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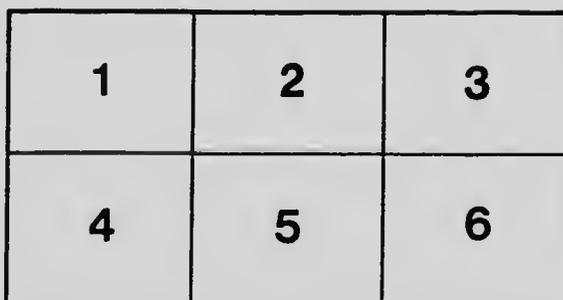
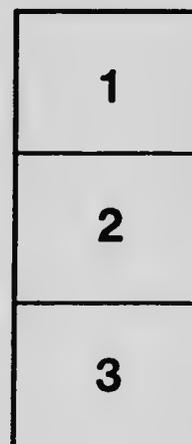
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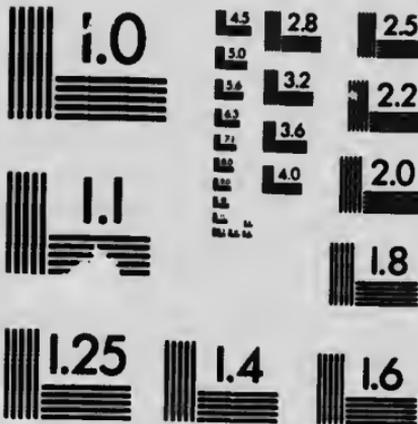
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Lime-Sulphur Wash

BY L. CAESAR.

In this bulletin an attempt is made to give the results of the latest investigations and experiments on the making of the lime-sulphur wash and the various uses to which it can be applied.

DIFFERENT FORMS OF THE WASH.

1. Concentrated lime-sulphur:
 - (a) Commercial or factory-made.
 - (b) Home-made.
2. The old home-boiled lime-sulphur, 20.15.40 formula.
3. Self-boiled lime-sulphur.

Of these different forms No. 1 is by far the most used to-day. A few years ago No. 2 was popular, but the concentrated form is now rapidly superseding it. The reasons for this are as follows: The old home-boiled is intended for use only before or as the buds are bursting and has to be applied warm, otherwise crystals soon form and clog the spray pump and nozzles, whereas the concentrated wash can be used not only for this early spraying, but also for the later sprayings after the foliage has appeared. It does not require to be applied warm, can be kept for months without deterioration, and, therefore, can be made in spare time in the spring and stored away until required. Moreover, being much more highly concentrated and, therefore, requiring a great deal of dilution, it is more economical to manufacture. Numerous tests have shown that when diluted to the proper extent it is just as effective against San José Scale or other pests as the old home-boiled form.

No. 3 is not much used yet in Ontario. It is intended chiefly for use on peach trees after the foliage is out to control Brown Rot and Peach Scab. The other forms of the wash are not satisfactory for this purpose because peach trees are very tender and these mixtures would have to be diluted so much to prevent burning that they would not be effective in controlling these peach diseases.

CONCENTRATED LIME-SULPHUR.

As indicated above there are two kinds of the concentrated lime-sulphur, namely, the commercial or factory-made and the home-made. These are identical in character, the only difference being that the commercial form is considerably stronger than the home-made and therefore will permit of a greater degree of dilution, and, as sold by most of the companies, contains little or no sediment. This is removed before barreling because it has not nearly so much value as the clear liquid and therefore many purchasers object to its presence.

There are several companies, situated in different parts of the province, that are manufacturing lime-sulphur. The writer has used considerable of the product of two of these and found them quite satisfactory. He believes that all the companies make good washes and that it is quite safe to purchase from any of them. The only objection to purchasing the commercial lime-sulphur is the cost. Home-made concentrated can easily be made and the rules for diluting it quickly learned, and as it is much cheaper fruit growers should learn to make their own unless they live near a company's factory and can purchase on very favourable terms. The comparative cost of the two kinds of the wash will be discussed below.

HOME-MADE CONCENTRATED LIME-SULPHUR.

Formula:—50 lbs. fresh stone lime, grading high in calcium.
100 lbs. sulphur, either flowers or a fine grade of flour of sulphur.
40 to 50 gallons of water, either hard or soft.

The amount of lime given in this formula can be modified profitably as mentioned below under the heading: "Best limes in order of merit."

When sulphur is purchased in bags containing 112 lbs., it is convenient to use the whole of this amount at a time instead of weighing out 100 lbs. In such cases 56 lbs. of lime would of course be required to keep the above proportions and 50 gallons of water are always preferable to 40.

LIMES SUITABLE FOR MAKING THE CONCENTRATED WASH.

During the last season an attempt was made to obtain samples of lime from all the different limestone formations of the province. These were all tested and, whenever it seemed desirable, were chemically analyzed through the kindness of the staff of the Chemical Department. A number of these limes were found to contain too high a percentage of impurities, chiefly magnesium, to make a good wash without too much sediment. *Prof. Van Slyke has shown that the presence of large quantities of

* Bulletin 319, Geneva.

magnesium injures the wash in other respects also. Of the remainder some were much superior to others.

BEST LIMES ARRANGED IN WHAT SEEMS TO BE THE ORDER OF MERIT.

Name of Lime.	Address.
Beachville	The Standard Lime Co., Beachville.
St. Marys	Standard White Lime Co., St. Marys.
Renfrew (two grades; get the purer).....	The Jamleson Lime Co., Renfrew, Ont.
Ottawa	Gloucester Stone & Lime Works, H. Robillard & Son, 236 Chapel St., Ottawa.
Selkirk	F. Helka, Selkirk, Ont.
Coboconk	Canada Lime Co., 34 Yonge St., Toronto.
Port Colborne	John A. Reeb, Port Colborne, Ont.
Trenton	W. H. Miron, Trenton, Ont.

Note.—Fruit-growers along the St. Lawrence can secure an excellent grade of lime from The Hackett Co., Ogdensburg, New York.



Fig. 1. Shows the comparative amount of sediment produced by each of nine kinds of lime boiled under the same conditions. The white line near the bottom of each vessel marks the height of the sediment.

As the limes are not all of the same strength the amount to be used with each 100 lbs. of sulphur may, with considerable advantage, be varied from the 50 lbs. given above in the formula as follows: About 48 lbs. seem best for Beachville; 50 for St. Mary's, Renfrew, Ottawa and Selkirk; 54 for Coboconk and Port Colborne, and 60 for Trenton.

It is very probable that there are a few more districts where suitable lime can be procured; hence fruit growers wishing to know whether the lime of their locality may be used should send to the writer samples of not less than one pound in weight.

DEVICES FOR BOILING.

Many different devices are used for boiling the mixture. It is not at all necessary to have an expensive outfit. A cheap one will give as good results. A kettle holding from 25 to 40 gals. water will serve the purpose, but it is rather slow, as only part of the amount indicated in the formula can be boiled at a time.



Fig. 2. Kettle used for boiling the lime-sulphur wash.

Fig. 2 shows such a kettle. A more economical device is shown in Fig. 3.



Fig. 3. Box with galvanized-iron bottom; a good outfit for boiling the wash.

This consists of a stout, close-fitting box with wooden sides and ends and galvanized-iron bottom. This box should be large enough to boil 50 gals. of the mixture at a time. Each box is about 6 feet long, 3 feet wide and from 14 to 18 inches deep. The sides and ends are made of 2 inch planks closely fitted together at the corners. The galvanized-iron bottom should extend slightly beyond the planks to protect them from the fire. It is nailed to them by ordinary wire nails. The box thus constructed is placed on a brick, stone or concrete foundation from 18 to 20 inches high with one end open for throwing in the fuel, and the other provided with a couple of lengths of stovepipe to create a draught and carry off the smoke. It is found very convenient to place a "molasses gate" or faucet with a good sized aperture near one corner to enable the operator to draw off



Fig. 4. Small steam generator, boils two barrels at a time; scarcely so good as the box.

the wash when ready. Before using the box it should be filled with water, and let soak a few hours. It is found that the mixture can be made very rapidly in these boxes because of the large amount of surface exposed to the flames. To prevent unnecessary loss of heat there should be a wooden covering made of three or four boards running lengthwise and fastened together by crosspieces near the ends. An opening must be left between the two middle boards wide enough for a hoe handle to run through easily to permit the necessary stirring.

Instead of boiling by direct heat from the fire many prefer to use steam. This is the most pleasant method and the most convenient, especially where a large quantity has to be prepared each day.

If it is desired to boil only two barrels at a time Fig. 4 shows a very convenient little steam generator costing about sixty-five dollars.



Fig. 5. Threshing engine used for boiling the wash.

Fig 5 shows an ordinary steam engine of about 15 horse-power which may be used to boil from eight to ten barrels at a time.



Fig 6. An outfit for boiling the lime-sulphur in larger quantities.

Fig. 6 shows a still larger outfit where the mixture is boiled in large tanks, each having a capacity of several barrels. The tanks, it will be observed, are placed on a platform, which is a few feet higher than the spray tank, so that the wash, when ready, can flow through a tap and large hose into the screen and be strained directly into barrels or other storage receptacles.

It is perhaps necessary to mention that, although boiling by steam is a very convenient and satisfactory way, it makes no better wash than can be made in the kettle or box or some other cheap device.

HOW TO MAKE THE WASH.

We shall first discuss the method of boiling in a kettle or box by direct heat and then the method of boiling by steam.

Put enough water in the boiling outfit to make a moderately thick paste with the sulphur, usually about 10 gals. Then light the fire and, while the water is heating up, throw in the sulphur and stir well with a hoe to make a paste and break any lumps there may be. Next add the remainder of the 40 or 50 gals. of water and, when it is nearly ready to boil, add the lime. When this has begun to slake, stir well with the hoe to prevent caking on the bottom and to keep the lime and the sulphur in suspension, as this hastens the chemical process of combination. The stirring should be frequent for about 20 or 25 minutes until all the lime and sulphur is in solution, after which it need be done only occasionally. Boiling should be continued for one hour or at least 50 minutes and water added in small quantities from time to time to keep the total always up to at least 40 gals., but preferably to 50 wherever the outfit is large enough to boil this amount. In order to keep track of this a measuring stick should be used to mark how high the total amount of water reaches when it is heated up. If a small crosspiece is nailed on the stick at this height it will be easier than a notch to see in the steam.

This method may be considerably varied to suit the convenience of the individual. If the boiling outfit is so small that the liquid will boil over if the lime is added after all the water has been put in, this difficulty can be overcome by throwing the lime on top of the sulphur paste and adding sufficient water to slake it thoroughly and then, when the slaking is over, adding the rest of the water and boiling as before for 50 minutes or one hour. The lime must of course be stirred when it is slaking. Some prefer to place sufficient water in the outfit to slake the lime, heat it to near boiling, then add the lime and, as soon as it is well slaked, add the sulphur and the rest of the water and boil for 50 minutes or one hour. The writer has found the first way the most convenient, but it is not necessarily the best; in fact one way in his tests gave just as good results as another.

When boiling by steam practically the same mode of procedure should be followed. If the boiling is done in barrels these should be only about half full, otherwise they will boil over. No water has to be added here to allow for evaporation, but care must of course be taken to see that the proportions given above in the formula are adhered to closely. There is sometimes a danger that the noise caused by the passing of the steam into the mixture may be mistaken for boiling, hence we must see that there is plenty of steam. If the pipe conveying the steam into the barrel reaches to about 10 inches from the bottom, this helps to keep the ingredients stirred up.

POINTS OF SPECIAL IMPORTANCE IN THE BOILING OF THE HOME-MADE CONCENTRATED.

1. The amounts of lime and of sulphur should be carefully weighed out and never guessed at.
2. Air-slaked lime should never be used as it does not combine well with the sulphur; hence always use fresh lime. If the lime, on its arrival, is placed in a dry room in well-covered vessels, it will not slake nearly so rapidly as if left exposed to the air, especially if the air is damp.
3. If possible, use 50 gals. instead of 40 gals. of water. In the writer's tests it was seen that where the same proportions of lime and sulphur were used, but the water varied from 30 to 50 gals., there was considerably more sediment from 30 gals. than from 40, and slightly more from 40 than from 50. When each lot was made up to 50 gals. at the end of the boiling and the strengths compared, the one boiled with 50 gals. was considerably stronger than that with 40 and much stronger than that with 30 gals. This shows clearly that we must be careful, when boiling, never to allow the liquid to get below the 40 gal. mark and preferably not below the 50 one. The only objection to keeping it always at 50 gals. instead of 40 is the need of a larger outfit for boiling than some have, and of extra receptacles for storing. Where this can easily be overcome, the 50 gal. should be used instead of 40. This shows that for the fruit grower it does not pay to attempt to make so highly concentrated a wash as the commercial companies do. It is easy, of course, to make it just as strong.
4. The process of bringing the sulphur and lime into solution and lessening the amount of sediment is aided by frequent stirring, especially during the first 20 or 25 minutes.
5. The boiling should be at a moderate but not furious rate.
6. Sometimes excellent mixtures are made by boiling only 45 minutes, but it will be found safer on the whole to boil one hour. The boiling should not be unnecessarily checked by adding large quantities of water at a time; it is better to add small amounts at frequent intervals.
7. If lumps of sulphur are found in the sediment that do not go through the screen, these may be crushed and thrown back into the boiler. This small addition of sulphur will not injure the next lot.

8. The colour of the sediment varies with different kinds of lime. This does not affect the value of the wash.

9 The amount of sediment from one kind of lime compared with another, while a fairly good test of the purity, is not an accurate one because the sediment of some kinds is much lighter and more flocculent than of others and does not settle so low. The hydrometer reading of the clear liquid is much more reliable.

STORING THE WASH.

As soon as the boiling has lasted for one hour, the mixture can be strained through a fine screen of from 30 to 40 meshes to the inch into

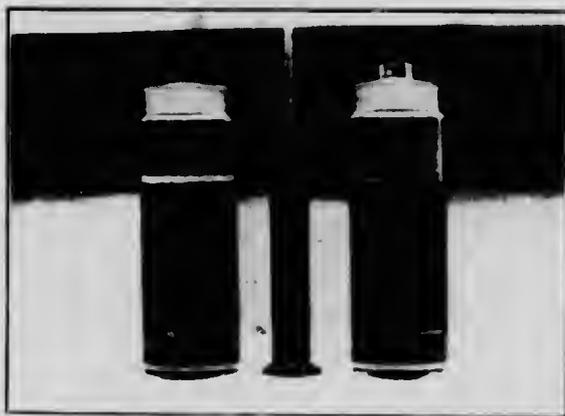


Fig. 7. (a) Shows the comparative amounts of sediment from boiling the same proportions of lime and sulphur in 40 and 30 gals. respectively. Note the larger amount of sediment in the latter case, thus showing the importance of keeping the water up to at least the 40 gal. mark. (b) Hydrometer in glass cylinder of the liquid.

a barrel or other receptacle and covered well to keep the air out, as this slowly but gradually causes the wash to deteriorate. If the liquid is going to be used in a week or less, it is not necessary to be particular about excluding the air very carefully. Empty kerosene or other good barrels may be used for storage. If the bung is removed, the liquid can be strained through the hole and the bung replaced when the barrel is full. If vinegar barrels or barrels that have held any kind of acid are used, they should first be filled with water and allowed to soak so that all the acid may be removed. Acid decomposes lime-sulphur. Open barrels or tanks may be protected from the air by pouring about one-eighth of an inch of any kind of oil over them. This can be skimmed off before using the wash.

If the weather is very cold, the barrels must be protected against frost. They do not freeze nearly so easily as water. The writer found that a

strength of 1.200 specific gravity left uncovered did not begin to freeze until the thermometer stood at 15° above zero Fahrenheit. Denser washes will stand more frost.

A wash properly protected from air and from freezing will keep a year or more without deteriorating to any appreciable extent.

AMOUNT OF HOME-MADE CONCENTRATED LIME-SULPHUR REQUIRED FOR ONE ACRE OF ORCHARD.

If the orchard is composed of fairly well developed apple trees from thirty-five to forty-five years of age, one barrel per acre of the home-made concentrated lime-sulphur, made according to the directions given above and properly diluted for each application, will usually be sufficient for the three regular sprayings that every orchard should receive. Roughly speaking, one may reckon that each tree on an average will be found to have required a little more than one gallon of the concentrated wash. Smaller trees will require a proportionately small amount; for instance, one barrel of the concentrated would ordinarily suffice for at least two acres of apple trees twenty years of age. A little thought will enable anyone to estimate fairly accurately how much of the mixture he will need to make for the season's spraying.

THE BEST TIME TO MAKE THE WASH.

Except where one is making large quantities to sell or for a co-operative association and finds it impossible to get the work done unless he begins very early, it would be wise to leave the making of the wash until some time in March or April. This will avoid the necessity of so much care in protecting it against frost.

HOW TO TEST THE STRENGTH OF CONCENTRATED LIME-SULPHUR AND DETERMINE THE PROPER AMOUNT OF DILUTION FOR EACH SPRAYING.

Every fruit grower should learn to test the strength of the concentrated lime-sulphur, whether it be home-made or commercial, and how to determine the proper amount of dilution for each spraying. In this way alone he knows just what strength he is using on his trees, and therefore is acting in a more business-like manner. To test the strength of the wash a small glass instrument, about a foot long, known as an hydrometer, is used. (See Figs. 7 and 8.) These hydrometers are of two kinds, one with specific gravity readings and the other with Baumé. The writer prefers the specific gravity one, because the proper amount of dilution can always be worked out with it from a simple rule given below, while, with the Baumé scale, one has to consult the table which is also given below. It is convenient to have an hydrometer with both readings, and such are manufactured. Some of the commercial lime-sulphur companies sell hydrometers specially made for the purpose, the price varying from 75 cents to \$1.00. Most wholesale druggists keep at least one kind of hydrometer for sale.

The specific gravity readings on the most convenient hydrometers run from 1.000 to about 1.350 or 1.400 and on the Baumé from 0 to 40 or 42. When an hydrometer is placed in a vessel of water it sinks to 1.000 on the specific gravity scale and to 0 on the Baumé. If the liquid is denser

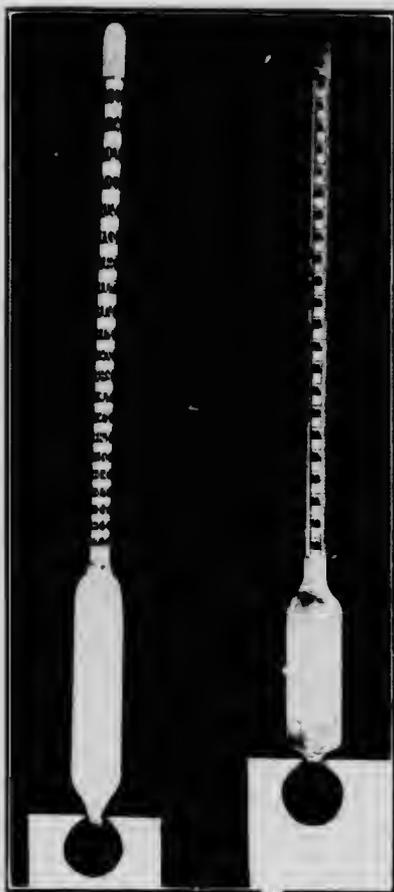


Fig. 8. Hydrometers (about $\frac{1}{2}$ lb. each). The one on the left has specific gravity, the other Baumé, readings.

than water it will not sink so deeply. In home-made concentrated, it usually sinks to somewhere between 1.200 and 1.240 specific gravity, or 24 to 28 Baumé, where 40 gals. are used in boiling, and from about 1.175 to 1.210, or 21 to 25 Baumé, where 50 gals. are used. In commercial lime-sulphur it sinks to about 1.300 specific gravity or 34 Baumé. Whatever point it sinks to is spoken of as the *reading* or strength of the wash, and the greater the number the more the wash will stand to be diluted before using it on the trees.

PRECAUTIONS TO BE TAKEN IN USING THE HYDROMETER.

1. All the sediment must first have settled to the bottom and only the strength of the clear liquid be tested. If this is not done the reading will be much too high; for instance, the writer tested a wash before the sediment was settled and it read 1.240, and after it was settled only 1.200, the latter, of course, being the correct reading.

2. The wash should be left long enough to have cooled down to the temperature of the surrounding atmosphere. In a number of tests it was found that a more accurate reading was obtained by waiting until the second or third day after the wash was made. The reason for this is not clear.

3. The hydrometer should be washed each time after the reading and not allowed to get dirty. If it is found difficult to clean, rub it with a little vinegar on a cloth and then wash this off.

It is convenient when storing the wash to keep out sufficient in a vessel about a foot deep to test when necessary. The strength can then be marked on the barrel for reference.

RULES FOR DILUTING BEFORE SPRAYING IF A SPECIFIC GRAVITY HYDROMETER IS USED.

Put the hydrometer in the clear liquid when it is cool and the sediment has settled. Note the reading. Suppose this is 1.240 sp. gr. The proper strength for use before the buds burst is 1.030, but if San José Scale has to be combated it is better to make it 1.032. To determine how much to dilute a wash reading 1.240 to get a strength of 1.030, divide the first three figures to the right of the 1 by 30, that is 240 divided by 30=8. This means that each gallon of the wash may be diluted with water to make 8 gals. of the strength of 1.030. For San José Scale divide by 32 instead of 30, that is 240 divided by 32=7½; so that in this case each gallon may be diluted to only 7½ gals.

For use on apples and pears just before the blossoms burst the proper strength is about 1.009. To get this strength from a wash reading 1.240, divide in the same way the first three figures to the right of the 1 by 9, that is 240 divided by 9=26⅔. This means that each gallon of such a wash for this application may be diluted with water to 26⅔ or 27 gals.

For the application just after the blossoms have fallen and for subsequent applications, if any are given, a strength of about 1.008 is satisfactory. To get this we proceed in the same way as above and divide the 240 by 8, which gives us 30, thus indicating that for this application each gallon may be diluted to 30. *In brief the rule is: Take the reading of the wash and divide the three figures to the right by 30 (or 32 if for San José Scale) for the first application; by 9 for the second and by 8 for the third, and dilute each gallon with water to the number thus obtained in each case.*

For the convenience of those who may happen to have an hydrometer with only the Baumé scale on it or for anyone who prefers to use a table instead of the above rule even with the specific gravity scale, the following table is given:

NOTE.—In this table the number of gallons of water to be added to each gallon of the concentrated wash is given, whereas in the rules just given above it is only the total number of gallons of spray mixture that each gallon of the concentrated wash will make that is given, and the number of gallons of water to be added is therefore one less than that total in each case.

TABLE FOR DILUTION OF CONCENTRATED LIME-SULPHUR.

Reading on Hydrometer.		First Application.		Second Application.		Third Application.	
Specific Gravity Scale.	Baumé Scale.	Lime-sulphur. Gallons.	Water. Gallons.	Lime-Sulphur. Gallons.	Water. Gallons.	Lime-Sulphur. Gallons.	Water. Gallons.
1.320 = 35 $\frac{1}{4}$ *	1 with 9 $\frac{7}{8}$	or 9 $\frac{2}{3}$	1 with 34 $\frac{1}{2}$.....	.....	1 with 39.	.....
1.310 = 34 $\frac{1}{2}$	1 " 8 $\frac{2}{3}$	or 9 $\frac{1}{3}$	1 " 33 $\frac{1}{2}$.....	.....	1 " 38.	.....
1.300 = 33 $\frac{1}{2}$	1 " 8 $\frac{1}{3}$	or 9.....	1 " 32 $\frac{1}{2}$.....	.....	1 " 36 $\frac{1}{2}$.	.....
1.290 = 32 $\frac{3}{4}$	1 " 8	or 8 $\frac{2}{3}$	1 " 31.....	.....	1 " 35.	.....
1.280 = 31 $\frac{3}{4}$	1 " 7 $\frac{3}{4}$	or 8 $\frac{1}{3}$	1 " 30.....	.....	1 " 34.	.....
1.270 = 31.....	1 " 7 $\frac{1}{3}$	or 8.....	1 " 29.....	.....	1 " 33.	.....
1.260 = 30.....	1 " 7	or 7 $\frac{2}{3}$	1 " 28.....	.....	1 " 31 $\frac{1}{2}$.	.....
1.250 = 29.....	1 " 6 $\frac{3}{4}$	or 7 $\frac{1}{3}$	1 " 27.....	.....	1 " 30.	.....
1.240 = 28.....	1 " 6 $\frac{1}{2}$	or 7.....	1 " 25 $\frac{2}{3}$.....	.....	1 " 29.	.....
1.230 = 27.....	1 " 6	or 6 $\frac{2}{3}$	1 " 24 $\frac{1}{2}$.....	.....	1 " 28.	.....
1.220 = 26.....	1 " 5 $\frac{3}{4}$	or 6 $\frac{1}{3}$	1 " 23 $\frac{1}{2}$.....	.....	1 " 26 $\frac{1}{2}$.	.....
1.210 = 25 $\frac{1}{4}$	1 " 5 $\frac{1}{2}$	or 6.....	1 " 22 $\frac{1}{3}$.....	.....	1 " 25.	.....
1.200 = 24 $\frac{1}{4}$	1 " 5 $\frac{1}{4}$	or 5 $\frac{2}{3}$	1 " 21.....	.....	1 " 24.	.....
1.190 = 23 $\frac{1}{4}$	1 " 5	or 5 $\frac{1}{3}$	1 " 20.....	.....	1 " 23.	.....
1.180 = 22 $\frac{1}{4}$	1 " 4 $\frac{2}{3}$	or 5.....	1 " 19.....	.....	1 " 21 $\frac{1}{2}$.	.....
1.170 = 21 $\frac{1}{4}$	1 " 4 $\frac{1}{3}$	or 4 $\frac{2}{3}$	1 " 18.....	.....	1 " 20.	.....
1.160 = 20 $\frac{1}{4}$	1 " 4	or 4 $\frac{1}{3}$	1 " 17.....	.....	1 " 19.	.....
1.150 = 19.....	1 " 3 $\frac{2}{3}$	or 4.....	1 " 15 $\frac{2}{3}$.....	.....	1 " 18.	.....
1.140 = 18.....	1 " 3 $\frac{1}{3}$	or 3 $\frac{2}{3}$	1 " 14 $\frac{1}{2}$.....	.....	1 " 16 $\frac{1}{2}$.	.....
1.130 = 16 $\frac{3}{4}$	1 " 3	or 3 $\frac{1}{3}$	1 " 13 $\frac{1}{2}$.....	.....	1 " 15.	.....
1.120 = 15 $\frac{1}{2}$	1 " 2 $\frac{3}{4}$	or 3.....	1 " 12 $\frac{1}{4}$.....	.....	1 " 14.	.....

* The fraction need not be taken into account unless the user wishes to do so.

† The smaller number is for use against San José Scale, the larger for use where there is no scale.

NOTE 1.—One should not test the strength of the diluted spray. All that is necessary is to dilute according to the rules given.

NOTE 2.—After determining the strength of a barrel of the home-made concentrated wash, it should always be well shaken before spraying, to distribute the sediment so that the mixture each time may be uniform in strength.

COMPARATIVE COST OF COMMERCIAL AND HOME-MADE CONCENTRATED
LIME-SULPHUR.

Each barrel of commercial lime-sulphur costs on an average \$8.00 f.o.b., and when the freight charges are added to this many of our growers have to pay at least \$9.00 per barrel, but we shall, however, speak of the commercial wash as costing \$8.00.

Those who make their own concentrated can nearly always secure their sulphur from the companies which are dealing in lime-sulphur for about 1½ cts. per lb., but as there is freight to pay on this, we shall suppose the sulphur costs 2 cts. a lb. Lime ordinarily costs not more than 25 cts. per bushel, but as some will have to obtain it by freight from a distance, we shall suppose it costs them in all 42 cts. per bushel. There is in addition to these the cost of barrels for storing, though usually there are several on hand; the cost of fuel and labour, and the interest on the original cost and maintenance of the boiling outfit. Taking all these into consideration we have the following:

Sulphur, 100 lbs. at 2 cts.	\$2 00
Lime, 50 lbs. at 42 cts. a bus	30
Labor, at \$2.00 per day	50
Fuel	10
Interest on outfit	10
Barrel	1 00
	<hr/>
Total cost	\$4 00

This wash is about two-thirds commercial strength, so the cost of an amount of it equivalent to one barrel commercial strength would be \$6.00. This leaves a balance of \$2.00 per barrel in favour of the home-made.

Whenever it is made in large quantities the cost is less, and therefore the gain per barrel greater than \$2.00.

THE OLD HOME-BOILED LIME SULPHUR.

As mentioned at the beginning of the bulletin this form of lime-sulphur was until the last few years very popular and in fact about the only kind used. The most common formula is 20 lbs. good fresh lime, 15 lbs. sulphur and 40 gals. water. The lime and the sulphur are usually boiled in about 15 gals. of water for one hour, and then are diluted to 40 gals. The mixture must be applied while still hot, or at least warm. The same kinds of outfits and the same methods of adding the ingredients as in the case of the home-made concentrated wash should be used. The water should be kept up to about 15 gals. during the boil-

ing and the same care taken to stir frequently. The wash, before using, must be strained through a screen of 20 to 30 meshes to the inch. This form of lime-sulphur, as mentioned above, cannot be stored, but must be used the same day as it is made, otherwise it will crystallize and clog the nozzles and spray pump. It is only used for the spraying before or as the buds burst. It is not, of course, so economical to make or convenient to use as the home-made concentrated, but is just as effective and is much liked not only for the good results it gives but also for the way in which it leaves the trees very white, thus showing clearly whether the work was well done.

SELF-BOILED LIME-SULPHUR.

The following are the directions given by Prof. Scott of Washington, D.C., for making this wash.*

" This mixture is composed of 8 lbs. of fresh stone lime and 8 lbs. of sulphur (either flowers or flour may be used) to 40 gals. of water. This appears to be about the correct strength, although in mild cases of scab and brown-rot a weaker mixture, containing 6 lbs. of each ingredient to 40 gals. of water, may be used with satisfactory results. The mixture can best be prepared in rather large quantities, say, enough for 160 gallons at a time, making the formula 32 lbs. of lime and 32 lbs. of sulphur to be cooked with a small quantity of water (7 or 8 gallons) and then diluted to 160 gallons.

" The lime should be placed in a barrel and enough water poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added after first running it through a sieve to break up the lumps. The mixture should be constantly stirred and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked, water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted and applied.

" The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot fifteen or twenty minutes after the slaking is completed, the sulphur gradually goes into solution, combining with the lime to form sulphides, which are injurious to peach foliage. It is, therefore, very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform

* Circular 120, Bureau of Entomology, Washington, D.C.

mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through the strainer."

The writer has used a good many barrels of this wash and found it very easy to prepare. To stir the mixture while boiling, a hoe was found satisfactory. With it the lime should be raised merely a little way from the bottom to let the water down and so prevent caking. It should not be brought to the top as that tends to check the boiling. The stirring must not begin until slaking has got well started.

As there is a great deal of sediment in this wash it can be strained much more easily if first diluted to about half the total amount. A screen of about 20 meshes to the inch may be used.

When applying the wash to the trees extra precautions should be taken to see that it is kept well agitated.

The cost per barrel at the prices of the materials given above is very low: Lime 5 cents, sulphur 16 cents, total 21 cents.

THE USE OF POISONS WITH LIME-SULPHUR.

Lime-sulphur itself is not an internal poison. It kills scale insects and some other very small but very troublesome pests, but does so by coming in contact with their bodies or by acting upon the waxy covering that protects them or by depriving them of the oxygen they need to breathe.* It does not kill the Codling Moth, Plum Curculio or any of the larger insects except in rare cases when, in their very early stage, the little worms may happen to get covered by the wash. For all these insects we need a poison which we can put on the leaves or fruit so that, when these are eaten, the insect will be killed. There is only one poison at present that we can safely recommend to be used with lime-sulphur for this purpose, namely, arsenate of lead. Other arsenical poisons, such as Paris green and arsenite of lime, when combined with lime-sulphur very frequently burn the foliage severely, especially in the later sprayings, although some years they do not do so. It is never safe to rely on them, and for that reason they cannot be recommended. It is very probable that new poisons equally as good as arsenate of lead and that can safely be combined with lime-sulphur will be discovered before long, but attention will then be called to them through the press, or in other ways.

Arsenate of lead is a white paste, costing from 8 to 14 cts. a lb., and from 2 to 4 lbs. are used with every 40 gals. of the diluted lime-sulphur. Before adding it to the lime-sulphur, it must always be stirred up in a gallon or two of water until it is all in suspension and is just like milk. When it is added to the lime-sulphur, it changes the colour of the latter,

* See Technical Bulletin No. 11, Michigan Agricultural College, Lansing, Mich.

a chemical change being brought about by the combination of the two substances. This chemical change results in the formation of a blackish precipitate which settles to the bottom rather quickly unless kept well agitated while spraying.

DOES THE ADDITION OF ARSENATE OF LEAD TO LIME-SULPHUR LESSEN THE VALUE OF EITHER SUBSTANCE?

This is a very important question, but as the result of several seasons' careful experiments conducted by himself and by others, the writer has no hesitation in saying that the value of neither the lime-sulphur nor of the arsenate of lead is lessened, in fact it is believed that arsenate of lead itself has considerable fungicidal value; and careful tests by Wallace, of Cornell University, have shown that lime-sulphur and arsenate of lead combined is a better fungicide than lime-sulphur alone.*

LIME-SULPHUR *VERSUS* BORDEAUX MIXTURE.

Numerous questions are asked as to the comparative merits of lime-sulphur and Bordeaux mixture. There can be no doubt whatever that for the first application, which should be made before or as the buds are bursting, lime-sulphur is very much the better spray for fruit trees and shrubs because it not only controls diseases that may be spreading at this time of the year as well as Bordeaux does, but it also at the same time kills several of our worst insect pests, such as San José Scale, Oyster-shell Scale and Blister Mite, which Bordeaux will not do.

For the other applications on apples and pears one mixture seems just about as good a fungicide as the other, as either of them will control the fungus diseases that are found on these trees in Ontario in a very satisfactory way if properly applied. It is just possible that the foliage is a little larger when Bordeaux is used, but this is not fully proven yet and whether it be so or not the foliage on trees sprayed with lime-sulphur is very healthy and quite as large as normal. The great objection to Bordeaux mixture is that it undoubtedly russets some varieties of apples very badly, making them look far from attractive. Lime-sulphur on the other hand leaves the skin of the apple smooth and as beautiful as in nature when not attacked by any disease. Furthermore lime-sulphur is a good deal more convenient to use because all one has to do is to go to the barrel of the concentrated wash, take out what is wanted, strain it into the tank and then add the necessary amount of water and the arsenate of lead; whereas Bordeaux mixture has to be made up fresh each day and this requires considerable time and work. Moreover, if the orchard is infested with scale insects, the later applications of lime-sulphur help

* Bulletin 289, Cornell University, Ithaca, N.Y.

to supplement the spring wash in controlling these. Neither mixture, if properly diluted and if applied thoroughly at the times indicated on the spray calendar, will cause any appreciable injury to the foliage. The cost of lime-sulphur for these later sprayings is about the same as or slightly less than that of Bordeaux mixture. In the writer's opinion it is wise to use lime-sulphur in preference to Bordeaux for all the sprayings of apple and pear trees.

For plums and cherries Bordeaux is probably quite as good, if not better, than lime-sulphur, though there is need of further tests to determine the matter absolutely. On gooseberries lime-sulphur is preferable and probably on currants also.

For *potatoes* and *grapes*, *Bordeaux* is almost unquestionably superior. The writer had the opportunity this fall of seeing Prof. Stewart's experiments with *Bordeaux* and lime-sulphur on potatoes at Geneva. These tests were repeated five times and in every case the *Bordeaux* sprayed rows, as seen in October, were decidedly superior to the lime-sulphur sprayed and to the unsprayed rows. As for grapes the experiments of Hartzell, of Geneva, and Reddick, of Cornell, have proven clearly that it is not safe to use commercial or home-made concentrated lime-sulphur on grape foliage as it frequently burns it severely if used strong enough to combat the Black Rot disease. The self-boiled lime-sulphur could, of course, be used without danger against Powdery Mildew if this begins to appear in the vineyard.

INSECTS THAT CAN BE CONTROLLED BY LIME-SULPHUR.

SAN JOSÉ SCALE.

(*Aspidiotus perniciosus*, Comst.)

Although the San José Scale is a very tiny insect (see Fig. 9), not nearly so large as the head of a pin, it is capable, if not kept under control, of completely destroying whole orchards in a very few years. Fortunately many of our best fruit growers in districts where this scale has been for years have learned how to keep it so thoroughly in check that they do not fear it at all, and even think it a blessing in disguise, because it has forced them to use a wash which has greatly helped their trees in other ways than merely by destroying the scale. Of the many spray mixtures which have been tried against the scale none has given so uniformly good results as lime-sulphur, so that it is to-day almost the only wash used to any great extent for combating this pest.

Treatment.—Spray very thoroughly in spring, preferably as late as time permits before the buds burst, using either the old home-boiled lime-sulphur (20 to formula) or the concentrated wash of the strength of about 1.032 specific gravity. Very badly infested trees should receive

two applications. These may both be made in the spring with an interval of a couple of days or more between them, or one may be made in autumn, as soon as the leaves have nearly all fallen, and the other in spring. Very large apple trees are hard to free from the scale, much harder than smaller or medium-sized ones. To make it easier to treat them thoroughly fruitgrowers in infested districts are heading the trees back severely. In doing this care should be taken to cut close to a side branch, sawing a little on the slope, so that the rain will run off, and to see that the wound is thoroughly painted over to prevent disease getting in and destroying the trees. It need scarcely be said that the pruning of infested trees



Fig. 9.—San José Scale on pear.

should be done before spraying, and that all prunings should be burned, not thrown into brush-heaps and allowed to remain there. If the loose bark be scraped off with a hoe early in the season it will allow the spray to reach scales that otherwise might escape. Careful cultivation and a liberal use of manure will assist the spray in giving renewed vigor to badly infested trees.

There is no insect, in Ontario at least, that requires more careful and thorough work on the part of the sprayer if he is to get good results, because, if even a few infested twigs are left unsprayed, there will frequently be enough scale on them to produce great numbers by autumn. From a single fertile female in spring at least 1,000,000 offspring may be

produced before the end of the season. Hence trunks, branches and twigs—in short, every part of the tree—must be very carefully sprayed.

OYSTER-SHELL SCALE OR APPLE BARK-LOUSE.

(*Lepidosaphes ulmi*, L.)

Though not nearly so destructive an insect as the San José, the Oyster-shell scale (see Fig. 10) is doing nearly as much damage to the province as a whole, because it is found in almost every orchard, whereas the San José scale is still almost entirely confined to the few south-western counties.



Fig. 10.—Oyster-shell Scale.

Treatment: Spray in spring at the same time as for San José scale, using the same mixture, at either the same strength or a little weaker, but not less than a specific gravity reading of about 1.030. A second spraying with the lime-sulphur diluted to 1.008 sp. gr. just after the blossoms fall (the regular time to spray for Codling Moth) helps to destroy the tiny young scales which have just finished hatching by this date. Scrape the rough bark off the trunk and large branches so that the spray may reach every scale. Cover every part of the tree with the wash. Cultivation of the soil in the early part of the season to give vigor to the trees helps

against this scale, as it thrives best on trees that are not strong. It is seldom that all the scales are killed in one season, but at the end of two or three seasons, if the orchard has been carefully sprayed, the trees will be found to be free from the pest. Old empty scales hang on for a year or two, but their presence is not a proof that the spray was inefficient. These scales in winter will have no eggs under them, while the healthy scales will be found to contain from about 20 to 120 tiny white eggs. These can easily be seen with a small magnifying-glass, especially if worked out upon any black surface. During the last four years numerous orchards in the province have been almost totally freed from the Oyster-shell Scale by the above treatment.

LEAF-BLISTER MITE.

(*Eriophyes pyri*, Scht.)

The Leaf-blister Mite (see Fig. 11) is a very tiny creature, so small that unless a number are clustered together they are invisible to the naked eye. In spite of their diminutive size they make their presence very noticeable on both apple and pear trees by causing numerous blisters on the lower side of the leaves. These spots are often confused with fungus diseases, but can easily be distinguished by their being slightly raised beyond the surface of the leaf. As the name indicates, they are blisters or swellings in which the mites live and reproduce. Affected leaves are quite conspicuous in the later half of the season. On the apple leaves at this time the blisters become reddish brown in colour and visible on both the upper and lower surface. On the pear leaves they are usually more clustered along the mid-rib than on the apple, and become nearly black, often disfiguring the foliage very greatly and being visible several rods away.

The Blister Mite has gradually been spreading all through the province, and is now found in numerous orchards. It does not, so far as we know, cause the tree to die, but weakens it greatly by interfering with the power of the leaves to perform their proper function of manufacturing food for the rest of the tree, and by causing them to turn yellow and drop early, especially in a dry season when the tree needs them most.

Treatment: Many tests on a large scale throughout the province have shown that even very badly infested orchards can be almost completely freed from this pest in two years by a single application of lime-sulphur each spring just before or as the buds are bursting. The strength may be 1.030 sp. gr., or even weaker. Fairly good results may be obtained by an earlier spray. It must not be left off too long, for the mites enter the leaves when these are just nicely opened and still very small. Once under the surface of the leaf the mite cannot be reached. Every twig and bud should be covered carefully, as the mites winter under the protection of the bud scales.

PEAR PSYLLA.

(Psylla pyricola, Forsh.)

The Pear Psylla (see Fig. 12) is another very small insect, being not more than about one-tenth of an inch in length. Its wings are clear, large and much longer than the body, which, as seen by the naked eye, is blackish to brown in colour. When one approaches near an adult, it will usually fly off to another leaf or part of the tree. The presence of the Psyllas on a pear tree can easily be determined by looking to see whether there is any clear, sticky liquid anywhere on the leaves. This substance is known as honey-dew and is secreted in great abundance if the insects



Fig. 11.—Blister Mite on leaf of apple and pear.

are present in large numbers. The young Psyllas are tiny, pale-colored, curious-looking creatures, with conspicuous red eyes, and with scarcely any resemblance to the adults. A hand lens will enable one to see them in these drops of honey-dew. A fungus grows in the honey-dew after a time and causes the parts where it is to turn black and very unsightly. The Psyllas pass the winter in the adult stage in any good hiding place on or near the tree, and come out with the warm spring weather and lay

their little yellowish eggs on the twigs before the buds have burst. The eggs begin to hatch about the time the leaf buds are bursting, and soon after the leaves are out the adult insects die. There is more than one brood in a year. Every few years we have a severe outbreak of the Pear Psylla, and much damage is done, but Ontario is seldom so severely troubled by this pest as New York or some of the neighbouring states. Natural forces seem to keep it well under control most years.

Treatment: Ordinarily the Psyllas can be kept in check by a very thorough spraying of lime-sulphur of about the strength of 1.030 sp. gr. This spraying should be done just after the leaf buds have burst in spring, but before the blossom buds have done so or the leaves have unfolded. Prof. Parrott, of Geneva, and his assistant, Mr. Hodgkiss, have proven that this wash, if thoroughly applied, will not only kill the young insects that have already hatched out, but also most of the eggs, which are by this time nearly ready to hatch. Freshly laid eggs are not destroyed by the wash, nor are the adult Psyllas. It would, therefore, seem wise for fruitgrowers to leave their pears to the last to be sprayed. If necessary



Fig. 12.—Pear Psylla, adult, greatly enlarged. The small cross beneath shows natural size. (After Marlatt.)

the lime-sulphur spray may be supplemented by an application of Black Leaf 40 as soon as the leaves have unfolded. This is a tobacco wash and can be secured in small packages from the Kentucky Tobacco Product Co., Louisville, Ky. Half a pound of it is sufficient for 40 gals. of water. It is seldom, however, that it is needed in Ontario for the Psylla.

APHIDS.

Most kinds of fruit trees are attacked in the early part of the season and again towards the end of it by aphids. These are very destructive some years, causing the leaves to curl and turn yellow, and dwarfing the fruit, which often, in the case of apples, hangs in small clusters that ripen prematurely and are worthless. The winter is passed in the egg stage, the eggs of most kinds being small, black and glistening, and laid on the smaller branches and twigs. They usually hatch about a week before the buds open.

Treatment: It is claimed by many that lime-sulphur will kill these eggs. The writer has several times tried to destroy them with it, but never with much success. He has also tested the wash on the freshly-hatched aphids, but has not been able to kill more than 50 per cent. of them by the most careful work. During the last spring many of the most enthusiastic advocates of lime-sulphur as a remedy for aphids were forced to change their opinion as to its merits against this pest. Fortunately for our fruitgrowers, weather conditions and natural enemies usually prevent very serious injury from aphids. Where it is necessary



Fig. 13.—*Chermes abietis*. Spruce Gall-louse, found chiefly on Norway spruce.

to spray for them, Black Leaf 40 applied as soon as the insects are noticed to be abundant is probably the best mixture we can use. Some experimenters claim that the Black Leaf 40 can be added to the lime-sulphur without injury to the tree or to the value of either wash. It was planned to test this mixture last spring, but unfortunately the Black Leaf did not arrive in time. Fruitgrowers should experiment with the combined mixture on a couple of badly infested trees applying the spray just as the buds are ready to burst, as the eggs will be hatched by this time. It is the young insects and not the eggs that we should aim to kill.

RED SPIDER

(*Tetranychus bimaculatus.*)

In dry seasons tiny, pale or reddish-coloured spiders, by working on the under side of the leaves and sucking the juices from them, cause the foliage to become blotched and reddish and the plants to be greatly weakened. The injury is often most conspicuous on currant and raspberry bushes.

Treatment: Spray the plants well from beneath with lime-sulphur, strength 1.008 or 1.009 sp. gr., whenever the spiders are noticed to be present. Repeat if necessary in about a week or ten days.



Fig. 14.—*Chermes similis*. Spruce Gall-louse, found chiefly on white spruce.

SPRUCE GALL LOUSE.

(*Chermes abietis*, Linn.)

We have two very destructive gall lice attacking spruce trees in Ontario: *Chermes abietis* and *Chermes similis*. The photographs show the difference between them. The former is found most commonly on Norway Spruce, and the latter is almost or possibly altogether confined to White Spruce.

Treatment: About three years ago Mr. J. W. Smith, of Winona, Ontario, discovered that lime-sulphur of the ordinary spring strength of



Fig. 15.—Apple Scab on fruit.

1030 sp. gr. would thoroughly control *Chermes abictis*. The spray must be applied before May, as the eggs are laid soon after this, and it will not kill these. Since Mr. Smith's discovery the writer and several others



Fig. 16.—Apple Scab on leaf.

have tried the lime-sulphur and found it quite satisfactory for this species. It will not, however, control *Chermes sanilis*. For this species we have not yet been able to find a really satisfactory remedy.

DISEASES THAT CAN BE CONTROLLED BY THE LIME-SULPHUR WASH.

APPLE SCAB.

(*Venturia inequalis* (Cke.) Aderh.)

Apple Scab or Black Spot of the apple is a disease that every grower is familiar with. It attacks the leaves as well as the fruit (see Figs. 15 and 16). In seasons that are wet or foggy at the time when the blossom buds are bursting and for a week or two later, it is much worse than in seasons that are dry and sunny at this time. It is also worse where wind-breaks or other causes prevent a good, free circulation of air through the orchard, or where the trees are so close together that the sunlight is shut out from the lower branches. Fameuse, McIntosh Red and a few other varieties are regularly much more subject to the disease than the rest of our apples. This disease, by getting on the stems of the young forming fruit, is often the cause of considerable dropping of apples.

Treatment: Usually in Ontario two thorough applications of lime-sulphur will completely control the disease. The first should be just as the buds are beginning to burst, as this is the time the scab is starting to spread rapidly through the orchard. Use lime-sulphur, strength 1.009, for this. The second must be at once after nearly all of the blossoms have fallen. (This is the same time as the Codling Moth spray. For this use lime-sulphur, strength 1.008. In moist localities, such as along the St. Lawrence valley, another spraying with the same strength of lime-sulphur about two weeks after the second should be given.

Occasionally we have very moist weather conditions in August and a late attack of Scab. This, however, happens only very rarely. An extra spraying under such conditions would, of course, be very valuable.

Good pruning and the removal of unnecessary wind-breaks to allow plenty of sunlight and air help greatly. Apple Scab is not, however, very difficult to control if the spraying is thoroughly done.

Bordeaux mixture may be substituted for lime-sulphur in this case, but will russet the fruit, especially of some varieties. The russetting is much worse some years than others.

BLACK ROT CANKER AND LEAF-SPOT.

(*Sphaeroopsis malorum*, Pk.)

In many orchards of the Province, but especially in the part east of Toronto, numerous cankers or dead areas are to be seen on the branches



Fig. 17.—Black Rot Canker on apple branch.

and trunks of apple trees. These cankers, as shown in Fig. 17, become after a time charred and black. They are caused by the Black Rot fungus, which also attacks the leaves and fruit. On the leaves it causes small, round, dead areas, and on the fruit a firm, not a soft, rot. The diseased fruit at first becomes brown and later black. The disease on the leaves and fruit is seldom very destructive, but on the larger branches and on the trunks it is often serious. The cankers are usually found on varieties that are too tender for the district and so suffer from sun-scald and winter injury. These injured areas and also wounds of any kind make favourable places for the fungus to enter and grow. Having once got a foothold, it usually spreads slowly around the branch or trunk until it encircles it and kills the part above.

Treatment: (1) Plant only hardy varieties well suited to the district; for instance, such varieties as Fameuse and McIntosh Red will thrive in districts where Baldwin, Greening or King will die.

(2) Keep the trees thrifty by cultivation or by mulching in the early part of the season, but do not cultivate later than the middle or end of June in cold districts. Then sow a cover crop and harden up the wood in this way for winter.

(3) On trunks or large branches cut out with a draw-knife the bark over the cankered area, taking pains to be sure that all is removed up to the perfectly healthy bark. Then wash this cut with strong lime-sulphur, or with bluestone (1 lb. dissolved in 12 or 14 gals. water). The undiluted concentrated lime-sulphur will not do any harm, but may be diluted a few times if desired. After washing, cover the wound either

with coal-tar or with white lead free from turpentine. Do the cutting out before the spraying begins in the spring.

(4) Spray the trees at the regular times indicated in the Spray Calendar, page 40, using the strengths indicated there. When spraying, be careful to see that the trunk and main branches are covered.

PEAR SCAB.

(*Venturia pirina*, Aderh.)

Pear Scab (see Fig. 18) resembles Apple Scab very closely, and, like it, attacks the leaves as well as the fruit. It is often found also on the twigs. Some varieties, especially Flemish Beauty, are very subject to it.



Fig. 18.—Pear Scab on fruit.

Its general habit of growth and the conditions that favour it are very similar to those mentioned under Apple Scab.

Treatment: The writer has controlled it completely on Flemish Beauty trees by four applications of lime-sulphur; the last of these might probably have been omitted. Spray at the times and with the strengths indicated in the Spray Calendar.

PEACH LEAF CURL.

(*Exoascus deformans* (Beck) Fuckel.)

Every peach grower is familiar with this disease and knows that it attacks the leaves early in spring and causes them at first to become thickened, curled and distorted, and of a pale whitish or often reddish

colour, and later on to become brown and dead and fall off. (See Figs. 19 and 20.) It is, next to Yellows and Little Peach, the most destructive disease that peach growers in Ontario have to combat. The loss takes the following forms: (1) In seasons of severe attack many young nursery trees are killed the first year they are set out before they have had a chance to get over the shock of transplanting. (2) There is a great drain on the vitality of the older trees from the loss often of a large part of their foliage early in the season and the necessity of producing a new



Fig. 19.—Peach Leaf Curl.

crop of leaves. Such trees are frequently not properly matured for winter and are sometimes killed by the cold. Trees severely attacked two or three years in succession not infrequently die, or at least lose a number of their branches. (3) The fruit is dwarfed, and often, in severe cases, drops off. This is to be expected from the fact that the food that makes the fruit is nearly all manufactured in the leaves, and that this source

of supply is cut off for a considerable period by the disease. (4) The disease often attacks young shoots or twigs and kills these.

Leaf curl is well known to be not so severe some years as others. Experience has shown that it is favored by damp, late springs, while it is almost completely kept in check by dry, sunny weather around the time of blooming and while the leaves are still quite small. In the year 1910 the spring was very late, cold and wet, and so the disease was exceptionally severe. Last year, 1911, the spring was early and we had beautiful, hot, sunny, dry weather, with the result that there was no Leaf Curl, or almost none.



Fig. 20.—Peach Tree almost defoliated by Leaf Curl.

Treatment: Spray with lime-sulphur, either old home-boiled or concentrated, of the same strength as for San José scale. This application must be made *early in spring and before the buds have begun to swell*. The disease apparently begins with the growing bud, so to prevent its getting a start we must spray early before the spores around the buds can germinate. *Most of the failures to control the Leaf Curl are due to spraying too late and not taking sufficient pains to see that every bud is thoroughly covered.* Bordeaux would also control the disease, but is not recommended, because in most peach districts San José scale is either present or likely to be introduced, and the lime-sulphur will keep it in check, while Bordeaux will not.

BROWN ROT OF THE PEACH.

(*Sclerotinia fructigena* (Pers) Schroet.)

This is the same disease that is so common on plums and cherries. Fortunately it is not so destructive, as a rule, in our province to peaches as to cherries and plums, or as it is to peaches in some parts of the United States, where it has been known to destroy as high as 40 per cent. of the whole crop in a year. Nevertheless we sometimes lose a good many peaches from this rot. Triumphs and a few other varieties are much more subject to the disease than Libertas and some of our other more profitable kinds.

Not only is the fruit attacked, but also the twigs and small branches on which diseased fruit is borne. The disease in such cases seems usually to work its way down from the infested fruit into the twig or branch and gradually girdle it. This, of course, causes the part above with all its leaves to die.



Fig. 21.—Mummied plums and peach due to the Brown Rot. About one-half natural size.

Like most diseases, there are certain conditions that favor the development of Brown Rot. The chief of these are damp, warm weather, lack of sunlight and of good air circulation, the presence of old mummied fruit on the trees, two or more fruits touching one another on the tree, and injuries from hail or biting insects, like the Plum Curculio.

Treatment: The above conditions favoring the disease give us hints as to how we may help to ward it off. (1) Give the trees plenty of sunlight and good air circulation by removing unnecessary windbreaks and

by judicious pruning. (2) Knock all old mummied peaches and plums off the trees in the fall and either gather and burn them or plough them under early in spring. (3) Thin the peaches so that no two will be touching one another. (4) Spray with lime-sulphur for Leaf Curl and this will protect the blossoms from attack. (5) If the Curculio is troublesome, spray with 2 or 3 lbs. of arsenate of lead to 40 gals. of water soon after the fruit is set, and remove all rubbish and thickets from around the fence corners, as the beetles winter in such rubbish. (Two or three pounds of freshly slaked lime may be added to each barrel of the spray mixture as a safeguard against burning.) (6) Spray with self-boiled lime-sulphur about a month or five weeks before the fruit is ripe. Bordeaux or commercial lime-sulphur is often injurious to the foliage, even when used very weak.



Fig. 22.—Peach Scab. Note the small blackish spots and the cracks in the fruit.

PEACH SCAB OR BLACK SPOT.

(*Cladosporium carpophilum*, Thüm.)

This disease causes small blackish spots here and there over the surface of the fruit. Sometimes these are very abundant and disfigure the fruit greatly; occasionally a fruit is so badly attacked that it cracks open in the same way as a Flemish Beauty pear does when attacked by Pear Scab. (See Fig. 22). As a rule, this is not a very destructive disease in Ontario.

Treatment: Spraying with the self-boiled lime-sulphur about a month after the fruit is set will usually control this disease quite satisfactorily, as shown by the experiments of Professor Scott, of Washington, D.C.

BROWN ROT OF PLUMS AND CHERRIES.

(Schlerotinia fructigena (Pers) Schroet.)

As mentioned above, this is the same disease as attacks the peach. It is frequently very destructive. The conditions that favour the disease on these fruits are the same those mentioned under Brown Rot of the Peach.

Treatment: As in the case of the peach, the trees should receive plenty of sunlight and good air circulation. Old mummies should be knocked

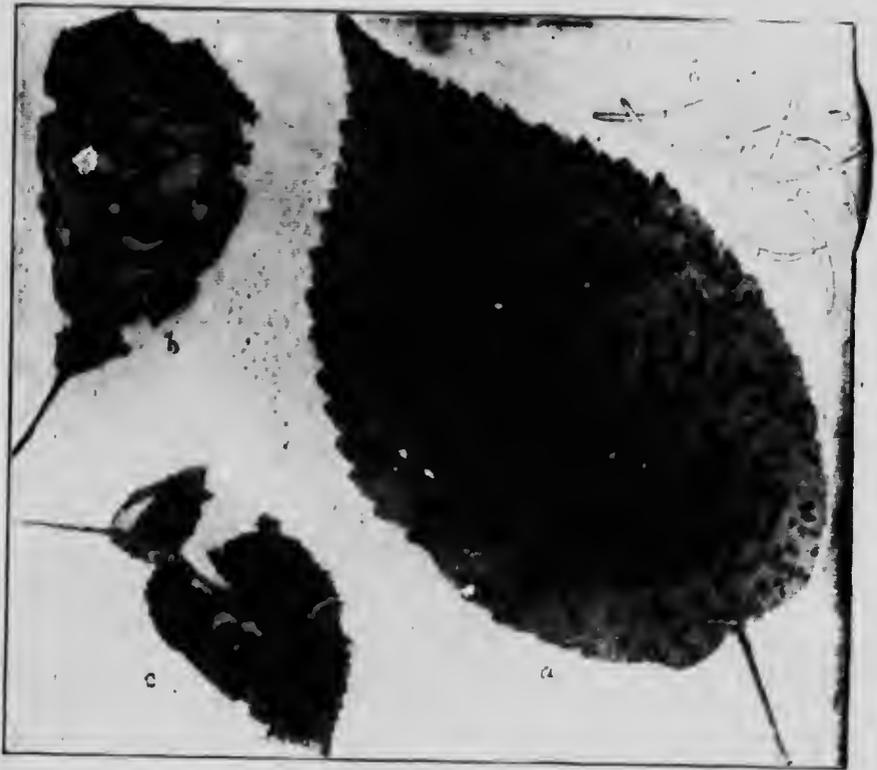


Fig. 23.—Leaf Blight or Shot-hole Fungus of cherry and plum.

off in the fall and either gathered then or ploughed under early in spring. In addition the trees should be sprayed thoroughly at least three times and with the mixtures indicated in the spray calendar. It would be better to spray plums again as late before picking as it is safe to do so without discoloring the fruit.

Whether lime-sulphur is as good a fungicide for plums and cherries as Bordeaux mixture is still in doubt. Some who have used it advocate it

very strongly; others say that Bordeaux is decidedly better. The writer has not had a chance to make a comparative test of the two mixtures, nor have any of the plant pathologists with whom he has talked. It is probable that for Japanese plums and possibly for sweet cherries Bordeaux will prove the better, except for the application before the buds have burst, when lime-sulphur, of the ordinary spring strength, should be used.

LEAF BLIGHT, OR SHOT-HOLE FUNGUS OF CHERRY AND PLUM.

(*Cylindrosporium padi*, Karsh.)

This disease causes small dead areas of varying size on the leaves of cherry and plum. Frequently these dead parts drop out, leaving little round holes as if the leaves had been riddled by shot. Some seasons cherry orchards in certain localities are almost defoliated. Plums are seldom so severely injured.

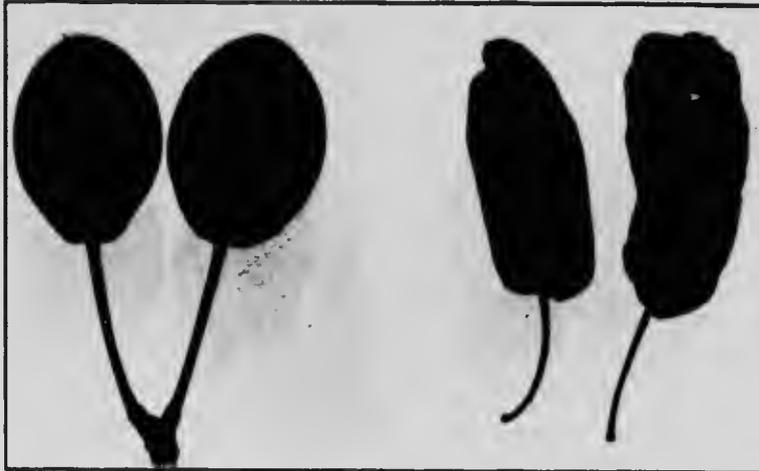


Fig. 24. Plum Pockets or Bladder Plums. The fruit on the left is healthy, that on the right diseased.

Treatment: The ordinary spraying of plums and cherries, as given in the spray calendar helps to control the disease, but sometimes it is necessary to spray again as soon as the cherries have been picked. Either lime-sulphur or Bordeaux may be used, as indicated in the calendar.

PLUM POCKETS, OR BLADDER PLUMS.

(*Euvoscus pruni*, Fuckel.)

Frequently one finds plums, especially of the American variety, that are abnormally large compared with healthy plums, and that turn first

whitish and then light brown or fawn. (See Fig. 24.) When these are squeezed they are soft, and, if opened, are seen to have no kernel. Such a condition is caused by a fungus disease. Damp, cold springs seem to favor its development.

Treatment: This spring the writer sprayed four trees in April before the buds had begun to swell, with the ordinary spring strength of lime-sulphur, and left a dozen or more as checks. On the sprayed trees all the fruit was sound, and on the unsprayed approximately 50 per cent. was diseased. The wind blew some spray over upon some branches of



Fig. 25.—Powdery Mildew of gooseberry. (After close.)

a few trees very close to the sprayed ones; these branches had very few diseased fruits. It seems clear, therefore, that Plum Pockets can, in the same way as Peach Leaf Curl, be controlled by an early spring application before the buds begin to swell.

POWDERY MILDEW OF THE GOOSEBERRY.

(*Sphaerotheca mors-uvae* (Schw. B. & C.)

This mildew attacks the leaves, twigs and fruit of the gooseberry, and sometimes also of the currant. (See Fig. 25.) The parts affected are at

first covered with a white, powdery substance, but later this becomes brown and tough or felty in appearance, causing much damage to the plants and ruining affected berries. It is especially destructive to European varieties.

Treatment: Spray with lime-sulphur, either the old home-boiled (20-15-40) formula) or the concentrated (strength 1.030 sp. gr.) before the buds burst in spring. Give a second application with the concentrated (strength about 1.009 sp. gr. or a little stronger) just before the blossoms open, and a third with the same strength as soon as the fruit is set. Some seasons it would be well to give a fourth application about ten or twelve days after the third.



Fig. 26.—Currant Leaf-spot.

CURRANT LEAF-SPOT.

(*Septoria ribis*, Desm.)

This disease will easily be recognized from the photograph. It is very common in most currant plantations and does considerable damage to the bushes.

Treatment: Spray in the same way as just indicated for gooseberries, but giving only the first three applications. After the fruit is picked a fourth application should at once be given. This treatment will also help to prevent injury from Red Spider.

CONCLUDING REMARKS.

The strength of lime-sulphur recommended for use on the various fruit trees and shrubs after the foliage has appeared is weaker than that recommended by most plant pathologists and entomologists. Most of these recommend for these applications a strength of 1.010 specific gravity, which is just one-third of the spring strength before or as the buds are bursting recommended by the writer. Any who wish to use this strength instead of 1.009 or 1.008 can determine the proper amount of dilution to obtain it by following the same rule as given above; namely, take the specific gravity reading of the concentrated wash and divide the last three figures of it by 10, and the number thus obtained will be the number of gallons to which each gallon of the concentrated must be diluted with water to give a strength of 1010. For instance, suppose the reading is 1.230 sp. gr.; divide 230 by 10 = 23; hence each gallon may be diluted to 23. If a Baumé hydrometer is used, consult the table on page 13, and see what specific gravity reading given there in the first column corresponds to your reading on the Baumé scale, and then, having found this, apply to it the rule just mentioned to get the proper dilution.

The writer has found in his experience, and knows that the experience of many others agrees with his, that the strengths he has recommended in this bulletin and in the spray calendar will give satisfactory results if the work is done thoroughly. He is strongly in favour of very thorough spraying, and the strengths recommended permit a tree even to be drenched without any appreciable injury to the foliage. There is more danger of damage from the stronger spray (1.010 sp. gr.) if heavy spraying is done. Pears are more subject to injury than apples.

Anyone who watches the average man spraying must admit that the work is seldom done thoroughly, either because the man is anxious to get it done quickly, or else because he wishes to be economical. Some are misled by the old rule to stop spraying as soon as the leaves begin to drip. This is not a safe rule to follow in most cases. *A tree should never be left till every leaf and fruit or part aimed at has been thoroughly covered, even though in doing so the mixture may be dripping upon the ground like rain.* There is a wonderful difference between thorough spraying and only half spraying; one pays many times over; it is doubtful whether the other pays at all.

Another matter likely to be overlooked in spraying is the necessity of keeping the mixture well agitated, so that it may all be of uniform strength. Lime-sulphur and arsenate of lead combined require very frequent agitation. Get good nozzles; large disk nozzles like those shown in the figures are very good. Renew the plates when the holes get worn too much. Keep the spray machine in good shape. Use as strong pressure as you can conveniently get. Spray at the times indicated in the spray calendar. Do thorough work. Every evening, after the spraying is over, pump a couple of pails of clean water through the nozzles to clean out all the mixture. This will save a lot of trouble from clogging.

ACKNOWLEDGMENTS.

In his study of the lime-sulphur wash and the various uses to which it may be applied, the writer has received many very valuable suggestions



Fig. 27.—A good type of nozzle and an elbow to control the direction of the spray.

from the publications of several investigators in the United States. Those to whom he is specially indebted are Prof. John P. Stewart, of Centre County, Pennsylvania; Prof. L. L. Van Slyke and his assist-



Fig. 28.—Angle nozzles, very convenient, especially in spraying for Codling Moth.

ants, Geneva, N.Y.; Prof. Erret Wallace, formerly of Cornell University, N.Y., but recently transferred to Washington, D.C., and Prof. W. M. Scott, of Washington, D.C.

SPRAY CALENDAR.

BY L. CAESAR, O. A. C., GUELPH.

PLANT & PEST.	1ST APPLICATION.	2ND APPLICATION.	3RD APPLICATION.	REMARKS.
APPLE Scab or black spot, canker, leaf spot, codling moth and other biting insects, scale insects, blister mite and aphids.	Shortly before the buds burst. Use A1 or B.	Just before the blossoms open. Use A2 or D with a poison.	Immediately after the blossoms have all, or nearly all, fallen, and before the calyces close. Use A3 or D with a poison. This is the application for codling moth.	Cut out, disinfect and paint or cover with coal tar cankered areas on trunks and large branches. In moist climates, or if the weather is wet or foggy, give a 4th application with A3 or D for Scab about two weeks after 3rd. See if aphids are present just before leaf buds burst; if so, spray at once with Black Leaf 40, or kerosene emulsion, or whale oil soap.
PEAR Scab or cracking, blight, codling moth, other biting insects, scale insects, blister mite, psylla and slugs.	Shortly before the buds burst. Use A1 or B.	Just before the blossoms open. Use A2 or D with a poison.	Just after blossoms have all fallen. Use A3 or D with a poison.	Cut out and burn blight as soon as seen, cutting always one foot or more below diseased areas. Disinfect tools after each cut. In moist or in foggy or wet weather give a 4th application of A3 or D about two weeks after 3rd. For Psylla, spray thoroughly with A1 or B just after buds burst, or with Black Leaf 40 just after the leaves open. For slugs spray with arsenate of lead or dust fresh air-slaked lime over the leaves.
PLUM & CHERRY Black knot, brown rot, leaf blight or shot-hole fungus, curculio, slug and aphids.	Just before the buds burst. Use A1 or B.	Just after fruit is set. Use A2 or D with a poison.	About two weeks later. Use A3 or D with a poison.	Watch for black knot, and whenever seen cut out well below diseased area and burn. If leaf blight is troublesome, give a 4th application with A3 or D as soon as fruit of cherry is picked. Destroy unmimed plums in autumn. Look for aphids just before buds burst, and if present spray at once with Black Leaf 40 or kerosene emulsion or whale oil soap. Treat slug as on pear.

SPRAY CALENDAR—Continued.

PEACH

Leaf-curl, scab or black spot, brown rot, yellows, little peach, curculio, borer, San José scale, shot-hole borer.

Before the buds begin to swell. (All must be done before sign of bursting of buds). Use A1 or B.

Just after fruit is set. (All use arsenate of lead alone any with water for curculio.

About one month after fruit is set. Use C.

If Brown rot is likely to be troublesome use C again about one month before fruit ripens. Destroy unmined fruit in autumn. Remove at once and burn any tree attacked by yellows or little peach, and also all suspected trees. Dig out borers at base of tree with knife in May, and again in October. For shot-hole borer cut down and burn before April all dead or dying trees or branches, and leave no brush heaps near orchard.

GRAPES

Black rot, powdery mildew, downy mildew, anthracnose, flea-beetle, thrip or leaf hopper.

When 3rd leaf is appearing use D.

Just before the blossoms open use D.

Just after fruit sets, use D.

Spray again whenever wet weather threatens. It should always be done *before*, not after rain. At first sign of powdery mildew dust with sulphur or spray with C. For flea-beetles use poison whenever they appear. For leaf-hoppers or "thrips" use Black Leaf 40 or kerosene emulsion or whale oil soap in July, to destroy nymphs. Clean cultivation is very important, and destruction of all old unmined grapes and prunings.

CURRANT & GOOSE-BERRY

Shortly before buds burst use A1 or B.

Just before blossoms appear, use A2 with poison.

Just after fruit is formed, use A2 with poison.

For worms, when fruit is ripening, use hellebore. Look for aphids just before buds burst; if present, spray with Black Leaf 40 or kerosene emulsion or whale oil soap. Of little use to spray, for these after leaves curl.

RASPBERRY & BLACKBERRY

Anthracnose, red rust, crown gall.

Before growth begins use A1 or B.

When shoots are 6 or 8 inches high. Use D and add poison for caterpillars are present.

If anthracnose is very severe, set out new plantation of healthy shoots. If disease begins, cut out old canes as soon as fruit is picked, also badly attacked new ones, and burn. For red rust remove and burn plants at once. No other remedy. For crown gall set out plants in fresh soil, rejecting any plant with a gall on root or crown.

STRAWBERRY
 Leaf-spot and white grub.
 For leaf spot set out only healthy plants with no sign of disease. First season spray with D before blossoms open and keep plants covered with mixture throughout the season. Second year spray before blossoming with D, and again soon after picking; or mow and burn over after picking. Don't take more than two crops off. Plow down at once after second crop. For white grubs dig out as soon as injury is noticed. Do not plant on land broken up from old meadow or pasture for three years after breaking.

BEAN
 Anthracnose and bacterial blight.
 Get seeds from pods showing no signs of disease. Do not work among the plants if they are wet with rain or dew. Spraying scarcely pays as a rule.

CABBAGE & TURNIP
 Flea-beetles, caterpillars, root maggots, aphids.
 For flea-beetle on turnip sow after June 21st, or dust plants as soon as they appear above ground with Paris Green, or spray with Bordeaux and a poison. Repeat in two or three days. For caterpillars dust with Paris Green until heads begin to form on cabbage and cauliflower, then spray with catnip-pyrethrum, 1 ounce to 2 gallons water. For root maggots use medium thick tarred felt paper discs, putting on as soon as plants are set out, or set out plants after July 1st. For aphids use kerosene emulsion as soon as they appear.

POTATO
 Tip burn, early blight, late blight, scab, Colorado beetle, flea-beetle, tubers.
 Keep foliage covered with D from time plants are about 5 inches high. Take special precautions to see this is well done if weather is at all damp after about 15th July, as late blight begins about this time. Add a poison to each application when necessary. For scab, soak tubers before cutting 2 hours in formalin solution, 1 pint of formalin to 30 gallons of water. Spread out on grass to dry. Wash all boxes, bags or other vessels to be used in same liquid. Plant none but perfectly healthy tubers.

TOMATO
 Leaf blight, black rot, fruit, flea-beetle.
 Spray plants in seed bed with D. Keep foliage in field covered with D until danger of staining flea-beetle.

ASPARAGUS.
 Rust, beetles.
 For rust, let no plants, not even wild ones, mature during cutting season. Late in fall, when growth is about over, cut and burn old plants. For beetles let poultry run in the plantation. After cutting season is over spray with arsenate of lead; repeat in two weeks. May add sticker and a little lime.

NOTE.—A1—Concentrated lime-sulphur, strength 1.030 specific gravity (1.032 for San José scale).
 A2—Concentrated lime-sulphur, strength 1.099 specific gravity.
 A3—Concentrated lime-sulphur, strength 1.008 specific gravity.
 B—The old home-boiled lime-sulphur, 20.15.40 formula.
 C—Self-boiled lime-sulphur.
 D—Bordeaux mixture, 4.4.40 formula.

FORMULAE FOR INSECTICIDES

I.—POISONS (for biting insects only).

- 1.—**ARSENATE OF LEAD**—Two lbs. to 40 gallons liquid spray; 3 lbs. for potato beetles.
- 2.—**PARIS GREEN**—(a) $\frac{1}{4}$ to $\frac{1}{2}$ lb. to 40 gals.; 1 lb. for potato beetles. If used with water alone, add 1 or 2 lbs. fresh lime. (b) 1 lb. mixed with 50 lbs. land plaster, air-slaked lime or some similar substance, for dusting on plants. (c) Poisoned bran, mix 1 lb. Paris Green with 50 lbs. bran moistened with sweetened water. Scatter in evening on soil by plants for cutworms.
- 3.—**ARSENITE OF LIME**—Boil 1 lb. white arsenic and 1 lb. sal soda (crystals) with stirring for about 15 minutes in 1 gal. water till all the arsenic is dissolved, then add 2 lbs. stone lime and let slake in boiling liquid. Add water to make up for what has evaporated. One quart of this when well stirred is sufficient for 40 gals. spray liquid. Arsenite of lime can be made in large quantities and stored. Label barrel "poison," and be careful to keep white arsenic itself labelled "poison." Keep barrel covered to prevent evaporation. Stir well before using. N.B.—With Bordeaux, 1, 2 or 3 may be used; with commercial lime-sulphur, 1; the others cause burning.
- 4.—**WHITE HELLEBORE**—One oz. to 2 gals. water, or dust undiluted over the plants. For root maggot dust close to plants, or pour around roots.

II.—CONTACT POISONS (chiefly for sucking insects).

1.—KEROSENE EMULSION.

Kerosene (Coal Oil)	2 gals.
Rain Water	1 gal.
Soap	$\frac{1}{2}$ lb.

Dissolve the soap in water by slicing and boiling; take from fire, and while hot pour in kerosene and churn vigorously for five minutes. For use dilute with 9 parts of water, so that the above 3 gals. of stock emulsion will make 30 gals. of spray mixture.

- 2.—**WHALE OIL SOAP**—For brown or black aphids, 1 lb. in 4 gals. For green aphids, thrip and leaf-hopper, 1 lb. in 6 gals.
- 3.—**TOBACCO WATER**—Boil 1 lb. refuse tobacco in 2 gals. of water for 1 hour, make up for water that evaporates.
- 4.—**Black Leaf 40**, made by Tobacco Product Co., Louisville, Kentucky.
- 5.—**PYRETHRUM** (or insect powder).

Pyrethrum Powder	1 oz
Water	2 to 3 gals.

Dry mixture, mix thoroughly 1 part by weight of pyrethrum with 4 of cheap flour, and keep in air-tight vessel for 24 hours before dusting over plants.

Note: Pyrethrum is useless if left exposed to the air.

- 6.—**LIME SULPHUR WASH**. (See under fungicides.)

FORMULAE FOR FUNGICIDES

I.—BORDEAUX MIXTURE.

Copper Sulphate (Bluestone)	4 lbs.
Unslaked Lime	4 lbs.
Water	40 gals.

Dissolve the copper sulphate in a wooden or brass vessel with hot water, pour into a barrel and add cold water to make 20 gals.; slake the lime, preferably with hot water; add cold water to make 20 gals. Stir both barrels well, and pour lime into the copper sulphate barrel. (Never mix concentrated milk of lime and copper sulphate solutions.)

A stock solution of each may be made and kept indefinitely if not mixed. Dissolve 40 lbs. copper sulphate in 40 gals. of water by suspending just below the surface of the water in a coarse sack. Each gallon of the liquid will now contain 1 lb. copper sulphate. Slake any desired quantity of lime and put into a box or barrel in shaded place, or sunk in the ground. Keep covered with small amount of water to exclude the air. Calculate how much is required for 4 lbs. lime if well stirred.

To test Bordeaux mixture, let a drop of ferro-cyanide of potassium solution fall into a little of the mixture in a saucer when ready. If this causes it to turn reddish brown, add more lime until no change takes place.

II.—LIME SULPHUR WASH. Consult Index to find any heading desired.

III.—DISINFECTANTS (for pruning tools and for wounds on trees).

- 1.—One pint formalin diluted to 2 gals. with water.
- 2.—Corrosive sublimate, 1 part to 1,000 by weight = 1 tablet to 1 pint of water. Apply with a swab on end of a stick.
CAUTION.—Corrosive sublimate is a deadly poison to man or beast if taken internally. It will also corrode iron or metal, so use in a glass or wooden vessel, and be sure to wash these out very thoroughly when through using them.
- 3.—Lime sulphur about twice spring strength, or Bluestone, 1 lb. dissolved in about 14 gals. water, may be used to disinfect wounds or cankers, but is not satisfactory in case of Pear Blight.

STICKER.

Resin	2 lbs.
Sal Soda (crystals)	1 lb.
Water	1 gal.

Boil together till a clear brown color which takes from 1 to 1½ hours. Cook in an iron kettle in an open place. Add the above to 40 gallons Bordeaux for use on smooth foliage like onions, cabbage or asparagus. If used with arsenate of lead, Paris Green, or arsenite of lime, add 1 or 2 lbs. of fresh lime to every 40 gallons of spray.

