SOME COMMON SPRAY MIXTURES

BY O. S. WATKINS
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SOME COMMON SPRAY MIXTURES

The protection of fruit trees from the ravages of fungous diseases and insect pests by spraying is no longer an experiment. No phase of horticultural activity is attracting more attention today than the proper use of fungicides and insecticides, since the quality of the fruit which is placed upon the market is determined largely by the character of the spraying which has been done.

FUNGICIDES

A fungicide is a preparation which has for its active agent some chemical in which the development of fungous spores is retarded or prevented. It is generally applied with water, which serves as a distributing agent for the active ingredient. Fungicides are designed to control such diseases as apple scab, apple blotch, bitter rot, brown rot, and many other fungi of a similar nature.

BORDEAUX MIXTURE

Bordeaux mixture is the standard fungicide for most of the diseases injurious to orchard and garden crops. It is made from copper sulfate and lime, and was introduced into this country from Europe in 1887 by the U. S. Department of Agriculture. The original formula has been modified somewhat, and the mixture giving the best results today is one made from—

4 pounds of copper sulfate
4 pounds of lime
50 gallons of water.

SMALL QUANTITIES

When the small home orchard composed of only a few trees is to be sprayed, the equipment should consist of a 50-gallon barrel, two tubs of at least 25 gallons capacity, two buckets and a paddle. Arrange the tubs so that one is on either side of the barrel. Place in one of the tubs 25 gallons of water, and dissolve in it 4 pounds of copper sulfate by suspending it in a coarse sack just below the surface of the water. About one hour should be allowed for this; but if hot water is available, the copper sulfate can be dissolved in a small
quantity in much less time, and then diluted to 25 gallons with cold water. In the other tub carefully slake 4 pounds of stone lime, using only sufficient (hot) water to have the lime, when thoroly slaked, in the form of a thick paste, in which form it should be allowed to cool. When cold, dilute to 25 gallons. The copper sulfate and milk of lime are now ready to mix, two persons being necessary for the operation. Have the contents of each tub well stirred; then pour a bucket of each simultaneously into the barrel, allowing the two streams to come together. Continue in the same way until the entire amount is made. Thoroly agitat e the blue mixture in the barrel, and transfer it thru a strainer into the spray tank. It is now ready for application.

LARGE QUANTITIES

In preparing Bordeaux mixture for use in the large commercial orchard, where spraying is done from one or more 200-gallon tanks, it is customary to make up stock solutions of copper sulfate and lime. This is to avoid delays occasioned by slaking each batch of lime, and dissolving each lot of copper sulfate.

Slaking the Lime.—One of the most important steps in the preparation of Bordeaux mixture is the slaking of the lime, and care must be taken to have this properly done. At least a day before the spraying operations are to begin, slake one or more batches of lime of 50 pounds each by placing the lime in a slaking box or barrel, together with 7 or 8 gallons of water, which is a sufficient quantity to start the action. As soon as the lime begins to slake, it should be continually stirred. More water should be added as needed from time to time to prevent the development of too much heat and the consequent "burning" of the lime. When too small an amount of water is used, the lime crumbles to a powder, with the result that there are many small lumps that do not completely slake, which will be thrown out when the lime is strained into the tank. On the other hand, too much water should also be avoided, for this likewise causes incomplete slaking, and therefore a reduction in the actual amount of lime added to the mixture. Lime, during the process of slaking, should have constant attention, adding only a small quantity of water at a time, so as to keep the action even and insure the lime being perfectly slaked.

When the lime is completely slaked it should be a rather thick paste, in which form it should be allowed to cool. In
slaking lime to be used in the preparation of Bordeaux mixture the paste mass should never be cooled artificially, for if this is done the action is not completed. When the slaked lime is cold, transfer to the stock solution barrel, if a slaking box has been used, and add sufficient water to bring the total volume in the barrel to 50 gallons. This is termed a stock solution, and when well mixed each gallon contains one pound of lime.

_Copper Sulfate Solution._—To prepare the stock solution of copper sulfate, suspend 50 pounds of the blue stone in a burlap sack near the top of a 50-gallon barrel nearly filled with water. Several hours should be allowed for solution to take place. When all of the sulfate is dissolved, bring the total volume in the barrel to 50 gallons. When well mixed each gallon contains 1 pound of copper sulfate.

As several days ordinarily elapse between the different applications, in order to keep the stock solutions at their original strengths the volumes of the material in each of the stock solution barrels should be noted at the completion of each application, and, before any more Bordeaux mixture is made, water should be added to replace that which has been lost by evaporation.

_Making the Mixture._—There are two methods by which Bordeaux mixture can be made in large quantities: one in which an elevated platform is used, and the water pumped by hand; and another in which no elevated platform is necessary, but all solutions are pumped by means of a tank filler.

(1) _With Aid of Elevated Platform._—For the making of large quantities of Bordeaux mixture certain equipment is necessary which will help diminish the labor and avoid waste of time. An elevated platform situated near the water supply is an essential feature. This platform should have two parts, one higher than the other. On the lower part is supported a mixing tank, which has a capacity equal to that of the spray tank, at such a distance above the ground as will allow the delivery of the mixture by gravity to the top of the spray tank driven underneath. On the upper platform there should be two diluting tubs, each of a capacity of at least 100 gallons, several barrels in which the stock solutions of copper sulfate and lime may be kept, and sufficient room for the operator. This upper platform should be at such a height that the two diluting tubs can be adjusted to deliver the solutions together thru a strainer into the mixing tank.
The necessary equipment provided, and the stock solutions prepared, to make 200 gallons of Bordeaux mixture, using the 4-4-50 formula, which calls for 4 pounds of copper sulfate, 4 pounds of lime and 50 gallons of water, proceed as follows: Measure into one of the diluting tubs 16 gallons of the stock solution of copper sulfate; then add 84 gallons of water. In the other tub, place 16 gallons of the well mixed stock solution of lime, and add water to make 100 gallons of diluted lime. There are now 100 gallons each of copper sulfate solution and milk of lime. In mixing, equal streams from each tub should be conducted directly into the strainer supported over the mixing tank. The milk of lime should be stirred continually, so as to have a homogeneous mixture at all times coming in contact with the copper sulfate solution.

(2) Using the Tank Filler.—During the last two or three years manufacturers of spraying machinery have introduced a very convenient device called a tank filler, by use of which all the water used in making spraying preparations can be pumped by the gasoline engine. To make 200 gallons of Bordeaux mixture, using the 4-4-50 formula, the following is the procedure: Transfer thru a strainer 16 gallons of the well mixed stock solution of lime into the spray tank; then add 84 gallons of water to bring the total volume of the diluted lime to 100 gallons. Next put 16 gallons of the stock solution of copper sulfate into a 100-gallon tub, which may be stationed on the ground, and add water to bring total volume of copper sulfate solution to 100 gallons. Thoroly mix the copper sulfate and water, and with the agitator in the spray tank working thruout the entire process, gradually introduce thru the strainer into the spray tank the copper sulfate solution. The resulting mixture is now ready for use.

**BORDEAUX INJURY**

Altho Bordeaux mixture has proved to be a very superior fungicide, it is far from being an ideal one. During the last few years applications of Bordeaux mixture have frequently caused an injury to foliage and fruit whereby the leaves turn yellow and fall and the apples become russeted. This injury is most common during continued rainy weather, but it has been shown that even then it can be greatly reduced by heeding the following:
1. Using only pure lime, free from all air-slaked particles
2. Using care in slaking the lime
3. Mixing the two solutions together properly
4. Being accurate in all weights and measurements
5. Making applications at the proper times
6. Spraying thoroughly
7. Adhering to directions.

In combining lime and copper sulfate in making Bordeaux mixture, a chemical reaction takes place, and investigations in the laboratory have shown that the composition of the resulting mixture is dependent not only upon the proportions of the materials that are used, but also upon the manner of combining the two. Copper sulfate may combine with varying amounts of lime, the minimum being in the proportion of one pound of lime to about four and one-half pounds of copper sulfate. However, a Bordeaux mixture made after a formula which calls for only one pound of lime to four pounds of copper sulfate, would be dangerous to use, as the lime would soon be leached out by the rains, leaving soluble copper salts on the foliage and fruit, which would likely cause serious injury. The maximum amount by weight of lime which one part of copper sulfate will combine with, is about an equal amount. Experiences in the orchard have shown that the best fungicide results when equal parts by weight of copper sulfate and lime are used. This is no doubt true, because in making a Bordeaux mixture from equal parts of the two salts, as is done in using the 4-4-50 formula, the most stable compound which copper sulfate and lime form, results.

The second factor influencing the composition of the Bordeaux mixture (the manner of combining the two solutions) is of equal if not greater importance than the proportion of each material used. The preceding recommendations are upon the plan of equal and full dilution before mixing, which has been shown by experience to possess advantages over other ways of mixing. Under no conditions should the lime be added to the copper sulfate, either diluted or in concentrated form, nor should the two ingredients be combined in concentrated form and then diluted. By this method of equal and full dilution before mixing, the chemical action between the copper sulfate and lime appears to take place quicker and more completely than by any of the other methods. The resulting mixture settles less rapidly,
is less frequently injurious, and attains a maximum of adhesive
ness.†

Some growers have the mistaken idea that it is possible to
lessen the danger of injury following the use of Bordeaux mix-
ture by still further increasing the amount of lime to an amount
much in excess of an equal weight. Since it is the copper that
causes the injury, it appears that the greater the amount of lime
used the less the amount of copper that can go into solution, but
under Illinois field conditions this does not hold true. An excess of
lime over that amount which will unite with the given amount of
copper sulfate is a detriment, in that it decreases the adhesiveness
of the mixture. This excess of lime, after it is sprayed upon the
trees, soon is converted into calcium carbonate and readily
washes off, carrying with it much of the Bordeaux mixture
which would not otherwise have been removed.

BORDEAUX-ARSENATE OF LEAD MIXTURE

Generally it is found advantageous to combat insects with
the same application that is used against fungous diseases. This
can be very satisfactorily accomplished by mixing the required
amount of arsenate of lead, as prepared according to directions
on page 15, with the diluted lime, just before it is mixed with
the copper sulfate solution.

LIME SULFUR AS A SUMMER SPRAY

Owing to the injury sometimes following the use of Bor-
deaux mixture, growers have been forced to seek a less caustic
fungicide to replace this very superior spray. Lime sulfur solu-
tion, which for a number of years has been the standard ma-
terial for controlling San Jose scale, has been found to possess
some fungicidal properties, and is giving promise, under some
conditions, of taking the place of the copper sprays. This spray
has not given as encouraging results under Illinois conditions as
reported in other states; so growers are urged to not rely entire-
ly upon it until it has been given a more thoro test under vary-
ing conditions.

Of the mixtures made from lime and sulfur that are used
as sprays for the summer treatment of fruit trees, the three fol-
lowing will be considered: home concentrated, commercial, and
self-boiled lime and sulfur mixtures.

†C. S. Crandall, Illinois Agricultural Experiment Station Bulletin 135, page 214.
Home Concentrated Lime Sulfur

Experiments have shown that concentrated lime sulfur solution equivalent in efficiency to the commercial brands can be made by the grower at considerable less expense than the cost of factory-boiled products. Making lime sulfur, however, is a painstaking and disagreeable job; so those who have use for only a few barrels are advised to purchase one of the commercial brands. Growers having several thousand trees to spray will find it quite a saving to prepare their own solution. The cooking may be done either by heating in a kettle directly with coal or wood, or by using steam as the source of heat. The formula by which lime sulfur may be most economically made is as follows:

50 pounds of lime
100 pounds of sulfur
66 gallons of finished solution.

The lime should be fresh stone lime, free from all air-slaked particles, and one that slakes rather slowly. Ground commercial sulfur will prove satisfactory.

Kettle Method.—The first thing that should be provided is a suitable house in which to make the solution, as it will be found quite difficult to control the fire out of doors. For best results two cookers are needed, one in which to cook the lime sulfur and a second to furnish a constant supply of boiling water. This latter cooker is not absolutely necessary, but by its use the actual time of preparation can be reduced almost one-half. There should also be prepared one straight paddle about four feet long, and another paddle about five feet long attached to one end of which is a perpendicular piece the depth of the kettle. The first paddle is to use while the lime is slaking, and the second will be found a convenient form to use after the bulk of the water has been added. A measuring stick, graduated to show the depth of ten, twenty, thirty, etc., gallons, up to the capacity of the kettle, is essential. Accurate weights and measurements are required, so that a reliable pair of scales should be used. These things having been provided, and the materials for making the solution being available, a concentrated lime sulfur solution may be prepared as follows:

Place in the kettle in which the lime sulfur is to be made, 15 gallons of water and start the fire. When the water is hot, put into it 50 pounds of lump lime, free from all air-slaked particles. When the lime is slaking vigorously put into it 100
pounds of sulfur, and mix thoroughly with the lime, adding sufficient water (preferably hot) to keep the mixture in the form of a thin paste. As soon as the lime is slaked and vigorous action has subsided, add sufficient water to bring the total volume of the mixture in the kettle to about 70 gallons. Keep the mixture at the simmering point and stir continually throughout the whole of the operation. The mixture is first of a yellow color and a rather heavy scum of sulfur floats on top. As the action continues, and the lime and sulfur go into solution, the scum disappears, and the color of the solution becomes orange red. If at any time during the process of cooking the mixture threatens to boil over, this can be prevented by throwing into it a small amount of cold water. Occasional measurements should be made with the graduated stick, as the volume of the mixture should at no time be less than 66 gallons, which should be the approximate volume of the finished product. Hot water may be added from time to time, as necessary, to keep up the volume. When it appears that there are no particles of free sulfur and lime present in the kettle, take a dipperful of the mixture, allow it to settle, and then slowly pour the mixture back into the kettle. If there are no balls of sulfur deposited in the bottom of the dipper the mixture has been cooked sufficiently long, and the contents of the kettle should be poured into a container and allowed to cool. When cold, the solution should be strained into the supply barrels and kept as nearly air-tight as is possible.

If hot water has been used to bring the total volume of the mixture in the kettle to 70 gallons, and the other directions carefully followed, complete solution of the lime and sulfur should be obtained with about one-half hour’s cooking. Under these conditions, provided a comparatively pure lime has been used, over 95% of the sulfur should be in solution, and the amount of sludge be less than 1%. The sludge is the dark green matter resembling fine mud which settles to the bottom of the barrel. It consists chiefly of calcium sulfite, a small amount of sulfur, and the insoluble impurities which were present in the ingredients from which the lime sulfur is made. If very much gravel or many particles of unslaked lime lodge on the strainer, this indicates a poor grade of lime and where possible another brand should be tried. The hydrometer should not be used if accurate dilutions are desired, so that care should be taken to have the final volume of each batch of lime sulfur approximately 66 gallons.

**Cooking by Steam.**—Many growers whose orchards require,
the use of a hundred or so barrels of concentrated lime sulfur solution, may find it profitable to equip a steam plant for making it. Either live steam, steam coils, or a jacketed kettle may be used. Since any one of a number of arrangements for cooking lime sulfur by steam is satisfactory, no definite steam cooking plant will be described, but only a few general principles given which apply to all. When live steam is used, it should not be depended upon to stir the mixture, but a mechanical device should be provided. The lime should be slaked in a tub and the sulfur mixed with it before they are put into the receptacle in which the solution is to be made, as the lime and sulfur cannot be thoroly mixed in a barrel. To prevent unnecessary handling of hot lime sulfur solution, the cooking vat should be elevated high enough so that the storage barrels may be filled directly by gravity. With a steam outfit, 260 gallons may very easily be made at one cooking, and unless a jacketed kettle is used, the use of a 300-gallon cask or tank is advised.

Crystallization.—Occasionally a batch of lime sulfur may not be properly made, and crystals form in the solution. When this occurs, strain the solution thru a piece of cheese cloth, and dissolve the crystals by heating with a small amount of the clear solution. Then add the reheated solution to the rest of the barrel.

Dilutions.—Properly prepared solutions made according to the above formula, either by the kettle method or by steam cooking, and diluted 1 in 18, give a spray material 50 gallons of which will contain about 4 pounds of sulfur in solution. This is the dilution which has given the most general satisfaction for the summer treatment of apples. If a spray for use upon the dormant wood is desired (see dormant spraying, page 17) dilute 1 in 5, which gives a spray each 50 gallons of which contains about 15 pounds of sulfur in solution.

COMMERICAL LIME SULFUR

From the first, considerable difficulty accompanied the use of lime sulfur for spraying purposes, since its preparation and application proved such disagreeable work. Under the old formula it was necessary to apply the mixture warm, for as soon as it cooled crystals separated out which lodged in the nozzles, causing considerable annoyance and delay. Naturally, this condition required that each batch of lime sulfur be made up immediately before application. This disadvantage attracted the attention of
manufacturing chemists, who succeeded in compounding a clear, storable lime sulfur solution which, diluted 1 in 11, gave a spray which compared favorably in efficiency with the homemade product. In spite of the high cost of this original commercial product, there was an ever increasing demand for it, and so enticing was the field to other manufacturers that a number of different brands of commercial lime sulfur soon found their way upon the market. Since most of the commercial solutions are quite similar in appearance, it was impossible to tell which solutions would be most effective. Because of this, the Illinois Agricultural Experiment Station collected samples of the different brands of lime sulfur offered for sale in this state and made chemical analyses of them. These analyses showed that there was considerable variation in the sulfur content of the different brands. Therefore, growers who intend to use one of the commercial solutions should purchase nothing but a clear solution, and demand that the number of pounds of sulfur in each gallon or barrel be stated. If this is known, a spray of definite strength can easily be made. For summer spraying, dilute so that each fifty gallons of spray as applied shall contain 4 pounds of sulfur in solution; if a spray of winter strength is desired, dilute so that each 50 gallons has 15 pounds of sulfur in solution. Do not be misled by a guarantee of a certain percent of sulfur, because such a guarantee means very little. Some brands are guaranteed to contain between such and such a percent of sulfur, and the difference in some cases between the different percents permits of a variation of nearly 50 pounds of sulfur per 50-gallon barrel, which is one-third of the total amount. Growers are urged to buy no solution a 50-gallon barrel of which does not contain approximately 135 pounds of sulfur.

**LIME SULFUR-ARSENATE OF LEAD**

Arsenate of lead should always be used with summer strength (4 pounds to 50 gallons) lime sulfur, not only for protection against chewing insects, but also to increase the fungicidal value of the spray. The best results have been obtained when lime sulfur was in combination with the tri-plumbic arsenate of lead. In making 200 gallons of the spray, strain into the spray tank 11 gallons of the home concentrated lime sulfur solution, or that amount of the commercial solution necessary to furnish 16 pounds of sulfur, and dilute to 198 gallons. Start the agitator, and when the lime sulfur and water are uniformly mixed introduce
thru the strainer the required amount of arsenate of lead, prepared as described on page 15.

**SELF-BOILED LIME AND SULFUR**

Self-boiled lime and sulfur is a special spray for peaches and should not be confused with the cooked solutions just described. This spray is a mechanical mixture, and the only heat employed in its preparation is that furnished by the slaking lime. This heat of slaking lime has the faculty of breaking the particles of sulfur into finer divisions than can be accomplished by mechanical means. Extreme care must be exercised in the preparation of this mixture, and the following directions carefully adhered to. The mixture which has proved most satisfactory is one made according to the following formula:

- 8 pounds of lime
- 8 pounds of sulfur
- 50 gallons of water.

A slow slaking lime free from all air-slaked particles should be used. Ground commercial sulfur which contains no hard lumps is satisfactory. Where possible, this mixture should be made in 200-gallon lots, as the heat developed in slaking 8 pounds of lime is hardly sufficient to completely break up the sulfur. The equipment needed for making self-boiled lime and sulfur consists of a smooth-bottomed barrel or tub, a hoe, paddle, buckets and scales. If 200 gallons of the mixture are to be made, place 32 pounds of lime in the barrel or tub with 5 or 6 gallons of water. As soon as the lime is slaking vigorously, put into it 32 pounds of sulfur. The mixture should be constantly stirred, and more water added as needed to form at first a thick paste of the mixture, and finally a thin paste. When the boiling has stopped, and before any red or orange streaks appear in the mixture, add several gallons of cold water to cool the mixture. Strain the cooled mixture into the spray tank, using the paddle to work thru everything that will pass thru the strainer; then dilute to 200 gallons. The mixture is now ready for application. The agitator should be allowed to run a few minutes before starting to spray, and be kept going as long as any spraying is being done, as the mixture settles very rapidly.

**SELF-BOILED LIME AND SULFUR WITH ARSENATE OF LEAD**

It is often desirable to apply arsenate of lead with self-boiled lime and sulfur; and this may be satisfactorily done. After the mixture is all in the spray tank and diluted to nearly 200 gal-
lons, start the agitator and strain into the self-boiled lime and sulfur the required amount of arsenate of lead as specified on page 15.

INSECTICIDES

An insecticide is a preparation used for killing insects. Insecticides are divided into two classes, stomach poisons and contact poisons.

STOMACH POISONS

Stomach poisons are used to combat chewing insects, which live by feeding upon the foliage, fruit or exposed surface of the tree. Under this class of insects may be grouped bud moth, leaf crumbler, canker worm, curculio, codling moth, leaf skeletonizer, tent caterpillar, grasshopper, fall web worm, etc. To control these, the poison is sprayed upon the tree so that it will be taken into the stomach of the insect with its food. The two most common stomach poisons in use today are Paris green and arsenate of lead.

PARIS GREEN

For a number of years Paris green was the most commonly used of all arsenical poisons, and today is the standard treatment for combating insects attacking certain plants. Paris green is copper-aceto-arsenite, and the commercial product should contain at least 50% of arsenious oxide in combination with the copper oxide and acetic acid. Water soluble arsenic is injurious to foliage and fruit and not over 3½% soluble arsenious oxide should be allowed in Paris green used for spraying.

Paris green is usually applied in proportions varying from 4 to 8 ounces for each 50 gallons of water or other spray mixture. The standard Paris green mixture, however, is as follows:

4 ounces of Paris green
½ pound of lime
50 gallons of water.

Carefully slake the lime in a small quantity of water, and dilute the resulting paste with enough water to make a milk of lime which will pour readily. Strain this milk of lime into the spray tank and dilute to 50 gallons. Mix the Paris green in a pint of water in a large bottle, and then pour it into the spray tank. After thorough mixing the material is ready to apply.

Paris green may be used with Bordeaux mixture, but should never be combined with lime sulfur. To apply with Bordeaux
mixture, mix the Paris green with the diluted lime from which the Bordeaux mixture is to be made, before it is brought into combination with the copper sulfate.

**Arsenate of Lead**

During the last few years arsenate of lead has been substituted to a large extent for Paris green, especially for use in spraying apples. It can be purchased already prepared or can be made up by the grower.

*Commercial Arsenate of Lead.*—There are a number of commercial brands of arsenate of lead for sale in this state which vary more or less in composition. Most of these are received in the form of pastes containing about 50% water. This paste is rather thick, and before using must be worked into a thin paste by first adding only a little water at a time, gradually working out all the lumps. In order to keep the arsenate of lead at a known strength, it is advised that it be made into a thin paste of a definite strength as soon as received. A very convenient way is to put 100 pounds of paste as received into a 50-gallon barrel, and work up, using only a little water at a time, until it is of a uniform consistency. When this is accomplished, fill the barrel with water, and a stock solution results each gallon of which when well mixed contains 2 pounds of arsenate of lead. For most purposes, arsenate of lead is used at a rate of 2 pounds for each 50 gallons of water or other spray mixture.

*Homemade Arsenate of Lead.*—Homemade arsenate of lead is usually made from arsenate of soda and acetate of lead, using the following proportions:

\[
\begin{align*}
\text{Arsenate of soda} & \quad 10 \text{ ounces} \\
\text{Acetate of lead} & \quad 24 \text{ ounces} \\
\text{Water (hot)} & \quad 5 \text{ to } 6 \text{ gallons}
\end{align*}
\]

The arsenate of soda should contain at least 50% arsenic oxid, and the acetate of lead at least 50% lead oxid.

Place the salts in separate wooden vessels and dissolve each in 2 or 3 gallons of hot water. When both salts are in solution, pour slowly about 2/3 of the lead acetate into the sodium arsenate, stirring continually. A test should here be made to determine that the lead is in excess, as free sodium arsenate is injurious to foliage. Take half a glass of the clear solution above the white flocculent arsenate of lead and add to it a few drops of a 5% solution of potassium iodid (securable of any druggist;—a four ounce bottle will suffice). If sufficient lead acetate
has been added, as soon as the potassium iodid touches the solution in the glass a yellow compound is formed. If this yellow compound is not formed, more acetate of lead should be added and the test repeated until the lead is in excess.

When all the arsenate of soda has been neutralized by the lead acetate, the mixture should be allowed to settle. When this is accomplished, pour off and throw away the clear solution above the white arsenate of lead, the remaining mixture now being ready for use. This amount of arsenate of lead should be used with about 50 gallons of water or other spray mixture.

When the commercial arsenates of lead were first introduced, their cost was considerably in excess of the cost of the homemade product. However, at present the commercial product can be obtained for an amount no greater than the cost of the ingredients out of which the homemade arsenate of lead is made. Therefore, unless for personal reasons the homemade product is preferred, one of the commercial brands is advised.

CONTACT POISONS

Certain insects obtain their food by means of sucking mouth parts which they insert beneath the surface of a plant and feed upon the juices thereof. Among this class of insects are scale insects and plant lice. To be effective against such insects, the spray used must be of such character that it will stop up their breathing pores or corrode their bodies. Contact poisons must hit the insects themselves.

LIME SULFUR

For a number of years lime sulfur has been the most satisfactory treatment for the control of San Jose scale. The solutions used are the same as those described on pages 9 to 12, and both the homemade and commercial lime sulfurs are efficient. The strength of solution necessary to be effective against these insects is one that is injurious to a tree in foliage, so that it is necessary to combat them during the dormant period. If the homemade solution is used, it should be diluted 1 in 5, which gives a spray containing about 15 pounds of sulfur in solution in each 50 gallons. The commercial solutions vary more or less in sulfur content, and unless their composition is known, so that they can be accurately diluted to produce a spray each 50 gallons of which contains about 15 pounds of sulfur in solution, to
be sure of applying a spray of effective strength 1 gallon of the commercial material should be used in each 9 gallons of the diluted spray.

NICOTINE SOLUTIONS

Some of the plant lice become so destructive that it is necessary to combat them during the growing season. Proprietary nicotine solutions have proved efficient for summer spraying, and as these are all accompanied with directions regarding their dilution and application, no definite recommendation is made.

WHALE-OIL SOAP

Whale-oil soap is used as a summer spray. It is efficient in the control of plant lice and can be purchased ready for use. The spray mixture is prepared by dissolving about 1 pound of the soap in boiling water and diluting to 8 gallons.

SPRAYING SCHEDULE FOR ILLINOIS APPLE ORCHARDS

The number of pests attacking Illinois orchards are many, but the methods of warfare waged against them are quite similar. The common diseases with which the grower should make himself familiar are apple scab, apple blotch, bitter rot, black rot and sooty blotch. Among the insects are San Jose scale, canker worm, bud moth, leaf crumpler, codling moth, currulio, tent caterpillar, fall web worm and leaf skeletonizer.

DORMANT SPRAYING

In combating San Jose scale and certain other scale and soft bodied insects, it is necessary to apply the spray while the trees are dormant, as the strength of solution necessary to be effective against them is injurious to a tree in foliage. Lime sulfur solution 50 gallons of which contain about 15 pounds of sulfur in solution, is most generally used for this spray. To obtain a spray of this strength, the homemade solution should be diluted 1 in 5, and the commercial solutions 1 in 9. This application should be made some time during the winter when the temperature is above freezing. In badly infested orchards two applications are advised, one in the fall, shortly after the leaves are shed, and one in the spring, just before the buds begin to swell. If only one application is to be made, the one in the spring is the one which should be made.
FIRST REGULAR APPLICATION

The first regular application should consist of 4-4-1-50 Bordeaux-arsenate (4 pounds of copper sulfate, 4 pounds of lime, and 1 pound of arsenate of lead in each 50 gallons), and should be applied after the cluster buds have separated, but before any of the blossoms are out. This is the first application for apple scab, and is effective against canker worm, leaf crumpler and bud moth.

SECOND REGULAR APPLICATION

The second regular application is very important, and may consist of 4-4-2-50 Bordeaux-arsenate (4 pounds of copper sulfate, 4 pounds of lime, and 2 pounds of arsenate of lead for each 50 gallons) or lime sulfur-arsenate. The lime sulfur solution should be one in which there are 4 pounds of sulfur in each 50 gallons of the spray. Two pounds of tri-plumbic arsenate of lead should be used with each 50 gallons of lime sulfur solution. This application should be made just as soon as most of the petals have fallen, and it is important that it be completed within 6 or 7 days. It is the second treatment for scab, and the most important one for the codling moth. It is also effective against curculio and certain leaf-eating insects.

The choice of either lime sulfur-arsenate or Bordeaux-arsenate is given for this application, since it is as the result of the use of Bordeaux mixture at this time that much of the russet is caused.

THIRD REGULAR APPLICATION

This application should consist of 4-4-2-50 Bordeaux-arsenate and be applied shortly after the second application and not later than 10 or 12 days after the fall of the petals. This is the third treatment for scab, the first for apple blotch, and the second for codling moth and curculio, and it is also effective against certain leaf-eating insects.

FOURTH REGULAR APPLICATION

This application should consist of 4-4-2-50 Bordeaux-arsenate, and should be made about 7 weeks after the fall of the petals. This application is the second for apple blotch, the first for bitter rot, and is effective against the second brood of the codling moth and late infection of apple scab.
ADDITIONAL APPLICATIONS

In orchards subject to severe attacks of bitter rot, an extra application of Bordeaux mixture midway between the third and fourth regular applications may be advisable. Such orchards should also be sprayed every 2 or 3 weeks throughout the remainder of the season with 4-4-50 Bordeaux mixture, or as often as is necessary to keep the bitter rot under control.