultural Experiment Station, which indicated that the dormant spray for San Jose scale should contain about 0.297 pounds of sulphur in solution and the summer spray 0.065 pounds. The percentage of sulphur in solution is ordinarily determined by the specific gravity method, the Baume scale generally being used. The density of the diluted spray as called for in most tables of dilutions is about 4.6 degrees Baume, or 1.0327 specific gravity, for a dormant strength and 1.0 degree Baume, or 1.0072 specific gravity for summer spraying.

This method, while simple and convenient, does not take into full consideration that all sulphur in solution may not be in the most active form and that the presence of many other materials in solution may affect the specific gravity.

Shafer (1) in 1911 determined that the effectiveness of lime sulphur as a contact was largely due to the ability of certain compounds in it to take up oxygen. He states that "Two properties—strong reducing power (i. e. great affinity to take up large amounts of oxygen) together with the ability to, at first, soften or partially dissolve the newly secreted wax at the margin of the scale—appear to be the most important in making lime-sulphur an efficient scalecide."

Tartar (2) states that "The compounds formed by the reaction between calcium hydroxide and sulphur, under ordinary commercial conditions of manufacture, are calcium tetrasulphide, pentasulphide, thiosulphate and sulphite. All of these compounds are readily soluble in water with the exception of the sulphite, which is comparatively insoluble, * * * * in general, the insecticidal properties of lime-sulphur are due principally to the following named properties:

The writer is indebted to Prof. Earl Douglass, of the Chemistry Dept., Colo. Agr. Expt. Station, for assistance in making the testing fluid, and for reading the manuscript of this paper.

"(1) Its power to take up large amounts of oxygen, (2) its ability to soften the newly secreted wax at the margin of scale insects, and (3) the amount of free sulfur formed in its decomposition. If this be true, then the question of the correct valuation resolves itself into the quantitative measurement of these factors.

"The amount of oxygen consumed depends upon reactions as represented in the following equations:

$$CaS_5 + 3O = CaS_2O_3 + 3\ S$$
$$CaS_4 + 3O = CaS_2O_3 + 2\ S$$
$$CaS_2O_3 = CaSO_3 + S$$
$$CaSO_3 + O = CaSO_4$$

"The combination of oxygen with the moist polysulphides is very rapid and quantities of the tetrasulfide or pentasulfide containing the same amount of calcium would absorb the same amount of oxygen and consequently produce the same amount of thiosulfate. This last named substance decomposes very slowly under ordinary conditions. For this reason, calcium sulfite is formed very gradually and the oxygen required to form the sulfate is absorbed slowly,—too slowly, in the writer's opinion, to make it of insecticidal importance. Investigations made by the entomologist of this station indicate that calcium sulfite has practically no insecticidal effect upon San Jose scale."

The above equations, besides showing the amount of oxygen consumed indicate the power of the various compounds to liberate free sulphur, the majority of it coming from the polysulphides.

In regard to the ability of lime-sulphur to soften the scale covering of San Jose scale Tartar (2) states:

"The writer's experience in handling the spray simply verifies the correctness of Shafer's statement that 'the so-called caustic action of the wash on the hands seems rather due to its strong reducing power (power to absorb oxygen) than to the alkalinity of the solution.' It is quite possible that this reducing power may also cause the softening of the so-called wax on the scale insects. If this be true, the 'oxygen' number mentioned above would give its quantitative measurement. At any rate, the power of the spray to soften the so-called wax is evidently due to some property of the polysulfides; and in the light of present knowledge no definite statement can be made regarding its exact nature or its exact quantitative analytical measurement."

In 1924 Abbott, Culver, and Morgan (3) tested against San Jose scale, solutions made up to correspond to the various compounds of lime-sulphur that might possibly have insecticidal value namely, calcium trisulphide, calcium tetrasulphide, calcium pentasulphide, calcium thiosulphate, calcium sulphite and sulphur. Their conclusions were that "Calcium thiosulphate, calcium sulphite and free sulphur were of no practical value."

The virtues of lime-sulphur as an insecticide, therefore, appear to lie in the so-called polysulphides, namely, calcium pentasulphide, calcium tetrasulphide and calcium trisulphide. The last named is least effective and fortunately forms only a small part of most liquid lime-sulphurs.

This value of the polysulphides, which are often spoken of on the basis of the sulphide sulphur present, has long been recognized in the preparation of sheep and cattle baths for the control of external parasites. Chapin (4) states: "Lime sulphur dipping baths, whether home made or proprietary, are essentially composed of two substances in solution, both of which contain sulphur, namely, calcium polysulphide and calcium thiosulphate. The Bureau of Animal Industry has no present proof that calcium thiosulphate is of any value for the treatment of scabies in either cattle or sheep, and pending further investigations, accordingly, must attribute the efficiency of dipping baths solely to the sulphur present in the form of calcium polysulphide."

The standard called for by the U. S. Bureau of Animal Industry for the dipping of sheep is a sulphide sulphur content in the prepared bath of 1.5 percent for sheep and 2 percent for cattle. In order to check frequently and quickly upon the sulphide sulphur content of stock baths, Chapin (4) has developed a rather simple iodine test that probably has a place in the evaluating of lime-sulphurs for spraying purposes. This, while probably not as accurate as the official methods of chemical analysis, has proved satisfactory in checking the strength of dipping baths and these must be much more accurately controlled than have been the strengths of tree sprays. The test is used by some manufacturers of lime-sulphur in establishing the strength of their material, as a basis for their guarantee for stock dips.

AN OUTLINE OF THE TEST

The following brief outline of the iodine test is made from Chapin's (4) original description of it.

The test is based upon the reaction between sulphides and iodine in neutral solution, whereby sulphur is precipitated and metallic iodide formed. It therefore, directly estimates, not the sulphur, but the metal calcium, combined with the sulphur in the polysulphides. The sulphur present can be accurately computed only when the sulphur and calcium are combined in unvarying proportions. Theoretically this requirement is not met in the case of lime-sulphur, but experience has shown that the variation in the carefully made liquid products is not so great but what the test is sufficiently accurate for practical purposes. The ratio provisionally adopted by Chapin is 4.6 atoms of sulphur to each atom of calcium, or by weight, 147.5 parts sulphur per 40.07 parts calcium. Since Chapin arrived at this ratio, Abbott, Culver, and Morgan (3) have stated that in more than 100 commercial lime-sulphurs analyzed the ratio was 4.68.

The test is made by adding standard iodine solution to a measured quantity of diluted lime-sulphur until the resulting liquid no longer gives color with a dilute alkaline solution of sodium nitroprussid, showing that calcium polysulphide has been entirely decomposed. The amount of iodine added to reach this point is then a measure of the amount of "sulphide sulphur." The test fluid is of such strength that, in the actual performance of the test, each cubic centimeter of it employed represents one-tenth of 1 percent of sulphide sulphur when the amount of lime-sulphur used is 24 cubic centimeters. The directions for making the test fluid and indicator solution, as given by Chapin (4) are as follows:

"In preparing it, 44 grams iodin and 88 grams potassium iodid are dissolved in water and made to 1 liter, and the strength of the solution is then adjusted against sodium thiosulphate or arsenious oxid. For example, 50 c.c. of a tenth-normal solution of either of the above standards should require 15.38 c.c. of test fluid of correct strength. The test fluid should, of course, be kept in glass-stoppered bottles only, and in a dark, cool place.

"The tablets for indicator solution are prepared after the following formula:

	Grams
Milk sugar, powdered	12
Sodium nitroprussid, powdered	20
Sodium carbonate, monohydrated, powdered	100

"Mix, moisten with 50 percent alcohol, granulate, and dry at room temperature, then mix granules with 3 percent of powdered talcum and compress to tablets of 0.255 gram."

The indicator solution is made ready for use by dissolving 1 tablet in 15 c.c. of water. This should be kept in amber glass, since it is rapidly decomposed upon exposure to light.

If the test is to be used for concentrated solutions they should first be diluted with sufficient water to bring the sulphide sulphur content to not much over 2 percent.

Chapin (4) describes the equipment and technique for making tests in the field. The ordinary titration equipment and technique seem to be more practical and accurate when they can be used.

RESULTS OF TESTS

Table 1 gives the results of this test upon a number of typical samples of commercial and home-made lime-sulphurs. It will be seen that the sulphide sulphur content varies a great deal. This however, is not as important as the ratio of the sulphide sulphur content to the specific gravity, which indicates the presence or absence of other compounds that affect the specific gravity and which we must consider as inactive as insecticides. Samples 1 to 16 inclusive are of commercial brands of lime-sulphur now on the market as tree sprays and stock dips. Their ratio of sulphide sulphur to specific gravity is rather high, the average being .961, the lowest .917 and highest .985. Samples 17 to 40 inclusive are "home made." Seventeen to 28 inclusive were made in a community plant at Paonia, Colo., where live steam is used in the cooking. Twenty-nine to 40 inclusive were made by direct heat in open kettles. The ratio of sulphide sulphur to specific gravity in these home-made materials is considerably lower, showing the presence of other compounds in solution that affect the specific gravity. The average ratio is .677, the minimum .604 and maximum .768.

Column 7, Table 1, gives in percentage the sulphide sulphur content of the samples when diluted to a strength called for, by standard specific-gravity-dilution tables for San Jose scale spraying. This indicates the variation in the amount of active ingredients that may exist with this system of dilution. The range is from 2.288 to 3.847 percent, or, in other words, the former has only 59 percent as much active ingredients as the latter. The average sulphide sulphur content of all commercial brands so diluted was 3.51 and of all home made, 2.70 percent, or 77 percent of the former. All tests were made of the clear liquid only.

Column 6 gives the gallons of concentrate called for by the specific gravity dilution tables to make 100 gallons of spray and column 10 the gallons required to make 100 gallons of spray having a sulphide sulphur content of 3.35 percent, which appears to be an effective strength. Only two samples of the commercial material failed to show this sulphide sulphur content and their variation from this was only slight while all the other samples failed by considerable amounts, one sample being as low as 2.288 percent. This would be only 68 percent of a 3.35 percent standard. The average of all the home-made materials was only 80 percent of this standard.

EFFECTIVE AMOUNTS OF SULPHIDE SULPHUR.—There is little experimental evidence to establish the amounts of suphide sulphur that the sprays should carry to be effective against the various pests. Three samples that were analyzed and tested against the San Jose scale by Abbott, Culver and Morgan (3) can be calculated to have carried 3.20, 3.30 and 3.31 percents respectively. According to Parrott a gallon of diluted lime-sulphur for San Jose scale spraying should contain 4.75 ounces of sulphur in solution, or 3.45 percent, for blister mite spraying, 3.56 ounces or 2.60 percent, and for summer spraying, 1.04 ounces or .0775 percent. Holland, Bourne and Anderson (5) state that the ratio of thiosulphate sulphur to polysulphide sulphur in commercial lime-sulphur liquids is one to 32. By correcting Parrott's figures for the sulphur in solution by deducting the thiosulphate sulphur, we would have a requirement of 3.35 percent of sulphide sulphur for San Jose scale, 2.55 percent for blister mite and .75 percent for summer spraying. These figures come within the range of the sulphide sulphur content of effective dilutions generally used, so are therefore suggested for use when dilutions are based upon the sulphide sulphur content.

Table 2 gives the dilutions for concentrates of 4 to 35 percent sulphide sulphur content.

PRACTICAL USE OF THE TEST

The test is sufficiently simple that it can be used by any fieldman and can be adapted to use in the orchard. The individual growers will not use it as freely as the Baume test, but few individuals are making their own solution. Most home-made materials are made in community plants. It would not be difficult for some careful workers in connection with these to learn the test. The commercial concentrates, if shipped under a sulphide sulphur guarantee, could be more accurately diluted than by the specific gravity basis.

The greatest error in diluting by the Baume test occurs with the home-made concentrates. This error, on the average, appears to be about 25 percent when the clear liquid is used. If the sludge is also included, the error is greater, as this must be considered as practically inert as an insecticide and therefore dilutes the active material. The amount of sludge varies a great deal, depending upon a number of factors such as proportion of ingredients, their purity, method and time of cooking, etc.

Quaintance (6) states: "In spraying for San Jose scale and the pear-leaf blister mite about 5 percent more of the solution should be used than the table of dilutions indicates, if the sludge has not been filtered out. In summer spraying, however, no allowance for sludge is necessary, as a large percentage of this is composed of finely divided sulphur, which is of value."

If the dilutions by Baume of the clear liquid from home-made materials are 25 percent below a desired content of sulphide sulphur and the sludge is also used and dilutes to the extent of 5 percent, it would appear that, if these dilution tables are used, the amounts called for should be increased by 30 percent.

DRY LIME-SULPHUR

The iodine test for sulphide sulphur directly estimates the calcium of the polysulphides, not the sulphur itself. The amount of sulphide sulphur is arrived at thru the knowledge that there is a rather constant ratio of calcium to sulphur in the polysulphides in liquid lime-sulphurs made by standard formulas under the usual conditions of cooking. The ratio provisionally adopted is 4.6 atoms of sulphur to each atom of calcium. Abbott, Culver and Morgan (3) state:

"Based on the analyses of more than 100 commercial lime-sulphur solutions the average molecular ratio $\frac{\text{Polysulphide sulphur}}{\text{Polysulphide calcium}}$ is 4.68, indicating a predominating percentage of the higher sulphide, CaS_5, whereas from the analyses of 38 samples of dry lime-sulphur the molecular ratio $\frac{\text{Polysulphide sulphur}}{\text{Polysulphide calcium}}$ is 3.53, indicating that the polysulphides are mainly the lower sulphides, CaS_4 and CaS_3.

"When the water is removed from liquid lime-sulphur to produce the dry calcium-sulphur, the calcium polysulphides are changed from the mixture of polysulphides 5 (CaS_5) and 4 (CaS_4) with the 5 predominating, which is found in liquid lime-sulphur, to a mixture of polysulphides 4 (CaS_4) and 3 (CaS_3) in approximately equal proportions. This change would, according to the experiments given in Table 10, reduce the effectiveness of the dry calcium sulphurs since the higher polysulphides were found to be more effective than the lower ones."

In the light of this it can be seen that the test is not accurate for dry lime-sulphur preparations. It overestimates the sulphide sulphur content, apparently, to the extent of about 25 percent, and the sulphide sulphur present is less effective since the lower polysulphides are the least effective. These statements are borne out by the results obtained by Abbott, Culver and Morgan (3) in testing the dry lime-sulphurs against San Jose scale. They concluded that even the excessive amount of 33 pounds to 50 gallons of water did not serve as an effective remedy against this scale.

The writer has, however, calculated the sulphide sulphur content of several samples of dry lime-sulphur by the iodine test without making any corrections for the lower ratio of the calcium and sulphur in the polysulphides of these materials. These results are given in Table 3 along with the dilutions necessary to give a sulphide sulphur content called for in San Jose scale and summer spraying. These dilutions are not given as suggestions of the amounts of these materials to use because of the over estimation of the sulphide sulphur. Also Abbott, Culver and Morgan (3) have shown that an increase of the amount to the point where the usual amount of sulphide sulphur is present does not give effective control of San Jose scale due to the lower effectiveness of the lower polysulphides and to an apparent decreased effectiveness caused by the presence of considerable amounts of insoluble sludge. The dry lime-sulphurs are, therefore, considered impractical as insecticides under ordinary conditions. The work of Abbott, Culver and Morgan (3) indicates that the same is true of the sodium and barium sulphurs.

SUMMARY

All experimental data indicate that the insecticidal value of lime-sulphur is largely, if not wholly, due to the ability of the calcium polysulphides in it to take up large amounts of oxygen.

The Baume hydrometer test is not always an accurate method of measuring the amount of polysulphides in a solution. The presence of other soluble compounds affect the Baume reading.

The iodine test for the sulphide sulphur seems to be more accurate than the Baume reading.

The ratio of the sulphide sulphur content of samples tested to their Baume reading varied from .604 to .985. The ratio was higher in commercial samples than in home made.

The effective amount of sulphide sulphur in the dilute spray seems to be 3.35 percent for San Jose scale, 2.55 percent for blister mite and .75 percent for summer spraying.

The commercial samples, with the exception of two, when diluted according to the standard Baume dilution tables, carried the specified percentages of sulphide sulphur. Some carried more than these percentages. The samples of home-made material carried from 68 to 88 percent of the specified amounts.

The error in diluting home-made lime-sulphurs by the Baume tables appears to be about 25 percent when sludge is not included. The presence of the sludge increases the error by another 5 percent.

The iodine test overestimates the sulphide sulphur content of dry lime-sulphurs. These materials, when diluted according to their sulphide sulphur content, become impractical as insecticides.

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Table 1. Sulphide Sulphur Content and Dilutions of Lime-sulphur Samples.

Sample Number	Density of Solution, Baume Degrees	Equivalent in Specific Gravity	Sulphide Sulphur Content. Percent (On volume)	Ratio of Sulphide Sulphur, Percent, to Degrees Baume	Dilution for San Jose Scale (on Baume) (1) For 100 gal. Spray use gallons of Concentrate	Sulphide Sulphur Content of Dilutions according to Baume	Dilution for Summer Spray (on Baume) (1) For 100 gallons of use gallons of Concentrate	Sulphide Sulphur Content of Summer Spray	Dilution to 3.35 percent Sulphide Sulphur Content for San Jose Scale. For 100 gal. Spray use Gallons Concentrate	Dilution to .75 percent Sulphide Sulphur Content for Summer Spraying. For 100 gallons of Spray use Gallons of Concentrate
1	33.1	1.296	30.5	.921	11.	3.355	2.5	.7625	10.98	2.45
2	33.7	1.303	31.5	.934	10.5	3.307	2.5	.7875	10.63	2.38
3	30.3	1.265	29.5	.973	13.	3.835	3.	.885	11.35	2.54
4	29.45	1.256	28.5	.967	13.5	3.847	3.	.855	11.75	2.63
5	33.1	1.296	32.4	.978	11.	3.564	2.5	.81	10.33	2.31
6	34.5	1.312	34.	.985	10.5	3.57	2.5	.85	9.85	2.20
7	34.25	1.309	33.1	.966	10.5	3.475	2.5	.827	10.12	2.26
8	33.6	1.302	32.5	.967	10.5	3.412	2.5	.812	10.30	2.30
9	32.5	1.289	31.3	.963	11.	3.443	2.5	.782	10.70	2.39
10	34.	1.306	31.2	.917	10.5	3.276	2.5	.78	10.73	2.40
11	32.25	1.286	30.6	.948	11.5	3.519	2.5	.765	10.94	2.45
12	34.45	1.311	33.7	.978	10.5	3.538	2.5	.842	9.94	2.23
13	33.	1.295	32.2	.975	11.	3.542	2.5	.805	10.40	2.32
14	32.8	1.293	31.9	.972	11.	3.509	2.5	.797	10.50	2.41
15	34.3	1.310	33.3	.970	10.5	3.496	2.5	.832	10.06	2.25
16	33.2	1.297	32.5	.978	11.	3.575	2.5	.812	10.30	2.30
17	25.5	1.214	18.21	.714	16.	2.913	3.5	.637	18.39	4.12
18	25.	1.209	17.47	.698	17.	2.969	3.5	.611	19.17	4.29
19	26.	1.219	18.21	.700	16.	2.913	3.5	.637	18.39	4.11
20	25.	1.209	17.37	.694	17.	2.952	3.5	.607	19.28	4.31
21	25.5	1.214	17.16	.672	16.	2.745	3.5	.600	19.52	4.37
22	26.5	1.224	17.69	.667	15.	2.653	3.	.530	18.93	4.23
23	26.	1.219	17.37	.668	16.	2.779	3.5	.607	19.28	4.31
24	29.	1.251	20.95	.722	13.5	2.828	3.	.628	15.99	3.57
25	25.5	1.214	17.37	.681	16.	2.779	3.5	.607	19.28	4.31
26	26.	1.219	17.69	.680	16.	2.830	3.5	.619	18.93	4.23
27	28.	1.240	18.95	.676	14.5	2.711	3.	.568	17.67	3.95
28	30.	1.262	21.90	.730	13.	2.847	3.	.657	15.29	3.42
29	27.	1.229	17.60	.651	15.	2.640	3.	.528	19.03	4.26
30	31.1	1.274	20.80	.668	12.	2.496	2.5	.520	16.10	3.60
31	30.3	1.265	20.2	.666	13.	2.626	3.	.606	16.58	3.71
32	24.5	1.195	15.	.612	17.	2.550	3.5	.525	22.33	5.00
33	25.	1.209	15.1	.604	17.	2.567	3.5	.528	22.18	4.96
34	29.8	1.259	22.9	.768	13.	2.977	3.	.687	14.62	3.27
35	28.5	1.245	18.2	.638	13.5	2.457	3.	.546	18.40	4.12
36	28.8	1.248	18.8	.652	13.5	2.538	3.	.564	17.81	3.98
37	28.5	1.245	20.4	.715	13.5	2.754	3.	.612	16.42	3.67
38	26.3	1.222	16.8	.638	16.	2.288	3.5	.588	19.94	4.46
39	29.8	1.260	20.2	.677	13.	2.626	3.	.606	16.58	3.71
40	29.6	1.257	19.6	.662	13.	2.548	3.	.588	17.09	3.82

(1) According to Table 1, "Standard Formula for Application," Mass. Agr. Exp. Station Bulletin No. 201.

Table 2. Dilution for Liquid Lime-sulphur to Give a Sulphide Sulphur Content of 3.35 percent for San Jose Scale, 2.55 percent for Blister Mite and .75 percent for Summer Spraying.

Percent sulphide sulphur content of concentrate (On volume)	Dilution for San Jose Scale. To one gallon concentrate add gallons water	Dilution for San Jose Scale. For 100 gallons of spray use gallons of concentrate	Dilution for blister mite. To one gallon of concentrate add gallons of water	Dilution for blister mite. For 100 gallons of spray use gallons of concentrate	Dilution for summer spray. To one gallon of concentrate add gallons water	Dilution for summer spray. For 100 gallons of spray use gallons of concentrate
35	9½	9⅝	12¾	7¼	45¾	2⅛
34	9⅛	9⅞	12⅜	7½	44½	2¼
33	8⅞	10⅛	12	7¾	43	2¼
32	8½	10½	11½	8	41¾	2⅜
31	8¼	10¾	11⅛	8¼	40½	2⅜
30	8	11⅛	10¾	8½	39	2½
29	7⅝	11½	10⅜	8¾	38	2⅝
28	7⅜	12	10	9⅛	36½	2⅝
27	7	12⅜	9½	9½	35	2¾
26	6¾	12⅞	9⅛	9¾	34	2⅞
25	6½	13⅜	8¾	10¼	32¼	3
24	6⅛	14	8½	10½	31	3⅛
23	5⅞	14½	8	11	30	3¼
22	5⅝	15¼	7⅝	11½	28½	3⅜
21	5¼	16	7¼	12¼	27	3½
20	5	16¾	6⅞	12¾	25½	3¾
19	4⅝	17⅝	6½	13½	24½	4
18	4⅜	18⅝	6	14¼	23	4⅛
17	4⅛	19¾	5⅝	15	21½	4½
16	3¾	21	5¼	16	20	4⅝
15	3½	22⅜	4⅞	17	19	5
14	3⅛	24	4½	18¼	18	5¼
13	2⅞	25¾	4⅛	19½	16	5¾
12	2⅝	28	3¾	21¼	15	6¼
11	2¼	30½	3¼	23¼	14	6¾
10	2	33½	3	25½	12½	7½
9	1⅝	37¼	2½	28½	11	8¼
8	1⅜	42	2⅛	32	10	9¼
7	1⅛	48	1¾	36½	8	10¾
6	¾	56	1¼	42½	7	12½
5	½	67	1	51	5½	15
4	¼	84	½	64	4	19

Table 3. Sulphide Sulphur Content of Dry Lime-sulphur Products and the Dilutions Necessary to Secure a Sulphide Sulphur Content of 3.35 percent for San Jose Scale and .75 percent for Summer Spraying.

Sample No.	Sulphide sulphur content. Percent	Dilution for San Jose scale: For 100 gallons of spray use pounds of concentrate	Dilution for San Jose Scale: For 1 gallon of Spray use ounces of concentrate	Dilution for Summer Spray: For 100 gallons of Spray use pounds of concentrate	Dilution for Summer Spray: For one gallon of Spray use ounces of concentrate
1	60	46.5	7.44	10.4	1.66
2	57.2	48.8	7.80	10.9	1.74
3	63.2	44.2	7.07	9.9	1.58
4	63	44.3	7.08	9.9	1.58
5	58.2	48.0	7.68	10.7	1.71
6	61.2	45.6	7.29	10.2	1.63
7	65.2	42.8	6.84	9.5	1.52
8	60.2	46.4	7.42	10.3	1.64
9	59.2	47.2	7.55	10.5	1.68
10	60.6	46.1	7.37	10.3	1.64
11	64.8	43.1	6.89	9.6	1.53