CONCENTRATED LIME-SULPHUR MIXTURES.

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BULLETIN No. 320.

CONCENTRATED LIME-SULPHUR MIXTURES.

P. J. PARROTT.

SUMMARY.

During recent years commercial preparations of the lime-sulphur wash have been introduced into this State, and in several centers of fruit production they have been extensively used to combat certain injurious insects and plant diseases. Thorough spraying with these mixtures at effective strengths has generally given satisfactory results on the scale and blister-mite; and the experiences of many large orchardists indicate that the best commercial brands are efficient substitutes for the home-made wash for these pests.

Analyses of samples of commercial mixtures sold in the State during the spring of 1909 showed some brands to vary in the density of the clear solution and in the amount of sediment they contained. The range of density was from 26.8 to 33.9 degrees Beaumé, and the variation in sediment was from 0 to 19.42 per cent.

Compouders of certain brands have established a standard strength for their lime-sulphur solutions, which is guaranteed to the purchaser. These preparations consist of a clear reddish liquid, which is free from sediment and tests between 32 and 34 degrees Beaumé. Brands that show considerable variation in their chemical or physical composition should be avoided.

Field experiments to test the value of the sediment of a commercial lime-sulphur mixture in controlling the San José scale demonstrated that the insoluble portion possesses very weak, if any, insecticidal properties on this pest. The sulphur sprays derive their chief insecticidal value from the soluble lime-sulphur compounds. The addition of the sediment of a commercial or
home-made lime-sulphur wash as extra material has apparently no detrimental influence on the effectiveness of the clear solution. The strength of the diluted preparation should be based on the clear solution.

On the basis of reasonable efficiency and cost, the strengths of effective mixtures for the San José scale, using a lime-sulphur solution testing 33 degrees B., range from one gallon of the concentrate diluted with eight gallons of water to one gallon of the solution diluted with eleven gallons of water. In orchards where the scale is not thoroughly controlled, the stronger mixtures are recommended. For spraying for the blister-mite, a dilution of one gallon of the concentrate to eleven gallons of water makes an effective spray.

Present evidence indicates that the common spraying arsenticls do not materially affect the value of lime-sulphur mixtures. In spraying for the scale or blister-mite, an arsentic in the usual amount for orchard treatment may apparently be safely added to a diluted sulphur solution for the purpose of controlling the bud-moth and casebearers, which are now very destructive in many apple orchards.

The second year's experiments with the home-made concentrated lime-sulphur wash gave satisfactory results on the scale and blister-mite. The different preparations showed some variation in the density of the solution and in the quantity of sediment, requiring the use of a hydrometer to obtain diluted mixtures of definite strength. This method of preparing a sulphur spray has several advantages, and should be tested by fruit growers owning suitable cooking outfits, to determine its applicability under their own conditions. The history of the commercial lime-sulphur mixtures indicates that the average fruit grower prefers to buy the prepared mixtures.
INTRODUCTION.

There is at the present time much demand for information along various phases of the subject of sulphur sprays. These demands the Station has attempted to meet:—(1) By a chemical study of the compounds formed in making a lime-sulphur wash; (2) by the determination of the composition of various commercial brands; and (3) by experiments, which are to serve as a basis for recommendations of the concentrated solutions. Some of the conclusions of the chemical investigations have been presented¹, and it is reserved for this bulletin to discuss especially some practical applications of the results of these efforts, that there may be a better understanding of the nature and uses of the concentrated preparations of the lime-sulphur wash for orchard treatment.

COMMERCIAL CONCENTRATED LIME-SULPHUR MIXTURES.

HISTORICAL.

The commercial lime-sulphur solutions were introduced in this State during 1907 and 1908, when two brands were tested experimentally in various communities, to determine principally their effectiveness for the scale and blister-mite, and for certain fruit diseases. The satisfactory results attending some of these tests were given widespread notice, which encouraged a much more extensive use of these mixtures during the past spring. The demand for the commercial brands prompted other companies to compete for the trade, so that there are now at least five companies which are selling their preparations to the fruit growers of this State. The mixtures were generally sold at from 17 to 20 cents a gallon according to the locality of the purchaser. In some communities, where competition was keen, the cost was as

¹ See Bulletin 319 of this Station by Dr. L. L. Van Slyke, C. C. Hedges and A. W. Bosworth. The analyses given in this bulletin were kindly furnished by these authors.
low as 15 cents a gallon. The sales for the spring of 1909 amounted to approximately 4,500 barrels.

In the use of these new sprays for the blister-mite, fruit growers generally have been very successful. In the operations against the scale, varying results have been reported. The failures for the most part have been largely due to attending circumstances rather than to any deficiencies in the leading brands. In the light of experimental tests and the successful operations of many orchardists it appears that the best commercial lime-sulphur solutions used at effective strengths are efficient substitutes for the home-made wash for these two pests. The history of these proprietary mixtures in the West indicates that in this State there will be in the future a more extensive employment of these preparations, largely because of their efficient properties and of the convenience in handling them.

NATURE OF THE MIXTURES.

The commercial mixtures, like the home-prepared wash, are derived from lime and sulphur. These ingredients, when used alone, dissolve only slightly in water, but when they are boiled together, they unite, forming a series of compounds which are very soluble. These make the lime-sulphur wash or spray which is employed as an insecticide. The commercial brands differ from the home-made wash principally in that they are in a highly concentrated state, which has made it feasible to prepare a sulphur wash as a commercial commodity, to be stored, shipped and sold for insecticidal purposes. The most concentrated of the leading commercial brands are approximately eight or more times as strong as the home-made mixtures. The best of these preparations also differ in appearance from the wash made by the fruit grower himself, in that the heavy sediment or mud has been excluded, either by settling or filtering. This process takes out the insoluble ingredients and leaves the solution a clear, sparkling, reddish or deep cherry color. The liquid contains the soluble lime-sulphur compounds, which give the wash its insecticidal value. Another important property of the more carefully prepared of the commercial brands, unlike the home-
boiled wash, is their comparative freedom from crystallization when cold, even in prolonged storage. This has been attained by using the minimum amount of lime necessary to combine with the sulphur, and by keeping the clear concentrate in tight containers.

The relative amounts of sulphur in solution in the common lime-sulphur wash and two commercial preparations, one being of low density and the other of high density, are as follows:

**Table I.—Soluble Sulphur in Lime-Sulphur Mixtures.**

<table>
<thead>
<tr>
<th></th>
<th>Degrees Beauем</th>
<th>Sulphur in one barrel</th>
<th>Total sulphur</th>
<th>Sulphide sulphur</th>
<th>Thiosulphate sulphur</th>
<th>Lime (CaO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Common lime-sulphur wash</td>
<td>6.6</td>
<td>15</td>
<td>3.50</td>
<td>2.40</td>
<td>1.10</td>
<td>3.00</td>
</tr>
<tr>
<td>Commercial concentrated lime-sulphur solution, low density</td>
<td>26.8</td>
<td>96</td>
<td>18.70</td>
<td>16.50</td>
<td>2.20</td>
<td>8.20</td>
</tr>
<tr>
<td>Commercial concentrated lime-sulphur solution, high density</td>
<td>34.5</td>
<td>135</td>
<td>26.50</td>
<td>25.60</td>
<td>0.90</td>
<td>10.90</td>
</tr>
</tbody>
</table>

**Variations in Commercial Mixtures.**

_Density of clear solution._—Variations in the degree of concentration of the commercial lime-sulphur mixtures may occur with different barrels of the same brand. Some companies compounding these sprays have apparently not been able to produce a wash of definite strength or have failed to realize the importance of maintaining a uniform grade for their product. In the early history of concentrated-wash making, it was apparently a difficult matter to make the different boilings of uniformly high density, and frequently preparations from the same firm

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2 This wash was prepared after the common formula of lime 20 lbs., sulphur 15 lbs. and water 50 gals. It is probably a stronger mixture than is generally made.
showed considerable variation in the amount of sulphur in solution in their preparations. Analyses of the samples of the different brands sold in this State during the past year show that this variation may still occur, for the range in densities of the solutions that were examined was from 26.80 to 33.90 Beaumé. The approximate amount and value of sulphur in solution in preparations included in this range of densities are given in the accompanying table.

**Table II.—Approximate Amount and Value of Soluble Sulphur in Mixtures Testing from 26° to 34° B.**

<table>
<thead>
<tr>
<th>Degrees Beaumé</th>
<th>Percentage of sulphur in solution</th>
<th>Value(^3) of sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>19.76</td>
<td>$7.87</td>
</tr>
<tr>
<td>27</td>
<td>20.56</td>
<td>8.19</td>
</tr>
<tr>
<td>28</td>
<td>21.28</td>
<td>8.48</td>
</tr>
<tr>
<td>29</td>
<td>22.04</td>
<td>8.78</td>
</tr>
<tr>
<td>30</td>
<td>22.80</td>
<td>9.09</td>
</tr>
<tr>
<td>31</td>
<td>23.56</td>
<td>9.39</td>
</tr>
<tr>
<td>32</td>
<td>24.32</td>
<td>9.69</td>
</tr>
<tr>
<td>33</td>
<td>25.08</td>
<td>10.00</td>
</tr>
</tbody>
</table>

**Occurrence of Sediment.**

In making a lime-sulphur wash, there is always more or less sediment or residue, which on settling largely accumulates in layers on the bottom of the cooking vessel. This is composed for the most part of undissolved lime and sulphur, of insoluble compounds derived from the lime and sulphur and of various impurities of the lime, principally magnesium. One of the striking differences among the brands sold in this State during the past year was in the relative freedom from sediment or sludge. Some preparations were entirely clear, the residue having been excluded, while preparations of another brand were apparently neither strained nor filtered, and contained a varying amount of sediment. The variation of the different brands in this respect is shown in the accompanying table.

\(^3\) Valuation is based on solution testing 33° B. and selling for $10.00 a barrel.
TABLE III.—Sediment in Commercial Preparations.

<table>
<thead>
<tr>
<th>Name of brand</th>
<th>Beaumé reading of clear solution</th>
<th>Sulphur in solution in one barrel</th>
<th>Sediment</th>
<th>Free sulphur</th>
<th>Sulphur as sulphite</th>
<th>Calcium, magnesium, etc.</th>
<th>Sediment in one barrel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasselli</td>
<td>Deg. 32.7</td>
<td>Lbs. 139</td>
<td>Per ct.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>32.0</td>
<td>131</td>
<td>Per ct.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>31.8</td>
<td>131</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Niagara</td>
<td>30.4</td>
<td>124</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>28.4</td>
<td>74</td>
</tr>
<tr>
<td>&quot;</td>
<td>34.5</td>
<td>130</td>
<td>6.8</td>
<td>15.9</td>
<td>29.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>31.1</td>
<td>106</td>
<td>5.9</td>
<td>16.7</td>
<td>29.9</td>
<td>110</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>31.4</td>
<td>119</td>
<td>0.9</td>
<td>16.0</td>
<td>29.0</td>
<td>45</td>
<td>—</td>
</tr>
<tr>
<td>Rex</td>
<td>31.2</td>
<td>129</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>33.0</td>
<td>138</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>31.2</td>
<td>129</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Thomsen</td>
<td>26.8</td>
<td>96</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&quot;</td>
<td>33.9</td>
<td>139</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

These variations in the amount of soluble sulphur and sediment largely explain the conflicting results obtained by fruit growers in their spraying operations for the scale. The analyses also emphasize the importance of uniformity of composition, especially in its bearing on the question of the market value of the goods and in the matter of dilution to obtain preparations of constant strength. The more reliable compounders have realized the necessity of producing a uniform, high-grade product, and have established a standard strength for their preparations, which is guaranteed to the purchaser. This standardization of the various brands will presumably be generally adopted, as there would apparently be but a small demand for mixtures that show considerable variation in their chemical or physical composition.

THE INSECTICIDAL PROPERTIES OF THE SEDIMENT OF THE LIME-SULPHUR WASH.

Considerable interest was created throughout the leading centers of fruit production by the claim that sediment is a desirable ingredient of a concentrated mixture. Mixtures containing
insoluble sediment or sludge were recommended and were reported as being sold for a higher price than the clear solution of the same brand. While the value of the sediment was not definitely known, it has been supposed that the efficiency of lime-sulphur washes as insecticides is chiefly determined by the soluble lime-sulphur compounds, and that in comparison with these the insoluble sludge is a much less important constituent. To determine the relative effectiveness of the soluble and insoluble ingredients of the lime-sulphur wash on the San José scale was the aim of the following experiments.

**EFFECTIVENESS OF SEDIMENT ON THE SAN JOSE SCALE.**

The trees in these experiments were much infested with the San José scale. The sediment was taken from several barrels of a commercial brand, containing about fifteen per cent. of insoluble material, which was obtained by filtering. The filtrate was then repeatedly washed until tests showed no traces of soluble sulphur. This filtrate, when dried and ground, presented the appearance of a greyish powder. Chemical analyses showed that the sediment consisted largely of calcium sulphite, calcium sulphate, and free sulphur.

*Series I.*—In this first series several tests were made with the sediment, in the proportions of one gallon of the stiff paste, thinned with nine or eleven gallons of water. The mixtures were applied with a spray pump. The applications after drying left a light coating on the trees, which was of a bluish gray color. For purposes of comparison some treatments were also made with a lime-sulphur solution testing 33° Beaumé at dilutions of one gallon to either nine or eleven gallons of water.

*Results on scale.*—Applications of the sediment of either dilution had no appreciable destructive effects on the scale. The production of the young at the beginning of the breeding season was apparently as abundant as that occurring on the untreated trees, and throughout the summer there was no appreciable difference in the amount of infestation of the checks and of the trees sprayed with the sediment. The treatment with the clear solution, diluted with nine parts of water, practically destroyed
the scales, as only an occasional active larva was observed. The weaker preparation, containing one gallon of the concentrate diluted with eleven gallons of water, while not so effective, greatly reduced the amount of breeding, and cleaned the bark of many of the older scales. The adhesiveness of the clear solution was noticeably superior to that of the sediment.

Series II.—These comprised a number of miscellaneous experiments, repeated at various intervals, with sediment from which the soluble sulphur compounds had been removed by decantation. This was applied at different consistencies by mixing with one or more volumes of water. For purposes of comparison many other trees, similarly infested with scale, were thickly painted with calcium sulphite, calcium sulphate, and lime paste. Some small trees growing in a greenhouse were given the same treatments to facilitate closer observations on the movements of the young scales.

Results on the scale.—The trees that were grown in the open field exposed to the usual conditions of weather were practically free of the heavy coating before the appearance of the lice, although the bark showed some discoloration by the treatments. Trees similarly painted with these materials but which were grown in a greenhouse, free from the influences of weather, retained their coatings intact for a long time after breeding commenced. None of the applications made to the trees growing in the open and subjected to normal weather conditions efficiently controlled the scale. The lime-sulphur sediment, calcium sulphite, calcium sulphate and lime wash, applied as a rather thick paint to form an appreciable crust on the bark, removed, on weathering off, some of the old scales, but in no instance did the treatments prevent considerable production of young scales.

Of the experiments in the greenhouse, the applications of these same materials, using them in the consistency of thin paint, had no important effect in reducing the numbers of young scales. The trees, however, which continued to be thickly coated with the application at the time of breeding, were generally exempt from new infestation. Large numbers of the mature females were able to project the posterior portions of their bodies
through the crust, but few young were born, and these were apparently unable to establish themselves.

Conclusion.—In the tests, conducted under ordinary field conditions, the insoluble sediment has shown very weak insecticidal properties. Thorough applications of it have never materially checked the breeding of the San José scale, and consequently have afforded very little, if any, protection to the trees. As has generally been believed, the experiments have shown very conclusively that, as regards this insect, the lime-sulphur wash derives its chief insecticidal value from the soluble lime-sulphur compounds. In purchasing preparations for scale treatment, the presence of sediment in appreciable quantities in a commercial lime-sulphur mixture is undesirable for two reasons,—(1) because of its cost, and (2) because of the danger of uncertain results in spraying, through the substitution of insoluble materials for the clear solution.

Judging from the results of these experiments, it would appear that there is no objection to adding the sediment, or sludge, of a commercial or a home-made lime-sulphur wash to a clear solution as extra material; to give body to the preparations. The actual value derived from their addition is not known. A heavy coating on the trees serves to indicate the thoroughness of the spraying, and according to its thickness and adhesive properties exerts certain smothering effects on such sluggish insects as scales and lice. On weathering off, the flakes of the insoluble materials also carry with them some of the protective coverings of the scales, and perhaps a few of the insects themselves.

STRENGTHS OF EFFECTIVE MIXTURES FOR SCALE AND BLISTER-MITE.

In the use of the commercial lime-sulphur solutions there has been quite a little uncertainty as to the range of dilution with water, to obtain mixtures of suitable killing properties. The proportions that have usually been recommended for dormant treatment in advertising circulars would appear, on the basis on the sulphur content, to make a weaker spray than the ordinary home-made mixture as it is used in this State for the treatment
of the San José scale. To determine the strengths of efficient mixtures, experiments were made with commercial brands at various dilutions for the treatment of the scale and leaf blistersmite.

EXPERIMENTS WITH CONCENTRATED SOLUTIONS ON THE SCALE.

The concentrated lime-sulphur wash used in these experiments tested 33° Beaumé and was free from sediment. The range of dilution was from one gallon of the clear solution with four gallons of water, to one gallon of the concentrate with fifteen gallons of water. Tests were made once in 1908 and were repeated in three different plats during 1909. The trees were of the same age and variety, and were generally well infested with the scale.

Results on scale and discussion.—As compared with untreated trees, all of the applications at the range of dilution given showed improvement in the conditions of the trees with respect to the scale. As was to be expected, the stronger mixtures, broadly speaking, were more efficient and gave uniformly better results than the weaker preparations. However, the experiments did not indicate as decisively as was desired the exact dilution, which, from the standpoints of reasonable efficiency and cost, would make a satisfactory spraying mixture for average orchard conditions. For practical use, the strengths of effective mixtures seem to range from one gallon of the concentrate diluted with eight gallons of water, to a dilution as weak as one gallon of the solution to eleven gallons of water. Until there is more evidence by the fruit growers themselves, showing the range of safe dilution for commercial mixtures under the usual orchard conditions, it appears from these results that it would not be safe to take chances with as weak mixtures as have been advised. For spraying for the scale, especially if abundant, it is recommended that a lime-sulphur solution, testing 33° Beaumé, be diluted in the proportions of one gallon to either eight or nine gallons of water. Brands of less concentration should be diluted with proportionately less amounts of water. In orchards that are regularly sprayed and in which the scale is well under control, it is possible that somewhat weaker preparations than those
advised may be safely employed, which can be more satisfactorily determined by the fruit grower himself from his own experience.

EXPERIMENTS WITH CONCENTRATED SOLUTIONS ON BLISTER-MITE.

The experiments were made on Greenings, about forty years of age and for several years considerably infested with the leaf blister-mite. The concentrated solution used in these tests was clear, and registered $33^\circ$ B. The range of dilution of the applications was from one gallon of the solution with eight gallons of water, to one gallon of the concentrate with fifteen gallons of water. Applications were made during November of 1908 and during April of 1909. In some of the preparations lime was used, to determine the value of its addition to a lime sulphur-solution for the treatment of the mite.

Results on mite and discussion.—All preparations of the lime-sulphur wash, at the dilutions mentioned, completely controlled the blister-mite. The addition of lime paste had no appreciable influence on the effectiveness of the mixture. From the results of these experiments, a preparation comprising one gallon of lime-sulphur solution, testing $33^\circ$ B. and diluted with eleven gallons of water is an efficient spray for blister-mite, and this strength is advised for the treatment of orchards infested with this pest, because of its reasonable cost, and its probable greater effectiveness for other parasites than more dilute preparations. As is indicated by the results of the tests, a weaker mixture than is advised could undoubtedly be safely used to control the blister-mite alone.

SPRAYING POISONS IN LIME-SULPHUR SOLUTIONS.

Present studies indicate that arsenical poisons may be combined with lime-sulphur solutions. The available poisons are arsenate of lead*, and arsenite† of lime. Fruit growers who are spraying for blister-mite may apparently safely combine the usual amount of an arsenical poison with a diluted sulphur solution for the purpose of controlling also the bud moth and case—

bearer, which are now very destructive in many orchards. The arsenite of lime* should be prepared as follows:

White arsenic ........................................... 2 lbs.
Sal soda crystals ........................................ 2 lbs.
Water ..................................................... 1 to 1½ gal.

Boil until entirely dissolved, which requires about fifteen minutes. Use this solution to slake three or four pounds of good stone lime. If this slaking is properly done, the arsenic will be combined very effectively, and the arsenite of lime thus formed will retain its strength indefinitely. When ready for use, add water to the product to bring the total up to two gallons, and stir thoroughly. Two pints of the well-stirred, uniform mixture will then evidently contain one-eighth of the original materials or one-fourth pound of white arsenic, in the form of arsenite of lime, which is equal to one-half pound of paris-green. This amount is ample for 50 gallons of diluted spray and it may be added immediately after dilution.

THE HYDROMETER AND ITS USES.

To obtain mixtures of definite strength, the lime-sulphur-solutions should be diluted according to their degree of concentration. The hydrometer is used for this purpose. It is a glass instrument, consisting of a weighted bulb with a long stem, which determines the weight or density of liquids. Its general appearance is indicated in Fig. 1. On the stem of the instrument there is a graduated scale, which should be read at the general surface of the liquid in which it is supported. Hydrometers are of two kinds,—the Beaumé and the Specific Gravity, which differ in the standards of measurements on which the graduated scales are based. There are instruments which have both measurements. Readings on the former are given in numerals expressed as degrees, while those on the latter are made in decimals. Instruments with a range of 0 to 36 degrees Beaumé or 1.000 to 1.330 Specific Gravity are recommended. Hydrometers do not detect

impurities in lime-sulphur solutions; these can be determined only by chemical analysis.

Hydrometers can be purchased from Bausch & Lomb Optical Co., Rochester, N. Y., Eimer and Amend, New York City, Whitall Tatum Co., New York City, and wholesale dealers in druggists' supplies. A convenient and useful outfit may be obtained from the Bausch & Lomb Co. This consists of two hydrometers, one to determine the density of the concentrated solutions, preparatory to dilution, one to gauge the strength of the diluted mixture, and a glass jar, to contain the liquids for the tests. Fig. 1. By the use of the two instruments the divisions of the graduated scale are made larger, which enables the readings to be made with greater ease and accuracy.

DIRECTIONS FOR DILUTING LIME-SULPHUR SOLUTIONS.

BRANDS OF STANDARD STRENGTH.

If the brand of concentrated lime-sulphur solution is of standard strength, the question of dilution is a simple matter. Such a preparation should be clear, free from sediment, and should test uniformly between 32 and 34 degrees Beaumé, which can
be verified by the hydrometer. For spraying for the San José scale and the leaf blister-mite, dilute as follows:

For **San José scale**, use one gallon of the concentrated solution with **eight** or **nine** gallons of water, employing the former strength when considerable infestation exists. The stronger mixture should give a reading on the hydrometer of 4.4 or 4.5 degrees B. or about 1.030 Sp. G.

For **blister-mite** use one gallon of the concentrated solution with **eleven** gallons of water. The diluted mixture should test on the hydrometer about 3.5 B. or 1.026 Sp. G.

**BRANDS OF VARYING STRENGTH.**

With mixtures of varying densities determine the strength of the clear solution by the hydrometer, and mark the reading on the container. In using this stock solution for strong mixtures for the scale or for the blister-mite, dilute in the proportions given in the accompanying table.
### Table IV.—Table for Diluting Solutions of Varying Concentration.

<table>
<thead>
<tr>
<th>Degrees Beaumé</th>
<th>Specific gravity</th>
<th>Amount of dilution, Number of gallons of water to one gallon of lime-sulphur solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For San José scale</td>
</tr>
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THE HOME-MADE CONCENTRATED LIME-SULPHUR WASH.

In Bulletin 306 of this Station, the attention of our fruit growers was called to the formula for a home-made concentrated lime-sulphur wash. The steps required in mixing the ingredients and in cooking the wash are similar to those in preparing the sulphur wash by the common method. In the treatment of the Station orchards and in several rather extensive cooperative tests, many barrels of mixture by the new formula were used, and whenever the preparations were applied at efficient strengths, as indicated by hydrometer tests, satisfactory results were obtained on the scale and blister-mite. It is a convenient method of preparing a lime-sulphur wash and could be employed for several useful purposes by fruit growers who have had experience in making their own sulphur sprays. It should especially meet the needs of farmers owning detached orchards at considerable distances from the cooking plants. The advantages of this mixture are:—It has no coarse sediment to clog nozzles and to cause the rapid wearing out of the packing, lining and other parts of the pump, and it may be prepared in concentrated solutions to be diluted as needed. For the present we advise fruit growers, making their own sulphur sprays for the treatment of the scale, to continue to use the common boiled wash for the larger portion of their operations and to employ the concentrated solution experimentally until its effectiveness for this pest under their own conditions is thoroughly established. The history of the commercial concentrated lime-sulphur solutions indicates that the average fruit grower prefers to use the prepared mixtures.

**Formula.*

Lump lime.......................... 60 lbs.
Sulphur.................................. 125 "
Water.................................. 50 gals.

* Some changes are being made as regards to the proportions of lime and sulphur but we give this formula as it is the one that we have used in our tests.
The forms of sulphur which are adapted for concentrated solutions are flowers of sulphur, and light and heavy sulphur flour. These can be obtained from the wholesale druggist handling spraying supplies. The lime should be fresh lump lime, free from dirt and grit. It should test not less than 90 per cent. calcium and should contain not more than five per cent. of magnesium oxide.

**COOKING THE WASH.**

Slake the lime, which should be of a consistency of thin paste, and add the sulphur. Stir the materials thoroughly during the cooking process in order to break up the coarse lumps of sulphur. Boil the wash vigorously for one hour, in which time the sulphur should be completely dissolved. In starting the wash to cook, a sufficient quantity of water should be used to provide for shrinkage so that there will be fifty gallons of mixture at the completion of the boiling. With kettles an allowance of ten or fifteen gallons may be required while an outfit using direct steam will usually not need additional water. A few boilings should indicate the quantities of water needed to make approximately the amount of concentrate given in the formula. In using barrels or kettles of fifty gallons capacity, it is advisable to make one-half of the mixture provided by the formula, to avoid losses by the boiling over of the materials.

**BARRELING THE CONCENTRATED SOLUTION.**

If the concentrate is not for immediate use, it should be stored in tight containers. After boiling is completed, strain the mixture into a barrel which should be corked. A sample of the clear solution should be tested by the hydrometer, and the reading marked on the container, to indicate the required dilution for future use. The coarse particles of sulphur in the residue may be cooked up in later boilings.

**STORAGE OF LIME-SULPHUR SOLUTIONS.**

Lime-sulphur solutions may safely be stored if they are not subjected to very low temperatures. In general one should
avoid prolonged storage and prepare the mixtures just preceding or at the time of the spraying operations, when dangers of freezing are avoided. According to Stewart* a solution of 32.1 Beaumé (1.28 Sp. G.) does not freeze above 5° F. and shows no deterioration by freezing. Mixtures of lesser density will freeze at higher temperatures. Preparations that are to be used within a few days may be kept if desired in open vats or barrels. In this case, transfer the hot concentrate to the proper container, and cover the surface of the liquid with a thin film of mineral oil.

DIFFICULTIES IN MAKING CONCENTRATED SOLUTIONS.

The principal difficulties to be met in making a concentrated lime-sulphur solution are to obtain preparations of high densities and to avoid large amounts of sediment. In the Station tests†, the different boilings varied in degrees of concentration and when lime containing magnesium was used, there was always quite a quantity of sediment. In our own experience we found it impracticable to attempt to obtain solutions of definite strength. As soon as the cooking was done, the preparation was immediately applied or barreled. For use, the clear solution was tested with a hydrometer, and the preparation was diluted with water according to its density. It is impossible to avoid a certain amount of sediment but to reduce the quantity one should employ high-grade lime, practically free from magnesium compounds. By using lime testing at least 90 per ct. calcium, and with thorough

† The variation in the density and in the amount of mixture in different boilings is illustrated by the following examples. One-half of the materials required by the formula were used. The lime was 91 per ct. calcium and five more pounds were added because of the impurities. The temperature of the mixtures was 70° F. and apparently all the sediment had settled when tests by hydrometer were made.

(1) Cooked by kettle;—extra water 22 gals. Amount of concentrate 31 1/4 gals. Clear solution tested 26 1/2° B.
(2) Cooked by kettle;—extra water 16 gals. Amount of concentrate 22 1/4 gals. Clear solution tested 33° B.
(3) Cooked by steam coil;—extra water 3 gals. Amount of concentrate 27 gals. Clear solution tested 27 1/4° B.
(4) Cooked by steam coil;—no extra water. Amount of concentrate 25 gals. Clear solution tested 28° B.
(5) Cooked by direct steam;—no extra water. Amount of concentrate 24 gals. Clear solution tested 32° B.
stirring and vigorous cooking we have been able to make concentrated solutions, which ranged in density from 25° to 33° Beaumé. There was practically no coarse sediment in any of the boilings, and usually all of the mixtures would pass through the ordinary strainer. It is not advisable to separate the clear liquid from the insoluble materials because of the time required by this operation and the loss of efficient liquids.