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EXPERIMENTS WITH HOME-MADE CONCENTRATED LIME-SULPHUR MIXTURES.

P. J. PARROTT AND W. J. SCHOENE.

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* Riverhead, N. Y. † Absent on leave. ‡ Connected with the Chautauqua Grape Work.

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EXPERIMENTS WITH HOME-MADE CONCENTRATED LIME-SULPHUR MIXTURES.

P. J. PARROTT AND W. J. SCHOENE.

SUMMARY.

This bulletin deals with the use of home-made concentrated lime-sulphur mixtures in various Station experiments during the past three years and in seventeen volunteer experiments conducted during 1910.

In the Station experiments of 1910 the densities of the clear solution in twenty-one preparations varied from 22° to 31°B., giving an average of 26 1-2°B. The sediment in eight samples that were analyzed ranged in quantities from 2.9 lbs. to 21.4 lbs. per barrel. The cost of materials to make a barrel of concentrate was about $3.05 according to the formula.

The home-made concentrates when used at effective strengths, as determined by hydrometer tests, have given, in the Station experiments for the past three years, efficient results on the San José scale and blister-mite.

In the volunteer experiments the densities of the mixtures ranged from 22° to 32.9°B. The cost of materials to make a barrel of concentrate was from $2.10 to $3.50. The amounts of clear solution and sediment varied considerably but, in the main, preparations of satisfactory densities with moderate amounts of sediment were obtained.

Of eleven volunteer experiments on blister-mite there are ten reports of satisfactory results by the use of the home-made concentrate and one report of failure. Of seven experiments on San José scale there are five reports of efficient control and two reports of partial success, due probably to difficulties in spraying large trees or to the use of mixtures of too low densities. The

results on scale emphasize the necessity both of thorough spraying and of using diluted mixtures of efficient strengths to obtain uniform results on this pest. There are four reports on spraying with arsenate of lead in a lime-sulphur solution for the codling moth which are inconclusive because of the conditions of the experiments.

Very dilute mixtures of the home-made concentrate have on the whole proven fairly safe on apple foliage. In a number of orchards slight injuries were noticed on the more tender leaves, especially following the spraying after blossoming. These injuries were generally obscured by the new growth in from seven to ten days. Damages of a more serious nature occurred in a few orchards. Dropping of fruit and leaves are noted in one experiment. Nearly all reports note relative absence of russeting of apples on trees sprayed with home-made concentrate. Of the seventeen fruit growers who have reported these experiments all have expressed their intentions to use lime-sulphur solution for summer spraying of apples.

The investigations of the Department of Chemistry have shown the desirability of changing the formula for making a home-made concentrate. A new formula is proposed which is as follows: Lump lime (pure lime, CaO, used as basis), 36 lbs.; sulphur, 80 lbs.; water, 50 gals.

The chief advantages secured by this formula are a more economical use of spraying supplies and reduced amounts of sediment.

INTRODUCTION.

This bulletin summarizes the results of various spraying tests by the Station and of a number of volunteer experiments during the past spring with the home-made concentrated lime-sulphur mixture. One feature of the commercial brands that especially impresses fruitgrowers is the greater convenience in the handling of concentrated solutions as compared with the ordinary lime-sulphur wash. Unlike the latter wash, the proprietary preparations may be used cold. They are storable and therefore available for use at one's convenience, and they are free from clogging sediment. Such differences are manifestly striking. For reasons of convenience and of possible economy, the question is frequently asked by fruitgrowers if it is practicable for them to make their own concentrate. As several formulas for preparing the concentrated lime-sulphur mixtures have been published, the Station encouraged a number of fruitgrowers to test them this spring, and thus decide for themselves as to the practicability of making such preparations. It was thought that their experience would be a safe indication as to what other fruitgrowers with similar spraying problems could likewise accomplish.

STATION EXPERIMENTS WITH HOME-MADE CONCENTRATED SOLUTIONS.

CONTROL OF THE SAN JOSÉ SCALE.

Since 1902, the Station orchards have been sprayed each year with the lime-sulphur wash for the purpose of controlling the San José scale. The wash was prepared by the common method until the spring of 1908, when Prof. A. B. Cordley * published a formula for making a concentrated lime-sulphur solution. The Station has since gradually discontinued the former practice of making this spray, and now uses in preference its own concentrated mixtures. There was at first some question as to the advisability of making this change for fear that the concentrated preparations, because of their variableness in densities of the clear liquid and amounts of sediment, might not prove efficient remedies for the scale; but during the three years in which they have been employed no difference in their effectiveness against this pest has been apparent, as compared with the results obtained in previous years' spraying with the common wash. Were they possessed of less efficient properties, any deficiency would have been indicated during this period by an increased infestation of the wood and fruit. Such has not been the case. While an

* *Rural New Yorker*, **67**:202. March 7, 1908.

occasional tree shows some evidence of the breeding of the scale, specimens of fruit blemished by this insect are very seldom found. In various experiments with home-made and commercial concentrates in badly infested orchards that are adjacent the results on the scale have been similar. The protection thus afforded to the fruit crops from spotting by the scale would seem to have safely established the effectiveness of the home-made concentrate for this pest.

HOME-MADE CONCENTRATE FOR BLISTER-MITE.

An application of a sulphur wash as buds are bursting affords efficient protection to apple trees from the blister-mite. In many tests with the common lime-sulphur wash, proprietary preparations and the home-made concentrate, there has been no appreciable difference in the effectiveness of these various sprays on the mite, when they were used at proper strengths and under similar conditions.

SUMMER SPRAYING WITH THE HOME-MADE CONCENTRATE.

The experience of this year indicates an extensive use of sulphur sprays for the treatment of trees in foliage, especially for varieties that are susceptible to russeting of the fruit by bordeaux mixture. If the value of the sulphur spray best suited for this purpose depends on the chemical union of the lime and sulphur, rather than on a mechanical mixture of these materials, there is no apparent reason why the home-made concentrates cannot be used for all purposes for which commercial solutions may be safely employed. During the season of 1910 a concentrate of our own manufacture was used almost exclusively for the summer treatment of apples, pears and plums on the Station grounds and for the spraying of apples in two adjacent orchards. These operations were designed to obtain data as to the comparative insecticidal and fungicidal properties of various sulphur sprays and bordeaux mixture, and as to the practicability of combining common spraying arsenicals with lime-sulphur mixtures. In the comparative tests of the home-made concentrate with proprietary preparations there has been no apparent difference in the results on foliage or in their effectiveness on various fungi and insects. Because of the promising results in most cases, the home-made concentrate will again be tried next year for summer as well as for the dormant spraying of apple orchards under Station management.

VARIATIONS OF THE HOME-MADE CONCENTRATE DURING 1910.

During the spring of 1910 twenty-one barrels of the home-made concentrate were made for the Station experiments. The densities of the clear solution for the entire number of the preparations varied from 22° to 31° B., giving an average density of 26½° B. Samples were taken to ascertain the relative amounts of insoluble materials in the mixtures, and in eight analyses the variation in the sediment was from 2.9 lbs. to 21.4 lbs. per barrel.

ADVANTAGES OF CONCENTRATED MIXTURE OVER THE COMMON WASH.

The home-made concentrated lime-sulphur mixture possesses several advantages over the wash as commonly made. To be noted especially by fruitgrowers not owning a cooking plant is the small outlay that need be expended for a cooking outfit of sufficient capacity to meet the requirements of the average orchardist. Iron kettles have answered the purposes of many fruitgrowers in preparing the concentrate. Those who have in the past disliked to prepare a lime-sulphur wash in kettles do not entertain the dislike to the same degree in making concentrated solutions, since a barrel of the concentrate, even of rather low density, will make several times its volume of a diluted spraying mixture of efficient strength. Those who already have cooking plants, equipped with steam, are required to make fewer boilings, thus reducing the operating expenses. If the concentrated solution is well made there is no coarse sediment to clog nozzles, and to cause the rapid wearing out of the packing, lining and other parts of the pump. As the concentrate may be kept in tight containers with comparative freedom from crystallization, even in prolonged storage, it may be made whenever convenient and used as occasion requires. The steps required in preparing the concentrated solution do not differ materially from those in preparing wash by the method familiar to many of our fruitgrowers.

DIFFICULTIES IN MAKING THE CONCENTRATED SOLUTION.

The principal difficulties that the Station has experienced in making lime-sulphur solutions are to obtain preparations of fairly high densities and to avoid large amounts of sediment. The different boilings have always varied in degree of concentration and in the quantities of the sediment. These difficulties have now been largely overcome by a vigorous boiling of the entire volume of the wash for an hour, with frequent stirring, and by the employment of clean lump lime, free from air-slaked material, which tests at least 90 per ct. calcium oxide and is practically free from magnesium compounds. The density of the clear solution during the past season usually ranged between 25° and 31° Beaumé, and because of the variation the use of a hydrometer is always necessary in order to determine the strength of the diluted mixtures. With the new formula that is now recommended (see page 481) fruitgrowers while obtaining mixtures of somewhat lower densities should be able to obtain larger quantities of the clear, reddish liquid, and little or none of the gritty or pasty sediment and but small amounts of the light, flocculent precipitate, which will usually pass through an ordinary strainer.

COST OF THE HOME-MADE CONCENTRATE.

The actual economy in making one's own concentrated lime-sulphur mixture is not generally understood. It is, in fact, somewhat less than is usually supposed. The reason is that the home-prepared mixtures, besides containing more or less amounts of sediment, are usually lower in density than the commercial brands, and consequently do not make as many gallons of diluted spray of a given strength. In estimating the difference in cost between a home-made concentrate and a commercial lime-sulphur solution, the variation in density of the clear liquid and in the amount of sediment should be taken into consideration. The accompanying table, based on mixtures used in experiments at the Station, shows clearly the apparent and real saving by making the home-made concentrate.

TABLE I.— COST OF HOME-MADE AND COMMERCIAL CONCENTRATES.

KIND OF MIXTURE	Amount of mixture		Volume* of mixture not clear	Density of clear solution	Number of gallons of diluted mixtures testing 4.5° B	Comparative values by percentages	Cost of materials, labor, etc. per barrel	Cost of mixture to equal fifty gallons of solution testing 33° B
	Number of gallons clear solution	Number of pounds of sediment						
			Per ct.	Degs. B.				
Commercial solution.......	50	0	00	33	450	100	$9 00	$9 00
Home-made concentrate 1..	48.5	19.2	32	27	339	75	†3.05	4.07
" " 2..	48.4	21.4	57	28.4	363	80	†3.05	3.81
" " 3..	49.5	9.2	48	26.6	339	75	†3.05	4.07
" " 4..	49.4	9.9	25	27.6	380	84	†3.05	3.63

†Formula:

Sulphur, 125 lbs.	$2.35
Lime, 60 lbs.	.40
Labor, fuel, etc.	.30
Total cost	$3.05

* These figures showing the relative volumes of sediment in suspension are based on samples that were allowed to settle for twenty-four hours. It will be observed that notwithstanding the volume in suspension the actual amount of dried sediment by weight is only a small percentage of the total product of the mixture.

VOLUNTEER EXPERIMENTS.

For the purpose of making available the experience of various orchardists in preparing concentrated lime-sulphur mixtures and to show what they have accomplished as a guide for others in similar efforts, it was thought desirable to include in this bulletin a discussion of these operations. These are designated "volunteer experiments" as they have been largely planned and carried out by the fruitgrowers themselves. To them belongs the credit — not to the Station. In compiling these experiments, the facts have been stated precisely as they were given to us; and for purposes of accuracy a copy of the manuscript discussing his experiment was also furnished to each orchardist for correction and approval.

For the sake of brevity the reports have been much condensed, but as far as possible the more important items needed to convey a fairly accurate description of the conditions and results of the experiments are given. The experiments are designated by numbers and are arranged in the order of their location, commencing with Niagara County and continuing through the leading apple-growing counties of western New York to the Hudson Valley.

EXPERIMENT NO. I.

S. S. Hopkins, Youngstown, prepared the concentrated lime-sulphur solution principally to combat the San José scale. The diluted spray was composed of one gallon of the concentrate testing 28° B. diluted with six or seven gallons of water. The materials to prepare the mixture were ground brimstone, and lime with a guaranteed analysis of 95 per ct. calcium oxide and practically free from air-slaked materials. The mixture was cooked by direct steam, using the formula: Lime 65 lbs. and sulphur 125 lbs. In starting the wash to cook, the lime and sulphur were first added to enough boiling water to slake the lime. After the lime had slaked, the full amount of water was added and the wash was boiled for an hour. The average density of 20 batches was 28° B. In none of the boilings did an excessive amount of sediment occur, and there was on an average about 3 gallons of sludge and 2 gallons of coarse, or pasty, unsprayable material to each batch. By using a steam cooking outfit about 9 barrels of concentrate were made in a day at a cost per barrel of about $2.55 for materials and 33 cents for labor. The concentrate was stored in oil barrels for an average of six days. One lot of 20 gallons was kept in an open cask for seven days, covered with oil. Mr. Hopkins thinks that the preparation of a concentrate is more convenient than making lime-sulphur wash by the old method, as much more mixture can be made at each boiling and there is not the trouble with crystallization of the solution upon cooling.

Results on scale.— The scale was efficiently controlled and apparently there was no appreciable difference in the effectiveness of the concentrated solution and the ordinary lime-sulphur wash upon this pest. Because of the favorable reports on lime-sulphur solutions as foliage sprays, it is intended during the coming year to use the home-made concentrate for the summer treatment of a portion of the apple orchards.

EXPERIMENT NO. II.

Asa Baldwin, Lockport, made the concentrated mixture and used it at a strength of 4½ to 5° B. as a dormant spray for the San José scale. The materials used were light sulphur flour and lime purchased from the following three sources: Niagara County, Ohio and Pennsylvania. The first three boilings were with steam, using Niagara County lime 50 lbs., sulphur 100 lbs. and water 50 gals. At the end of the cooking the volumes had increased to 56 or 58 gallons of mixture which tested from 20° to 22° B. These preparations consisted largely of clear liquid, with very little sediment, all of which was sprayable. The next two barrels were made in a kettle, using Ohio lime, the formula being lime 65 lbs., sulphur 125 lbs.; and at the end of the cooking there were about 52 to 54 gallons of liquid which tested about 26° B. These mixtures seemed to have more fine, greenish sludge, but all of it passed nicely through the nozzles, forming a heavy coating on the trees. The last two barrels were made with Pennsylvania lime 65 lbs. and sulphur 125 lbs. This lot was cooked by kettle and tested 26° B. These mixtures were darker and thicker than the others, and contained very little clear liquid. There was only about one gallon of coarse sediment per barrel, which consisted mostly of small lumps of sulphur. Four barrels of concentrate were made in a day, costing per barrel for materials $2.65 if Niagara County lime and sulphur 100 lbs. were used and about $3.50 if Pennsylvania lime and sulphur 125 lbs. were used. The cost of labor was about 50 cents per barrel. The material was stored in barrels which were purchased of a local dealer.

Results on scale.— Applications of the concentrated solution gave entirely satisfactory results in controlling the scale on apples and pears. It is planned to use the concentrate next year as a summer spray because apples were badly russeted this season by bordeaux mixture.

EXPERIMENT NO. III.

A. H. Ernest, Lockport, prepared the home-made concentrate according to the formula, lime 50 lbs., sulphur 100 lbs., and water to make 50 gallons of mixture. The lime was fresh lump lime, with a guaranteed analysis of 95 per ct. calcium oxide. The sulphur was commercial ground brimstone. The mixture was cooked by direct steam. In each boiling there was an average of about forty-eight gallons of liquid, one and a half gallons of sediment, and a half-gallon of unsprayable material. The range of densities of the clear liquid was 28° to 33°, averaging about 31° B. From nine to ten barrels of concentrate were made in one day at a cost of $2.60 per barrel, allowing $2.30 for spraying supplies and 30 cents for labor. The preparations were contained in barrels purchased from local dealers. A concentrate of reasonably high density is regarded as not difficult of attainment.

Results on leaf curl.— Applications of diluted mixtures testing about 4.5° B. gave excellent results in the protection of peach foliage from this disease.

Results on apple scab.— The results of spraying for this disease were uncertain, as there was an almost complete failure of the apple crop. Applications of the diluted spray, testing about 1.5° B. just after blossoming caused considerable injury to the foliage of a number of apple trees, while the larger portion of the orchard was unaffected. It is planned to employ the home-made concentrate next year for San José scale and blister-mite, and for future summer spraying.

EXPERIMENT NO. IV.

F. W. Paine, Medina, made the concentrated lime-sulphur solution for the special purpose of controlling the San José scale, blister-mite and peach leaf-curl, and for some experimental tests to determine its effect on foliage and its value as a preventive of apple scab. The concentrate was prepared according to the formula: Lime 55 to 60 lbs., sulphur 110 lbs., and water to make 50 gals. of mixture. The spraying supplies were commercial sulphur flour, and lime guaranteed 98 per ct. calcium oxide. The preparations were cooked in an iron kettle of 70 gallons capacity. Samples of different boilings, taken in glass jars, indicated that about four-fifths of the mixture consisted of clear liquid. The density of the solution ranged from 26.5° to 29.5°B., averaging about 28.5°B. A large amount of sediment occurred in only one boiling, when about one-third of the mixture was dark colored. There was in none of the preparations any unsprayable material. The concentrate was kept in an entirely satisfactory condition in oil barrels from four to five weeks. From one to four barrels of mixture were made in a day at odd intervals during the rainy season. A barrel of the concentrate cost approximately $2.90, allowing $2 for the sulphur, 40 cents for lime and 50 cents for labor. No serious difficulties were encountered in making the preparations, and it is planned to use the home-made concentrate in the future. To control the scale and blister-mite the concentrate testing 28.5° B. was diluted with seven gallons of water, and for foliage treatment a gallon of the mixture was used to about twenty-eight gallons of water.

Results on scale.— The scale was held in check, but the results as a whole were not as satisfactory as desired. It is believed that the fault lay in diluting the concentrate with too much water, although the difficulties in spraying large apple trees thoroughly may have been largely responsible for the partial failure.

Blister-mite.— This pest was satisfactorily controlled.

Leaf curl.— There was practically none of this disease on sprayed trees.

Apple scab.— There was very little scab on the leaves and only a slight amount of spotting of the fruit. In general the condition of the trees was satisfactory for the crop was never more free of scab or the foliage more thrifty. The occurrence of scab was attributed to the interlacing of the branches of the trees and lack of pruning which, in some instances, made thorough spraying almost impossible. The spraying after blossoming caused slight burning of the leaves, especially on those portions of the trees where the applications were the heaviest. The damage became less conspicuous with each succeeding day and was hardly noticeable after a period of ten days. On account of these injuries more dilute mixtures will be used for future summer spraying. There was slight russeting of apples which was however not much more conspicuous than that occurring on unsprayed trees. Pears appeared to be more susceptible to injuries of foliage than apples. On account of its cheapness and the satisfactory results in general on insects and fungi, the lime-sulphur solution is preferred to bordeaux mixture, and next season it will be relied on entirely for summer spraying of apples and pears.

EXPERIMENT NO. V.

A. J. Skinner, Medina, prepared the concentrated lime-sulphur solution for the special purpose of controlling the blister-mite. The diluted spray was applied at a strength of one gallon of the solution, testing 32° B., diluted with eleven gallons of water. The materials for making the mixtures were commercial brimstone, and lime guaranteed 95 per ct. pure. The preparations were cooked in an iron kettle of 70 gallons capacity, and they varied in density from 29° to 32° B. Sediment was present in large quantities in the first boiling, and because of its abundance the proportions of the lime and sulphur were varied. The best results were obtained by using the formula: Lime 65 lbs., sulphur 100 lbs., and water 65 gals. By using this formula there was on an average about twelve gallons of blackish sediment of varying consistency, nearly all of which was sprayable. No analysis was made of the lime, but the occurrence of the sediment would suggest that the lime was of a rather inferior quality. The cost of making a barrel of concentrate was estimated at about \$2.70, allowing \$2.20 for the spraying supplies and 50 cents for labor. Vinegar barrels purchased from local grocers were used to contain the concentrate, which kept in a satisfactory condition during a short period of storage. Because of the economy and comparative ease of making solutions of fairly high densities, it is planned to employ the home-made concentrate for future spraying.

Results on blister-mite.— Trees sprayed with the lime-sulphur solution showed no appreciable evidence of the work of the blister-mite. The lime-sulphur solution is preferred to bordeaux mixture for the summer spraying of apples.

EXPERIMENT NO. VI.

G. D. Simpson, Carlton, used his own concentrated lime-sulphur solution testing about 29.5° B for blister-mite at the rate of 1 to 9, and as a summer spray at 1 to 25, 1 to 33 and 1 to 40. The materials used were ground brimstone, and lime which was purchased with a guarantee of 95 per ct. of calcium oxide. The lime consisted of clean lumps, practically free from air-slaked material. The wash was prepared in a 75-gallon kettle. The proportions of lime and sulphur were varied respectively as follows: 50 to 100, 57½ to 115, 60 to 120, 60 to 125, and 50 gallons of water was used in each case. The mixtures after boiling were about two-thirds clear solution, which in four batches gave an average density of 29.5° B. Each batch contained about a pint of unsprayable material composed of undissolved sulphur and grit from the lime. The mixture was stored in oil barrels, and a quantity of it was kept for six months or more in storage in a satisfactory condition. With sulphur at \$1.78 per cwt. and lime at \$1.35 per barrel the cost of materials for a barrel of concentrate was \$2.50. A barrel of the concentrate was made by one man in two hours. The method of preparing the wash that gave the most satisfactory results was to heat 10 gallons of water in the kettle, then add the sulphur and stir to break up the lumps. Half the lime was then used, the mixture being stirred while the lime was slaking, and sufficient water was poured in to keep the wash in a thin, pasty condition. The remainder of the lime was used as soon as the slaking of the first amount was completed. The full quantity of water was added as soon as all the lime had slaked and the entire mixture was boiled until it turned to an amber color. The first application of the lime-sulphur solution, 1 to 9, was made as the buds were opening, for the special purpose of destroying the blister-mite. A second treatment was given just before blossoms opened, using the concentrate at 1 to 33, with 2½ pounds of arsenate of lead to a barrel of the diluted spray. After the blossoms dropped there was a third spraying at a dilution of 1 to 40, with arsenate of lead. Two weeks later a fourth application of 1 to 25, containing arsenate of lead, was made from the east side of nine rows of apples, and on account of interference by rain the remaining four rows of the orchard were not sprayed till one week later.

Results on blister-mite.— The foliage was practically free from blister-mite as a result of this treatment and spraying during the previous year with the lime-sulphur wash.

Green aphis and woolly aphis.— There was no evidence that the various applications of the sulphur solution had any appreciable influence on the numbers of these insects.

Apple scab.— The crop showed practically no evidence of this disease throughout the summer, but during the latter part of September there was a slight amount of scab on some varieties. The Baldwins produced the largest and cleanest crop ever grown in the orchard. There was very little russeting of the fruit. There was, however, a slight burning of the foliage by the second treatment, while the spraying to complete the last application caused considerable burning of both fruit and foliage, resulting in a loss of about two-thirds of each. According to present plans it is intended to use the lime-sulphur solution, containing arsenate of lead, for the summer spraying of apples.

EXPERIMENT NO. VII.

George B. La Mont, Albion, prepared the concentrated solution to combat the blister-mite and as a foliage spray for apple scab. The materials employed in making the mixture were sulphur flour and lime guaranteed 95 per ct. calcium oxide. The wash was cooked in a kettle, the formula being lime 37 lbs., sulphur 75 lbs. and water 55 gallons. At the end of the boiling about 40 gallons of liquid were obtained which gave an average reading on the hydrometer for nine cookings of 26¾° B. At no time was there an excessive amount of mud or sediment, and usually there was about one-half gallon of unsprayable material to each 50 gallons of concentrate. With one kettle about two barrels of concentrated mixture could be made in a day at a cost per barrel of $2.25 for supplies and $1.50 for labor. The mixture was stored in barrels purchased from a local hardware dealer.

Results on blister-mite.— Spraying for the mite gave very good results.

Apple scab.— The applications of the lime-sulphur solution were efficient preventives of apple scab. There was in no instance any evidence of burning of the foliage, and it is believed that there was no spray injury of apples, although where the solution was used 1 to 40, some of the fruit showed slight russeting. Wherever bordeaux mixture was used apples were very badly russeted. Chief reliance will be placed on sulphur sprays for foliage spraying of apples.

EXPERIMENT NO. VIII.

B. L. Perkins, Albion, made his own concentrated lime-sulphur mixture and applied it in the proportions of one gallon of the solution, testing about 30° B., diluted with eleven gallons of water, to control blister-mite on apples and leaf curl on peaches. More diluted mixtures were also used for the treatment of trees in foliage. The materials to make the wash were sulphur flour, and lime purchased with a guarantee of 95 per ct. purity. The wash was boiled in a kettle and five batches were made after the formula: Lime 50 lbs., sulphur 100 lbs. and water 50 gallons. The average density of the preparations was 29.6° B. There was not more than a gallon of thick sediment in any of the mixtures, and only a pint to a quart of unsprayable material, which was much less than was present in a commercial mixture that he had used in the past. The preparations were made just a few days before the spraying season and were kept in a satisfactory condition in storage. With one kettle, four barrels of concentrate were made in a day, at a cost per barrel of $2.18 for materials and 50 cents for labor. The barrels used for storage were molasses barrels purchased from a local grocer at 75 cents each. The only difficulty experienced by Mr. Perkins was in completely dissolving the sulphur and thus reducing the amount of insoluble materials in the sediment. He believes that in making his own preparations he has saved several dollars on each barrel of concentrate.

Results on blister-mite.— Apple trees were almost completely free from injuries to foliage by this pest.

Peach-leaf curl.— There was very little evidence of this disease, except on portions of an occasional tree which was perhaps not thoroughly sprayed.

Apple scab.— The fruit showed only slight indications of this disease, and there was much less spray injury of apples as compared with trees treated with bordeaux mixture. The home-made concentrate will largely be depended on for the future, for dormant treatment as well as for summer spraying.

EXPERIMENT NO. IX.

L. R. Rogers, Albion, used concentrated lime-sulphur of his own manufacture for blister-mite, leaf curl and apple scab. This was applied for dormant treatment at the rate of 18 gallons of a solution testing about 30° B. to a 200-gallon tank, and as a foliage spray at a strength of 8 gallons of the solution testing 29½° B. to a 200-gallon tank. The materials used in the preparation of the wash were commercial sulphur flour and lime guaranteed to contain 95 per ct. calcium oxide and not over 2 per ct. magnesia. It was practically free from air-slaked lime. The wash was cooked in a kettle, and the formula used was lime 50 lbs., sulphur 100 lbs. and water to make 55 gallons of mixture. The results of a number of boilings were as follows: Lot No. 1 boiled less than one hour, no coarse sediment but solution not entirely clear, density of clear solution 30¼° B.; Lot No. 2 boiled over one hour, no coarse sediment, clear solution held in suspension some flocculent material, density of clear solution 30° B.; Lot No. 3 boiled 1¼ hours, clear solution with hardly any sediment of any kind, density of clear solution 29° B. None of the mixtures were strained as all the material was sprayable. One lot was stored in open barrels for two days without crystallization, while another lot was stored for a week in an open barrel with formation only of a paper-like sheet of crystals over the top. Two barrels of concentrate were made in a half of a day at a cost per barrel of $2.13 for materials and 50 cents for labor.

Results on blister-mite.— The spraying did not give satisfactory results in controlling the work of the mite. This failure was not laid to any deficiency in the concentrated solution but was attributed to the lateness of the application.

Leaf curl.— Peach trees were sprayed first with bordeaux mixture and again a few days afterward with lime-sulphur solution with completely satisfactory results on leaf curl.

Apple scab.— Apple trees were sprayed once after the blossoms dropped, with the lime-sulphur solution, but later treatments were with the bordeaux mixture. Apple scab on the leaves was not controlled as satisfactorily as was desired. It is intended to make next year much larger quantities of the home-made concentrate for spraying during early spring of all varieties of fruits and for the summer treatment of apples.

EXPERIMENT NO. X.

Bert H. Henion, Brockport, made the concentrated lime-sulphur mixture and employed it largely to combat the blister-mite and for summer spraying for apple scab and codling moth. The solution was applied to dormant trees at a strength of 3½° to 4½° B., while for foliage treatment the concentrate testing 31° B. was diluted with thirty or forty parts water. The materials used were ground brimstone, and lime with a guaranteed analysis of 90 per ct. to 95 per ct. of calcium oxide. The wash was cooked in a 90-gallon kettle by direct team, using the formula: Lime 60 lbs., sulphur 125 lbs. and water 50 gallons. After the completion of the cooking, the mixture consisted of about two-thirds clear liquid, and had not more than 3 quarts of thick, unsprayable sediment to each barrel of concentrate. The average density of five batches was 31° B. In no case did an excessive amount of sediment occur. Mixtures have been made which have kept satisfactorily in storage over a year. Five barrels of concentrated mixture were made in one day, which cost on an average of about $2.31 for the sulphur, 40 cents for lime, 15 cents for coal and 30 cents for labor per barrel. Mr. Henion experienced no difficulty in making a satisfactory solution, but in advising other fruitgrowers to make their own mixture, he lays much emphasis on the importance of breaking up the lumps of sulphur and lime at the start, in order to obtain solutions of reasonably high densities.

Results on blister-mite.— Spotting of apple leaves by this pest was completely prevented.

Codling moth.— By the use of arsenate of lead in the lime-sulphur solution the losses to apple crop by this insect were very small.

Apple scab.— In comparison with the checks, marked results in preventing this disease on fruit were very apparent on all trees sprayed with the lime-sulphur solution 1–40. The foliage of Greenings showed conspicuous spray injury by the treatment with 1–30, and only slight damages from applications of 1–40. The crop of this variety was one of the cleanest ever harvested, largely due to the absence of russeting, which has frequently attended the use of bordeaux mixture in the past. Baldwin apples russeted badly, but trees sprayed with bordeaux mixture were usually much more blemished in this respect. Preference is given to the lime-sulphur solution for summer spraying of apples.

EXPERIMENT NO. XI.

H. L. Bulkley, Brockport, used the home-made concentrate of a density of 32° B. for blister-mite at a strength of 1 to 10 or 11, and for summer spraying of apples about 1 to 35. The materials for the preparation of the mixture were ground brimstone, and lime with a guaranteed analysis of 95 per ct. calcium oxide and practically free from air-slaked material. The wash was cooked with direct steam. The formula of 60 lbs. lime, 125 lbs. sulphur and 50 gallons of water was used, which gave about 40 gallons of clear liquid and 10 gallons of dark liquid, one gallon of which consisted of coarse and unsprayable sediment. The average reading of the clear solution of four preparations was 32° B. The mixture was stored in tight barrels and was used at intervals during one month. Four barrels were made in eight hours at a cost per barrel of $2.76 for materials, and $1.50 for labor.

Results on blister-mite.— Spraying with the home-made concentrate entirely controlled the work of the blister-mite on apple trees.

Apple scab.— The crop was clean with the exception of the variety Snow, which showed a small amount of scab. There were some evidences of burning of the foliage, and considerable russeting of the fruit, which was more conspicuous on trees sprayed with bordeaux mixture than on those sprayed with lime-sulphur solution. The opinion, however, is expressed that none of the treatments were responsible for the russeting, as unsprayed trees in the immediate vicinity were more affected.

EXPERIMENT NO. XII.

M. E. Ross, Avon, and Samuel Fraser, Geneseo, made four batches of the home-made concentrate for the treatment of peaches for leaf curl. The spraying supplies were sulphur flour, and lime with a guarantee of 95 per ct. calcium oxide. The boiling was done by direct steam. The formula that was first tested was lime 60 lbs., sulphur 100 lbs. and water 50 gallons, but owing to the abundance of sediment the amount of lime was reduced in the last boiling to fifty pounds. In one batch of fifty gallons about one-third of the mixture was clear solution, while the residue was a dark greenish material of the consistency of molasses which choked badly the nozzles and the pump. In each boiling the sediment was of such a character that it could not be used in the spraying outfit and was therefore rejected. The cost of fifty gallons of the clear solution testing 27.5° B. was about $5.35 for the supplies, not including the expense of fuel and labor. On the basis of these results preference is given to the commercial mixtures.

Results on leaf curl.— This disease was satisfactorily controlled by the home-made concentrate. The lime-sulphur solution will be used in the future for the summer spraying of apples.

EXPERIMENT NO. XIII.

John Q. Wells, Shortsville, used the concentrated mixture testing about 32° B. at the rate of one gallon diluted with eight gallons of water for scale, and one gallon diluted with eleven gallons of water for the blister-mite. The materials used were commercial sulphur flour and flowers of sulphur, and lime which was guaranteed to be 99 per ct. calcium oxide and free from air-slaked material. The wash was prepared in a kettle and the formula used was lime 55 lbs., sulphur 120 lbs., water 50 gals. About 70 to 75 per ct. of the wash was of a clear amber color; and the balance consisted of a blackish liquid. The average density of five cookings was 32.9° B. There was very little mud and less than a quart of unsprayable material to each cooking. Mr. Wells states further that he experienced no trouble in making a satisfactory concentrate, and that it is no more difficult to make a barrel of concentrated mixture than the wash by the usual formula. The average cost of materials to make one barrel of concentrated mixture was $2.60.

Results on scale and blister-mite.—Both pests were efficiently combated by spraying with the concentrated solution.

Apple scab.— The apple crop was very free from scab and there was no appreciable evidences of either burning of the foliage or russeting of the fruit by summer spraying.

Codling moth.— Only small percentages of the apples were damaged by the codling moth, and it is believed on the basis of one year's experience that arsenate of lead used in a lime-sulphur mixture has proven as efficient a treatment for this pest as the same poison in combination with bordeaux mixture. In the future the lime-sulphur sprays will be used instead of bordeaux mixture for the treatment of apples.

EXPERIMENT NO. XIV.

E. D. Palmer, Stanley, prepared the concentrated wash for use on trees infested with scale and blister-mite. The diluted spray was applied at a strength of 4° to 4½° B. just before leaves appeared. The grades of materials used to make the mixture were sulphur flour and lime with a guarantee of 95 per ct. calcium oxide. The latter was clean lump lime and free from air-slaked material. The mixture was cooked by direct steam, the formula, lime 65 lbs., sulphur 125 lbs. and water 50 gallons, being employed. One hour's boiling increased the volume to about 54 gallons. The average density of the clear solution for 20 boilings was 26.5° B. At no time was the amount of sediment or mud excessive. Some barrels contained from 10 to 15 gallons of flocculent sediment and in others the insoluble material was as low as 6 gallons. Of unsprayable material consisting of coarse sediment there was about 3 quarts to a barrel of 50 gallons. The material was stored in barrels tightly corked for seven days without the formation of crystals. With the cooking plant as described, operated by one man, 5½ barrels of concentrated solution were prepared in a day at a cost per barrel of $2.74 for materials and 63 cents for labor and fuel. The containers used for storing the concentrate were oil and molasses barrels, purchased from local stores.

Results on blister-mite and scale.— The applications of the lime-sulphur solution efficiently controlled the blister-mite. The effects on the scale were not quite as satisfactory, for there was more or less breeding of the insect on some trees, resulting in a varying percentage of spotted fruit. Owing to the favorable reports from the use of sulphur sprays for foliage treatment, it is planned to employ the home-made concentrated solution for summer spraying of apples in place of bordeaux mixture.

EXPERIMENT NO. XV.

F. A. Salisbury, Phelps, used concentrate at 1 to 8 for blister-mite and leaf curl and 1 to 24 and 1 to 30 for apple scab and codling moth. The materials to make the mixture were sulphur flour, and lime guaranteed to contain 90 per ct. calcium oxide. The wash was prepared in iron kettles, the formula being lime 40 lbs., sulphur 80 lbs. and water to make 50 gallons. About 42 gallons of concentrated solution was obtained in each boiling, which gave an average density for 11 batches of 26.3° B. With two kettles about 300 gallons of concentrate were made in a day. The cost of materials averaged about $2.25 per barrel and labor about 40 cents. Kerosene-oil barrels purchased from a local dealer at $1.30 were used to contain the concentrated mixture. There was in none of the preparations an excessive amount of sediment, and as a rule there was not more than a quart of each lot that was unsprayable. In every batch there were about 15 gallons of very fine flocculent sediment which passed nicely through the nozzles. The mixture was stored for three weeks in barrels tightly corked and some of the material was also left in open barrels without a covering of oil during this time. Even with the exposed mixtures no crystals formed with the exception of a slight scum on the surface of the liquid, which was not considered important. On the basis of this year's experience it is more economical to make one's own concentrate than to buy commercial preparations.

Results on blister-mite.— This pest was completely held in check.

Codling moth.— Arsenate of lead in the lime-sulphur solution gave very satisfactory results in protecting the apple crop from losses by this insect.

Apple scab.— The fruit was the cleanest produced in many years. The spraying with lime-sulphur solution caused little or no injuries to the foliage and very little russeting of the fruit. The lime-sulphur solution is preferred to bordeaux mixture for the summer treatment of apples.

Leaf curl.— Early spraying gave almost complete protection to peach trees from this disease.

EXPERIMENT NO. XVI.

Arthur E. Bell, Milton, used the home-made concentrated mixture to combat the San José scale and the red spider. For the treatment of trees during the dormant season a gallon of concentrate of a density of 32° B. was diluted with eight gallons of water, and for the summer spraying of apples, pears and raspberries dilutions varying from 1 to 30 to 1 to 35 were employed. The mixture was made according to the formula, lime 55 lbs. and sulphur 125 lbs., and the boiling was done with steam coils. The average density of the preparations was 32° B. The concentrate was stored in barrels for about three weeks without any evidences of crystallization. The cost of the mixture was $2.78 for materials and $1 for labor, fuel, etc., per barrel. Mr. Bell states that the preparation of the concentrated wash has distinct advantages over the usual way of preparing this spray, which are the absence of coarse, clogging sediment, and its storable qualities, thus permitting preparations to be made when help is available.

Results on scale.— Young trees and currants badly infested with scale were especially selected as a test of the efficiency of the concentrate for this pest, and on all of these plants the scale was kept well under control.

Codling moth.— The results from spraying with lime-sulphur wash containing arsenate of lead on this pest were disappointing, for a great many apples were "wormy."

Red spider.— This pest was efficiently combated by summer spraying with the solution. Raspberry leaves that had been injured by red spider showed considerable spray injury.

Apple scab.—Apple scab was not noticeable on trees sprayed with the lime-sulphur solution, and there were no evidences of burning of the foliage. The lime-sulphur solution will be used in place of bordeaux mixture for summer spraying.

EXPERIMENT NO. XVII.

J. A. Hepworth, Marlboro, prepared the concentrated solution for the special purpose of spraying for the San José scale. The materials used were commercial sulphur flour and lime testing 97.6 per ct. calcium oxide. Lime, 60 lbs., and sulphur, 125 lbs., were used and the wash was cooked by direct steam in quantities of 100 gallons at one boiling. About three-fourths of the mixture was clear liquid, with a density of 28° to 30° B.; while the remainder was a thin, dark liquid, all of which was sprayable. There was about one-half gallon of unsprayable material to each barrel. Very little sediment occurred when the sulphur was made into a paste before mixing with the lime and when the mixture was well stirred during the period of cooking. Some of the concentrated mixture was stored in tight barrels all winter without the formation of crystals. With sulphur at $1.80 per cwt. and lime at $1.25 per barrel, the average cost of supplies to make a barrel of concentrate was $2.90. Labor, fuel and repairs amounted to about 25 cents per barrel. No difficulties were encountered in making the concentrate, and this method of preparing one's supply of lime-sulphur mixture is preferred to that usually practiced.

Results on scale.— Applications of the concentrated mixture almost completely checked the breeding of the scale and thus protected the new growth and fruit in a very satisfactory manner from this pest.

Apple scab.— Some summer spraying was done with very dilute preparations to control the apple scab, but the crop was so small that there was no opportunity to ascertain the value of this spraying for this disease. However, there was no burning of the foliage or russeting of the fruit. On the basis of the results of these tests, the home-made concentrate will be used hereafter in place of bordeaux mixture for summer spraying.

SUMMARY OF VOLUNTEER EXPERIMENTS OF 1910.

The formula, quality of preparations and cost of materials to make each of these home-made concentrates are shown in the following table:

TABLE II.— SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN MAKING CONCENTRATED LIME-SULPHUR SOLUTION.

No.	Locality	NAME	Formula			Density of clear solution	Volume of clear solution*	Cost per barrel		Kind of cooking outfit
			Lime	Sulphur	Water			Material	Labor	
						Degs. B.	Per ct.			
1	Youngstown..	S. S. Hopkins	65	125	50	28°	85	$2 55	$0 33	Direct steam
2	Lockport.....	Asa Baldwin	50	100	58	22	......	2 65	50	Steam
			65	125	52	26	......	3 50	50	Kettle
3	" ...	A. H. Ernest	50	100	50	31	90	2 30	30	Direct steam
4	Medina......	F. W. Paine	60	110	50	26.5 to 29.5	80	2 40	50	Kettle
5	"	A. J. Skinner	65	100	65	29 to 32	75	2 20	50	Kettle
6	Carlton......	G. D. Simpson	50	100	50	28	65	2 50	30	Kettle
			57	115	50	30.7				
	"	"	60	120	50	30	......	2 50	30	Kettle
			60	125	50	29				
7	Albion.......	Geo. B. La Mont	37	75	50	26.7	80	2 25	1 50	Kettle
8	"	B. L. Perkins	50	100	50	29.6	......	2 18	50	Kettle
9	"	L. R. Rogers	50	100	50	30	......	2 13	50	Kettle
10	Brockport....	B. H. Henion	60	125	50	31	65	2 71	45	Direct steam
11	"	H. L. Bulkley	60	125	50	32	80	2 76	1 50	Direct steam
12	Geneseo.....	M. E. Ross and Samuel Fraser..	60	100	50	27.5	33	2.10	.....	Direct steam
			50	100	50					
13	Shortsville...	John Q. Wells	55	120	50	32.9	70–75	2 60	.....	Kettle
14	Stanley......	E. D. Palmer	65	125	50	26.5	70–80	2 74	63	Direct steam
15	Phelps.......	F. A. Salisbury	40	80	42	26.3	60	2 25	40	Kettle
16	Milton.......	Arthur E. Bell	60	125	50	32	90	2 78	1 00	Steam coil
17	Marlboro.....	J. A. Hepworth	60	125	50	28 to 30	75	2 75	20	Direct steam

* These figures were based on samples that were allowed to settle in glass jars. The actual amount of sediment by weight was not determined. The analyses given in Table I show the actual weight of sediment in mixtures containing different volumes of it in suspension. While the volume of sediment in suspension appears large, the actual amount of dried material is usually only a small percentage of the total quantity of a mixture that is properly prepared.

RESULTS OF HOME-MADE CONCENTRATE ON BLISTER-MITE AND SCALE.

One of the principal objects of the volunteer experiments was to determine if fruitgrowers could efficiently combat the blister-mite and San José scale by home-made concentrated mixtures. There are eleven experiments on blister-mite, and of these there are ten reports of satisfactory results in protecting apple foliage from this pest. The single failure (see Experiment 9) was attributed to lateness of application and not to any deficiency in the concentrate.

In spraying for the scale there were seven experiments, five of which were successful and two were partial failures. The disappointing results occurred in old apple orchards. The failure to control the scale entirely under such circumstances is not unusual with other kinds of spraying mixtures or with other forms of sulphur sprays. These experiences call attention to the necessity of thorough spraying and of the importance of using mixtures at effective strengths to obtain uniformly satisfactory results on this pest. The accounts of the spraying operations indicate that fruitgrowers appreciated the significance of the variations in their mixtures and were able, by the use of an hydrometer, to obtain diluted preparations of required density.

RESULTS OF HOME-MADE CONCENTRATE ON DISEASES.

In directing the volunteer experiments it was not intended to consider the fungicidal properties of the home-made concentrate, but as mention has been made in several instances of the effectiveness of the treatment for various diseases a word of explanation is desirable. Owing to the nature of the spraying operations, the results considered by themselves are in most cases not conclusive. The chief value of the reports is that they represent the opinions of the fruitgrowers themselves, who have estimated the benefits derived from their spraying by the general conditions of the crop or of the trees. In all instances spraying seems to have afforded efficient protection against leaf curl. The absence of scab and the clean character of the apples from trees sprayed with the home-made concentrate are in accord with the general experience of fruitgrowers who sprayed with the lime-sulphur wash this year.

INJURIES TO FOLIAGE AND FRUIT BY HOME-MADE CONCENTRATE.

Injuries by summer spraying with the lime-sulphur wash have been noted in a number of experiments. These have been stated to occur on the foliage and the fruit, and in the reports of the co-operating orchardists have been popularly characterized as burning of the leaves and russeting of apples.

BURNING OF LEAVES.

Injury to the leaves was a common attendant, this spring, of spraying with lime-sulphur mixtures and was perhaps more generally observed following the application just after blossoming than at any time during the spraying season. Trees that were affected had a varying percentage of the foliage spotted with brown areas of irregular sizes and shapes, which were especially prominent on the terminal growth, sides of unfolding leaves and leaves with upturned edges. In a few instances spraying at this time was accompanied with more or less defoliation. In general, the ill effects of the treatment on apple leaves were not of great consequence or of a lasting nature. The weather subsequent to the spraying was, because of frequent rains, very favorable to rapid growth, and injuries which at first excited more or less apprehension were soon obscured by the new foliage. The condition of orchards sprayed with the sulphur solutions was generally very satisfactory during the remainder of the season. Because of the extent of the new growth and the comparative freedom of the trees from insects, diseases and spraying injuries of the fruit, the burning of the leaves occurring early in the season is usually regarded as an incidental result, to which much importance should not be attached in view of the superior quality of the apple crop and the excellent condition of the foliage in late summer. Pears were generally more susceptible than apples to injuries of foliage by the lime-sulphur solution.

Injuries of a more serious nature than those described were of comparatively rare occurrence. Such injury has been noted once, in Experiment No. 5, in which the fourth spraying caused considerable defoliation of the trees and dropping of apples. These results are perplexing, as this orchard is one of the most carefully managed plantings in the series of these experiments and had been thoroughly treated according to an approved spraying schedule. The circumstances of the treatment indicate that the injury was rather of an unusual nature. It is possible that the spraying mixture was too strong or was used too freely or that this experience is one of the rather rare instances of cumulative injuries from successive treatments as described by Scott* or of arsenical burning from the use of arsenate of lead in lime-sulphur sprays as recently mentioned by Wallace.†

RUSSETING OF APPLES.

One of the significant results of these experiments has been the comparative freedom of the apples from russeting. The absence of such blemishes on fruit from trees sprayed with the lime-sulphur wash has been the more conspicuous since there has been much complaint this season of severe russeting of apples by other spraying mixtures. The responses of co-operating orchardists with reference to the occurrence of russeting on trees sprayed with the lime-sulphur mixture have generally been "no russeting," "slight russeting," "no appreciable russeting" or "much less russeting than with bordeaux mixture." The fruit has, as a rule, been highly colored, with little or no russet blotches, such as had frequently attended spraying with bordeaux mixture, to detract from the waxy finish of the apple. Of the seventeen experiments only two have reported severe russeting of fruit, which was computed as less serious in extent than that occurring with bordeaux mixture.

ANOMALIES OF OCCURRENCE.

As has been the experience with bordeaux mixture, various anomalies have occurred in this summer's spraying with the lime-sulphur wash. Applications which have proven safe in most or-

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* Lime-sulphur Preparations for Apple Diseases, U. S. Dept. Agr. B. P. I. Circular No. 54, p. 12.

† Cornell Bul. 288.

chards have caused more or less damage in some plantings. Injuries have occurred in some localities while in other parts of the State no unsatisfactory results have been noticed. Portions of a tree or a few trees may show burning while the remainder of the orchard may be unharmed. A variety such as Greening may have fruit immune to russeting and yet sustain injuries to foliage. Some varieties are more susceptible to injuries than others. Burning of leaves has attended the first spraying after blossoms dropped and in others has not occurred till later sprayings. Applications from the same tankful of mixture have caused injuries in one orchard and not in another. Trees have been drenched with strong mixtures without harmful results while more dilute preparations in moderate amounts have caused burning. The reasons given by orchardists for these contradictory results are "rapid growth of fruit and foliage," "leaves young and tender," "too much rain," "cold weather and rain," "cloudy conditions," "lack of sunshine," "prolonged cloudy weather," "sunshine following showers," "excessive use of spraying mixtures" "uneven distribution of the spray by worn-out nozzles" and "spraying while dew is on foliage."

It has not been possible to account for all the differences in the results by spraying. These seeming anomalies suggest that the occurrence of injuries were not due to a single factor but to several contributing factors, each of relatively greater or less importance according to the conditions of the orchard. Very tender foliage[1] of apples is susceptible to burning by the lime-sulphur solution and slight injuries are apparently unavoidable. The degree of tenderness of the new growth of the tree and its susceptibility to the spraying mixture appears also to vary with weather conditions. Cordley suggests[2] that "abundant sunshine and mild

[1] During 1910 pears generally seemed to be more susceptible to injuries of foliage than apples. Grapes were less resistant than pears. Mr. F. Z. Hartzell, in charge of investigations on grape insects, states that the foliage of Moore Early was badly burned at 1–60, and of Niagara and Concord at strengths of 1–75 to 1–100, while Delawares were uninjured at dilutions not stronger than 1–65. Damage to foliage was more serious on vines attacked by destructive numbers of leaf hoppers. Similar results have been noticed on raspberry foliage injured by red spider (*Bryobia pratensis* Gar.). During 1909 and 1910 J. P. Stewart (Letter December 7, 1910) also noticed that varieties differed in degree of susceptibility and that there was an apparent seasonal difference in varietal resistance. Apples this past year showed more injuries to foliage at dilutions of 1–28 than during 1909 when sprayed with 1–14.

[2] A. B. Cordley, *Better Fruit*, **8**: 34.

temperature produces a vigorous, hardy, spray-resisting growth of foliage, * * * while excessive rainfall, cloudy weather and low temperature produces a growth less vigorous, less hardy, more edematous and more susceptible to spray injury." During cloudy and humid weather evaporation is also less rapid and the foliage is consequently longer exposed to drops of the spray of injurious densities.

On the basis of his investigations in New York, Wallace[1] considers that the conditions of foliage with respect to injuries by fungi and insects, general vigor of trees and the nature of spraying, whether excessive or moderate, have also an important bearing on the occurrence of injuries. Stewart[2] in summarizing the season's results in Pennsylvania states that "some burning of foliage, and occasionally of fruit, is likely to occur as a result of spraying with the lime-sulphur solution. Ordinarily the injury is negligible in extent, and as the trees recover rapidly the slight sacrifice in leaves may usually be overlooked. The occasional occurrence of decided injury, however, is of great importance and cannot be traced to a single cause. The rupturing of the epidermis by insects, fungi and frosts is one of the main factors. The epidermises may also be broken by the spray itself as a result of abundant application, which collects into drops and evaporates to injurious densities. (Penn. Sta. Ann. Rept. 1908–9, pp. 286–289.) With the breaking of the epidermis opportunity is afforded for severe injury by later treatments. This latter consideration would seem to account for the occurrence of severe injuries resulting from the third or fourth application of lime-sulphur solution in a proper spraying schedule, which should eliminate the work of insects and fungi as the determining factors; and for the destructive effects of an application of lime-sulphur solution following treatment with bordeaux mixture, which may also rupture the epidermis of relatively young leaves." 'Lime-sulphur[3] solution is probably more severe upon broken epidermises than bordeaux mixture, though less harmful on sound ones."

[1] Errett Wallace, Cornell Bul. 288.
[2] J. P. Stewart, letter December 7, 1910.
[3] J. P. Stewart, *Rural New Yorker*, 69; 1096. 1910.

DIRECTIONS FOR MAKING AND STORING THE HOME-MADE CONCENTRATED LIME-SULPHUR WASH.

FORMULA.*

Lump lime	Pure CaO	36 lbs
	or	
	95 per ct. CaO	38 lbs.
	or	
	90 per ct. CaO	40 lbs.
Sulphur		80 lbs.
Water		50 gals.

MATERIAL.

The forms of sulphur which are adapted for concentrated mixtures are flowers of sulphur, and light and heavy sulphur flour. There is also a cheaper grade on the market which is sold as "ground brimstone" or "commercial sulphur flour 99½ per ct." for about $1.75 per cwt. This when finely ground and bolted has given satisfaction. Sulphur can be obtained from the State Fruit Growers' Association, wholesale druggists and dealers in spraying supplies.

The lime should be fresh lump lime, free from dust and grit. It should test not less than 90 per ct. calcium oxide and should contain not more than five per ct. of magnesium oxide. Fruit-growers may sometimes purchase a satisfactory local lime, but before undertaking extensive operations one should assure himself that the quality is desirable. The Station has a list of dealers who will guarantee their lime; and this will be sent on application.

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* The attention of fruit growers is called to the new formula which has been devised by the Chemical Department of this Station, as described in full in Bulletin 329. The investigations of the lime-sulphur mixture have shown that by the proposed formula there is a more economical use of the spraying materials, which effects a considerable reduction in the cost of making the concentrate.

The formulæ which have been largely used in the experiments discussed in this bulletin are,—

1.	Lump lime	60 lbs.
	Sulphur	120 lbs.
	Water	50 gals.
2.	Lump lime	50 lbs.
	Sulphur	100 lbs.
	Water	50 gals.

COOKING THE WASH.

Heat about ten gallons of water in the cooking vessel and use it to slake the lime. To avoid losses of materials by spilling over, the lime should be added in small quantities at a time. As the slaking commences empty in the sulphur, and keep the mixture well stirred to break the lumps of sulphur and lime. When the entire amount of lime has been slaked, add the full amount of water. A sufficient quantity should also be added to provide for shrinkage by the cooking so that at the completion of the boiling there will be approximately fifty gallons of mixture. With kettles, an allowance of ten or more 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. Boil the wash vigorously for one hour, in which time the sulphur should be completely dissolved.

A measuring stick, gauged to the capacity of each cooking vessel, will enable the fruitgrower to judge fairly accurately the volume of his spraying material.

STORAGE OF LIME-SULPHUR SOLUTIONS.

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 in later boilings. It is not advisable to attempt to separate the clear liquid from the sediment because of the time required by the operation and the loss of efficient liquids.

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 danger of freezing is 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 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.

DILUTIONS FOR DORMANT AND SUMMER SPRAYING.

For strong mixtures for the scale, the diluted preparation should test about 4.5° B.; for blister-mite about 3.5° B.; and for summer spraying of apples about 1° B.† Using these figures as bases, the table below has been calculated, which shows the dilution required for a wide range of densities.

TABLE III.— DILUTIONS FOR DORMANT AND SUMMER SPRAYING WITH LIME-SULPHUR MIXTURES.‡

Reading on hydrometer	Amount of dilution. Number of gallons of water to one gallon of lime-sulphur solution		
Degrees Beaumé	For San José scale	For blister-mite	For summer spraying of apples
35	9	12½	45
34	8¾	12	43¼
33	8¼	11½	41½
32	8	11	40
31	7½	10½	37¾
30	7¼	10	36¼
29	6¾	9½	34¼
28	6½	9	32¾
27	6	8½	31
26	5¾	8	29½
25	5¼	7½	27¾
24	5	7	26
23	4½	6½	24¼
22	4¼	6	22¾
21	3¾	5½	21¼
20	3½	5	19¾
19	3¼	4¾	18¼
18	3	4¼	17
17	2¾	4	16
16	2½	3¾	15
15	2¼	3½	14
14	2	3	12¾

* Penn. Sta. Bul. 92.

† This density of the diluted mixture is based on the recommendation of Wallace (Cornell Bul. 289) who advises for summer spraying of apples one gallon of concentrate testing about 32 to 33° B. diluted with forty gallons of water.

‡ These dilutions are based on the calculations in Table XI, Bul. 329.

THE HYDROMETER AND ITS USES.

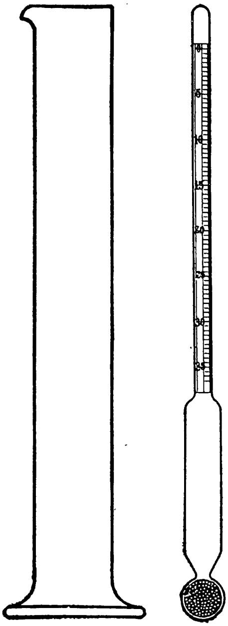

Fig. 1.

The lime-sulphur solution made by the fruitgrowers is likely to vary in strength or degree of density of the clear liquid. It is important, especially in spraying for the scale, that the solution shall be diluted according to its degree of concentration in order that the mixtures may always be of a definite strength. Knowing the density of the clear solution, it is a simple matter to obtain diluted mixtures that are approximately uniform in their insecticidal properties. 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, which also shows a convenient glass vessel for holding the lime-sulphur solution. 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 in common use 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 38 degrees Beaumé or 1.000 to 1.349 specific gravity are recommended. Hydrometers do not detect impurities in lime-sulphur solutions; these can be determined only by chemical analysis. Hydrometers of the above specifications can be purchased from the Bausch and Lomb Optical Co., Rochester, N. Y., and undoubtedly from wholesale dealers in druggists' supplies.