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Sprays
Their Preparation and Use

R. H. ROBINSON

Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis

FOREWORD

THE successful production of orchard and certain other farm crops depends in a large measure upon the quality of the spray materials used and the care exercised to control insect pests and fungous diseases. In order to prevent spray injury and to obtain effective results, it is important that proved methods of preparing, diluting, and combining sprays be followed.

Various insecticides and fungicides, such as lime-sulphur solution, bordeaux mixture, oil emulsions, dust combinations, spreaders and adhesives, may be home prepared at material savings in cost. The need for methods describing up-to-date procedures for preparing the different spray materials is apparent.

This bulletin outlines methods for the preparation of various insecticides and fungicides; describes the manner of mixing sprays in the tank and the precautions to observe in the use of combination sprays; and discusses the chemical and physical properties of commercial products, with suggestions and precautions for their use.

WM. A. SCHOENFELD
Dean and Director

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By

R. H. Robinson

INTRODUCTION

THE successful production of orchard and certain other farm crops depends, in a large measure, upon the quality of the spray materials and the manner in which they are used to control insect pests and fungous diseases. The quality of both home-prepared sprays and the commercial product depends upon the care exercised and the procedure followed in the preparation of the spray material. In the preparation and use of homemade products, precautions must be closely observed or the effectiveness of the spray is greatly reduced. Likewise, in the proper use of commercial products, recent recommendations must be followed in order to obtain best results. A greater responsibility now rests upon the spray manufacturer because of the numerous new materials that are developed each year. No longer can the Experiment Station make field tests of all these products until the manufacturers carry on preliminary field studies that must show promise for specific purposes.

The introduction of many new spray materials and the prevalent custom of employing combination sprays give rise continually to problems that must be solved in order to obtain best results in the orchard. Most of these troublesome problems are caused by chemical reactions or physical modifications that either reduce the efficiency of the spray materials or form a byproduct that causes foliage burn or other harmful effects. A study of the chemical reactions under laboratory conditions has in many instances disclosed means of overcoming the difficulty.

The purpose of this bulletin is to outline proved methods for the preparation of those insecticides and fungicides that may be homemade and to emphasize the precautions that should be taken in order to insure best results. There is included also general information regarding physical and chemical properties of the different commercial products and their stability and compatibility when used in combination with other sprays.

Requirements for effective pest control. In addition to the selection of good spray material, proper timing of applications is very necessary, and complete coverage of the tree, insect, or plant is essential for effective control of the insect pest or plant disease. Unless this care is exercised much labor and costly spray materials are wasted, and the quality of the crop reduced accordingly. Consult your county agricultural agent or write to the Experiment Station for further detailed information pertaining to the control of specific insect pests or plant diseases.

Sprays should not be allowed to stand in the spray tank. Sprays should be applied immediately after being mixed in the spray tank. Many spray materials change chemically after dilution with water, especially combinations of two or more insecticides or fungicides, and their effectiveness may be reduced. It is very important, therefore, that sprays be applied immediately after preparation and not left in the tank over the noon hour or overnight.

Recommended combinations of two or more sprays. It is common orchard practice to combine two or even more different spray materials by mixing them in the spray tank and applying them as a unit. In order to retain the active principles of each insecticide or fungicide present in the combination and to reduce danger of injury to foliage to a minimum, most combinations should be prepared by following a definite procedure. Recommended combinations and the order of mixing them in the spray tank are given in this bulletin under appropriate headings. When special commercial products are used, such as spreader-stickers designed to flocculate the spray mixture, care should be taken to follow directions outlined by the manufacturer.

Purchase and use insecticides and fungicides on the basis of their active ingredients. Many similar products on the market contain varying amounts of the active ingredients. For example, among the copper compounds, cuprous oxide may contain as high as 88.0 per cent copper, while another product may have a diluent mixed with it so that the copper content may be as low as 10.0 per cent. Again, Cresol compounds may have 50.0 per cent or more of the active ingredient, phenols, in the emulsified form while other products sold for the same purpose may contain 10 per cent or less of the phenol. The active ingredients of various commercial products should be given on the label. When not declared, this information may be obtained from the dealer or from leaflets describing the spray material.

Precautions in the use of new spray materials. Each year many new spray materials are offered on the market or for field experimentation for various purposes. Growers are warned against the use of these products except on a very small scale until reliable information can be obtained by experiment station workers regarding the effectiveness of any material for a specific purpose. It is surprising how few of the newer spray materials have been found effective or as good as insecticides or fungicides that have been in use for years. Every effort is being made by experiment station and government workers to learn of new spray materials, especially those nontoxic to man, that may be substituted effectively and economically for the old products.

ARSENATE OF LEAD

Arsenate of lead and other arsenicals cannot be home prepared. Their manufacture requires careful chemical control and special equipment in order to make a high-grade product of desirable chemical composition.

Acid and basic lead arsenate compared. There are two commercial forms of lead arsenate used as insecticides. One, usually referred to as Standard lead arsenate, is known chemically as lead hydrogen or acid arsenate; the other is Basic lead arsenate, which is of variable composition, and is commonly referred to as neutral or basic lead arsenate. Investigations at the Oregon Experiment Station and in other states have shown that the standard lead arsenate is more toxic to insect pests than basic lead arsenate, and consequently the commercial production of the latter is limited. The basic lead arsenate, however, is used occasionally for specific purposes and, wherever recommended, care should be taken to obtain this type. Packages in which it is sold are marked plainly to distinguish it from the lead hydrogen arsenate, which is labeled Standard Lead Arsenate.

High-grade lead arsenate must be high in total arsenic and combined with lead to form the chemical compound, lead hydrogen arsenate, $PbHAsO_4$, for optimum killing efficiency. It must be low in water-soluble arsenic and free from foreign impurities in order that foliage burn may be reduced to a minimum. Since most manufacturers have perfected their processes for the production of lead hydrogen arsenate, high-grade material is the rule on the market. Occasionally, however, poor results are observed from the use of a certain brand of lead arsenate. This usually occurs when a manufacturer "doctors" his product in an attempt to make it more effective. Chemical and physical analyses will not always disclose the deficiency. The chemical analyses of various brands of Standard lead arsenate are given in Table 1.

Table 1. ANALYSIS OF DIFFERENT COMMERCIAL BRANDS OF STANDARD LEAD ARSENATE

Name of manufacturer	Arsenic oxide total	Lead oxide total	Arsenic oxide water soluble
	Per cent	*Per cent*	*Per cent*
Acme White Lead and Color Works	32.4	64.0	.16
California Spray Chemical Corporation	32.2	64.8	.33
Chipman Chemical Engineering Co.	32.5	64.0	.12
General Chemical Co., Astringent brand	31.5	62.9	.34
Niagara Spray & Chemical Co.	30.5	64.7	.27
Pittsburg Plate Glass Co. (Corona)	32.3	64.1	.26
The Dow Chemical Co.	32.8	64.7	.22
The Grasselli Chemical Co., DuPont	32.9	64.4	.35
The Latimer-Goodwin Chemical Co.	31.6	63.3	.13
The Sherwin-Williams Co.	32.6	63.9	.16

The foregoing results indicate that there are only slight differences in the composition of the various brands. The low water-soluble arsenic content of all samples further emphasizes the high degree of purity of the commercial product. We can conclude from these analyses that from the standpoint of their chemical composition all present brands of lead arsenate are high grade and safe for general use. Also, effective control of codling moth or other insects may be anticipated from the use of any particular commercial brand providing the product has not been modified to make it less toxic.

Recommended combinations. Lead arsenate may be combined with bordeaux mixture, nicotine sulphate, oil emulsions, and lime-sulphur solution or any of the wettable sulphurs. Precautions to observe are as follows:

Lead arsenated flocculated spray. (For codling moth control.) Fill the spray tank with water and add the required amount of lead arsenate. The overflow must be kept at an absolute minimum. Then add the flocculating mixture (see spreaders) slowly. The lead arsenate should flocculate moderately heavily and the spray should be applied immediately. For special commercial flocculating mixture, follow directions of the manufacturer.

Lime-sulphur lead-arsenate combination. Fill the spray tank nearly full with water and add the required amount of lime-sulphur solution or other sulphur spray. Then add $\frac{1}{3}$ pound of casein spreader and 1 pound of lime to each 100 gallons of spray in the tank. Finally, mix the lead arsenate with a little water and add the thin paste to the spray tank just before beginning spraying operations.

Nicotine-sulphate lead-arsenate combination. Fill the spray tank nearly full with water and add the required amount of nicotine sulphate. Add 1

pound of hydrated lime and ½ pound of spreader to each 100 gallons of the spray. Finally, just before beginning to spray, make a thin paste of the lead arsenate and pour it into the tank.

Nicotine-sulphate lime-sulphur lead-arsenate combination. Fill the spray tank nearly full with water and add the required amount of nicotine. Start the agitator and proceed as given under the *lime-sulphur lead-arsenate* combination.

Bordeaux lead-arsenate combination. Prepare a full tank of bordeaux mixture as given on page 17. Add water to the required amount of lead arsenate to make a thin paste and pour into the tank just before beginning to spray.

Oil-emulsion lead-arsenate combination. Start the agitator and add about 20 gallons of water to the spray tank. Then add the required amount of oil emulsion and fill tank with water. Finally, just before beginning to spray, mix the lead arsenate with enough water to form a thin paste and pour into the spray tank.

CALCIUM ARSENATE AND OTHER ARSENICALS

Calcium and zinc arsenate and zinc arsenite are important metallic substitutes for lead arsenate and may be used for various purposes. Calcium arsenate is effective for the control of codling moth in the Willamette Valley and as a general garden insecticide. The different arsenicals are used as the active poisoning ingredient in several baits such as those used for control of strawberry weevil, cutworms, slugs, grasshoppers, etc. Since a tolerance for lead has been established on fruit and vegetables, and because of the toxicity of lead to human beings, lead arsenate should be used only when necessary and where recommended.

Calcium arsenate, zinc arsenate and arsenite, paris green, and certain other arsenicals, are less stable than lead arsenate, and break down chemically to form water-soluble arsenic. Water-soluble arsenic will cause burning of foliage and injury to fruit. While these arsenicals may be applied to some resistant fruits and vegetables without causing injury, yet burning of foliage may occur under unfavorable climatic conditions. They may be made safe by the addition of a mixture of zinc sulphate and lime (1 pound hydrated lime mixed with 2 ounces zinc sulphate to 100 gallons of spray), and thus reduce injury to a minimum. Directions for the control of any insect pests where these substitute arsenicals are recommended should be followed carefully. These directions may be obtained from the county agent or Agricultural Experiment Station.

Recommended combinations. Calcium and zinc arsenate or zinc arsenite may be combined with lime sulphur, nicotine sulphate, bordeaux mixture or oil emulsions. The order of mixing in the spray tank is the same as given for lead arsenate on pages 8-9 except that the above arsenicals replace the lead arsenate.

LIME SULPHUR

Lime sulphur is the most important of the sulphur sprays. It is an efficient contact poison for certain scale insects and an important fungicide for several

fungous diseases. When sulphur is combined chemically with calcium under certain conditions it forms calcium polysulphide, the principal active ingredient in lime-sulphur solution. The effectiveness of lime-sulphur solution as a dormant spray is largely due to the ability of the calcium polysulphide to take up oxygen.

Commercial lime-sulphur solution. Commercial brands of concentrated lime-sulphur solution are available in all of the fruit districts of the state. The different brands vary somewhat in concentration, but for all practical purposes the strength may be best indicated by means of a hydrometer that registers the density or Baumé reading. The different brands of commercial lime-sulphur offered on the Oregon market vary in density from 28° Baumé to 33° Baumé. It is usually more economical to buy the high-test product. It is important also for the orchardist to know the Baumé reading of the lime-sulphur solution in order that dilutions may be made in accordance with recommendations for specific spraying purposes. The orchardist is advised to test the lime-sulphur solution with a Baumé hydrometer and make dilutions for spraying in accordance with Table II.

Table 2. DILUTION TABLE FOR LIQUID LIME SULPHUR

Strength of concentrated lime-sulphur solution Degrees Baumé	Specific gravity	To make 100 gallons of dilute spray use the number of gallons of concentrated lime sulphur indicated in the columns below, and add water to make 100 gallons.				
		1. Dormant strength for scale clean-up (5.2° Baumé) Dormant	2. strength for blister-mite and twig-miner (3.6° Baumé)	3. Early spring spray (1.7° Baumé)	4. Mid-spring spray (1.4° Baumé)	5. Late spring sprays (1.1° Baumé)
		Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*
34°	1.304	11.1	7.5	3.1	2.3	1.8
33°	1.295	11.6	7.8	3.2	2.4	1.9
32°	1.283	12.0	8.0	3.3	2.5	2.0
31°	1.272	12.4	8.3	3.4	2.6	2.1
30°	1.261	12.8	8.5	3.5	2.6	2.1
29°	1.250	13.4	8.9	3.6	2.7	2.2
28°	1.239	13.9	9.3	3.8	2.8	2.3
26°	1.218	15.0	10.0	4.0	3.0	2.5
24°	1.198	16.4	11.0	4.4	3.3	2.8
22°	1.179	18.3	12.3	4.8	3.7	3.1
20°	1.160	20.8	13.8	5.4	4.2	3.5

Commercial brands of various dry lime-sulphur and sulphide products are discussed on page 11.

Home preparation of lime-sulphur solution. Liquid lime sulphur may be home prepared and a product obtained testing 26° to 30° Baumé that is equal in effectiveness to the best commercial brand. Like the commercial lime-sulphur solution, it must be diluted for spray purposes in accordance with the dilution table and for the specific purpose for which it is to be used. In the preparation of lime-sulphur solution, care should be exercised in order to obtain as complete a reaction as possible between the lime and sulphur and to prevent the formation of excess sludge. Chemical tests and practical trials have shown that lime and sulphur, when boiled in the proper amount of water, will go into solution best in the proportion of 1 part of high-grade quicklime to 2 parts of

sulphur. For the orchardist who makes his own lime-sulphur solution, the ingredients may be used in the following proportions:

Quicklime (stone lime)	50 pounds
Sulphur (finely ground or powdered)	100 pounds
Water to make finished product	50 gallons

Any multiple of the above proportions may be used for the preparation of concentrated lime-sulphur solution, depending upon the capacity of the container.

To prepare **small amounts of lime sulphur,** 50 gallons for example, the following procedure will be found practicable:

1. Place in an iron oil barrel (supported on its side by brick or stone to allow for fire beneath and with about one-fourth segment cut out of the barrel) or other container, 45 gallons of water and heat to about 180° F.

2. Dump in the required amount of lime; namely, 50 pounds, and allow to slake. (The quicklime will slake without burning or drowning provided the water is heated to about 180° F.)

3. Add the required amount of sulphur, namely 100 pounds, cover, and bring to a boil *quickly.* Then boil for 50 minutes. The boiling should be vigorous and continuous and the mixture should be *stirred constantly* throughout the operation. The volume should be maintained at not less than 50 gallons and hot water should be added at intervals to compensate for loss by evaporation.

4. The lime-sulphur solution may be cooled a little and then strained through a 50-mesh brass or tinned iron screen into a wooden or iron barrel. Keep airtight and take Baumé reading just before using.

Precautions. It is important to use fresh, high-grade quicklime and to obtain special pulverized or finely ground sulphur. Lime that has been allowed to stand around and become air-slaked cannot be used for the preparation of lime-sulphur solution. If a low-grade or an impure quicklime is used, an additional quantity must be taken and large amounts of sludge will be formed. It is usually advisable to take a little more lime than recommended above since lime is usually only 90 to 95 per cent pure.

Keep boiling liquid covered—with small hole in cover for handle of stirring paddle. Overboiling or underboiling increases the amount of sludge.

Care should be taken to maintain the volume advised for the particular amount being prepared. Hot water only should be added.

Dilution of lime-sulphur solution. Every orchardist should obtain from the druggist a Baumé hydrometer in order to test his lime-sulphur solution before using, whether the home-made material or the commercial product. Unless this test is made, he will be unable to use the correct amount of water in diluting his spray for application in accordance with recommendations in Table 2.

To prepare **large amounts of lime sulphur.** If steam is available, quantities may be prepared limited only by the size of the vessel used. For a 100- to 1,000-gallon outfit, a single circular perforated steam coil may be placed on the bottom of the tank or other vessel. The coil should be so perforated that steam would shoot up through a false bottom or screen made of heavy tinned wire and erected 6 inches to 2 feet above the coil, depending upon the capacity of the tank. A mechanical agitator with sweeping arms rotating on a

shaft is fitted at the bottom and in the center of the vessel. The agitator revolves between the screen and the bottom of the vessel. If some perforations of the coils are deflected against the bottom of the tank and in one general direction, a circular motion of the liquid would be set up and aided by the agitator.

To prepare 500 gallons of the lime sulphur proceed as follows:

1. Run in about 300 gallons of hot water, turn on steam, and start agitator.

2. With water near boiling point, add first a quantity of quicklime; say 50 pounds, followed immediately by double the amount of sulphur; namely, 100 pounds. The heat liberated by the lime is lowered by the sulphur and thus utilized. Continue adding materials until 500 pounds of lime and 1,000 pounds of sulphur have been added.

3. Add more water to make a total volume of 1,000 gallons, cover well, and boil for about 50 minutes.

4. The finished product is allowed to cool and after the sludge has settled the clear liquid is drawn off into airtight storage barrels.

The Baumé readings should be taken of each batch of lime sulphur prepared and these readings plainly marked on the containers. The temperature of the lime-sulphur solution should be about 60° F. at the time the Baumé reading is recorded.

Recommended combinations. Lime-sulphur solution, either the home-prepared or the commercial product, may be combined with lead arsenate and nicotine sulphate in accordance with the following directions:

Lime-sulphur lead-arsenate (or other arsenical) combinations. Follow directions as given on page 7.

Lime-sulphur nicotine-sulphate combination. Fill the spray tank nearly full with water and add the required amount of lime-sulphur solution. Add 2 pounds of hydrated lime and ¼ pound of spreader for each 100 gallons of spray. Dilute the required amount of nicotine sulphate with an equal amount of water and add to the tank.

Nicotine-sulphate lime-sulphur lead-arsenate combination. Follow directions as given on page 8.

Lime-sulphur oil-emulsion combinations. Recent investigations indicate that a mixture of lime sulphur and oil emulsion may be used advantageously as a dormant spray. Since only a limited amount of work has been carried on with this combination, it is important that full directions be obtained from the Experiment Station or County Agent regarding the purposes for which it may be used. It may be prepared in the spray tank as follows: Fill the spray tank with water and add the lime-sulphur solution. Then, with the agitator going, add the oil emulsion slowly. If the oil emulsion is not the flowable type, the combination may be made as follows: With the agitator going, cover the paddles partly with water and add the oil emulsion. Then, fill the tank nearly full with water and finally pour in the lime-sulphur solution.

COMMERCIAL DRY SULPHIDE SPRAYS

Besides the lime-sulphur solutions, there are several commercial products in more or less common use. Among them may be mentioned dry lime sulphur, barium-tetra-sulphide (B.T.S.), calcium sulphide and soluble sulphur.

Dry lime sulphur is the product obtained in the dehydration of the concentrated lime-sulphur solution, after the addition of a stabilizer such as cane sugar. Apparently there is partial decomposition of the polysulphides during the process of manufacture since the percentage of both free sulphur and thiosulphate sulphur is higher and the polysulphide sulphur is lower than the amounts found in the concentrated lime-sulphur solution calculated on a dry basis. The most recent guaranteed composition of dry lime sulphur is as follows:

	Per cent
Calcium polysulphide	70.0
Calcium thiosulphate	5.0
Free sulphur	10.0
Inert ingredients	15.0

It may therefore be considered that, for *summer spraying*, about 85 per cent of the dry lime sulphur consists of active ingredients and the 15 per cent of inert materials is of no value as a spray. For dormant spraying, however, the 10 per cent free sulphur, because of particle size, and the 5 per cent calcium thiosulphate have little or no value.

Summer spraying with dry lime sulphur. The amount of dry lime sulphur to use for summer spraying may be calculated on the basis of the foregoing analysis. For any bad summer infestation, such as apple scab, the amount of active ingredients present in a gallon of dissolved dry lime sulphur should be equivalent to that present in a gallon of liquid lime sulphur of any recommended strength. An average analysis for lime-sulphur solution, 32° Baumé, is as follows:

	Per cent
Calcium polysulphide	30.5
Calcium thiosulphate	1.5
Water	68.0

A gallon of lime sulphur 32° Baumé weighs about 10.7 pounds. Calculating the amount of active ingredients from these figures, we find that there are 3.4 pounds per gallon.

When dry lime sulphur is used, either for the dormant spray or for the summer sprays, it should be applied in amounts equivalent to the liquid lime sulphur in order to obtain equivalent protection. Since each gallon of lime-sulphur solution contains 3.4 pounds of active ingredients it would take, for summer application, 4.0 pounds of a dry lime sulphur having 85 per cent active ingredients to be equivalent to 1 gallon of commercial concentrated 32° Baumé liquid lime sulphur. In making dilutions for the various sprays, therefore, 4.0 pounds of the dry lime sulphur should be used for each gallon of liquid lime sulphur, Baumé 32°, necessary. While this amount is much higher than is recommended by the manufacturer, field experiments carried on in different parts of the country have indicated conclusively the need of using larger amounts than the manufacturers have recommended in the past, particularly when weather conditions favor the development of serious disease epidemics. Where light infestations occur or climatic conditions at the time of spraying are favorable, the smaller amounts recommended by manufacturers may give control.

Dormant spraying with dry lime sulphur. From the composition of dry lime sulphur given above, a maximum of 70 per cent only is of value for dormant spraying. Calculating on this basis, about 5 pounds of the dry lime sulphur should be dissolved in 1 gallon of water to be equivalent to 1 gallon of liquid lime sulphur, 32° Baumé.

For dormant spraying and scale clean-up, dry lime sulphur should be used at the rate of about 60 pounds to 100 gallons of water. This amount dissolves with difficulty and more than ordinary care must be exercised in order to bring the maximum amount of the dry lime sulphur into solution. If hot water in the amount of 10 gallons or more is used, the dry lime sulphur is dissolved more readily. The procedure suggested is as follows: Add 10 gallons or more of the hot water to the spray tank and start the agitator. Then sift in the dry lime sulphur and add enough water to permit the agitator to rotate freely. Finally, turn on the cold water, filling the tank slowly in order to give time for all of the dry lime sulphur to dissolve. If these precautions are not taken, solid particles of the dry lime sulphur may remain undissolved and will not adhere to the tree in that state. When undissolved, moreover, the solid particles are of no value as a dormant spray. Less amounts than specified will give control only where comparatively light infestations occur or climatic conditions at spraying time and immediately following favor control.

Barium-tetra-sulphide (B.T.S.) has been shown to be a fairly effective contact poison, but it possesses no distinct advantage over the lime-sulphur solution except that it is in powder form and convenient to handle. Its cost, however, is prohibitive, and consequently it has not been used to any extent in the Northwest.

Calcium sulphide. Field tests by Hurt and Schneiderhan of the Virginia Experiment Station have shown that calcium sulphide is a valuable fungicide for summer spraying. Excellent results were obtained in the control of scab and brown rot on peaches.

The calcium sulphide used in experimental work was prepared by the reduction of anhydrous calcium sulphate. The product contained 65.0 per cent calcium sulphide together with some calcium sulphate and small amounts of other impurities. It is slightly soluble in water, but was found less caustic and gave less injury that some other summer fungicides. This fungicide should be used only in districts and for purposes where it is specifically recommended.

Soluble sulphur is a concentrated sulphide solution similar to lime sulphur except that lye is used instead of lime in its preparation. As a dormant spray it has been found satisfactory, but not superior to lime-sulphur solution. It cannot be used as a summer spray or later than the dormant spray since it causes very severe foliage burn.

"WETTABLE SULPHURS" FOR SUMMER SPRAYS

Mixtures in which sulphur is the active ingredient have been recognized for some time as among the best summer fungicides. Until comparatively recently the self-boiled lime sulphur was the standard spray used. This has been superseded by the "wettable sulphur" such as the Oregon cold-mix, the New Jersey dry-mix, and commercial brands. These forms have given effective control without causing spray injury or otherwise harming the plants or the crops.

Many commercial brands of wettable sulphur are available on the Oregon market. These are combinations of sulphur mixed with some substance such as casein, starch, lime, or glue that aids in wetting the sulphur when mixed with water. The quality of the different brands of wettable sulphur depends on the grade of sulphur used in the product. Very finely ground sulphur or high-quality dusting flowers of sulphur produces the most effective product. The

sulphur used in wettable sulphurs should pass through a 300-mesh screen. For special purposes, very finely ground sulphur, most of which will pass a 600-mesh screen, or "flotation" gas works sulphur, which is even smaller in size, is used. In addition to the sulphur, the commercial brands may contain varying amounts of inert filler or hydrated lime, depending on the purpose for which they are to be used. For use on plants or fruits susceptible to injury, brands that contain an excess of lime should be used. For the more resistant foliage lime is unnecessary unless applied in very hot weather. If a commercial brand of wettable sulphur is to be used, the orchardist should ascertain the amount and quality of sulphur present and the specific purposes for which it is intended.

Self-boiled lime sulphur. As stated above, the self-boiled lime sulphur has been superseded by the wettable forms. Since the wettable sulphurs have given better results than the self-boiled lime sulphur, the orchardist is advised to use one of the forms described below. Directions for the preparation of self-boiled lime sulphur are therefore omitted.

Tank-mix wettable sulphur. A tank-mix wettable sulphur spray may be very easily prepared by the addition of sulphur to a dilute solution of any one of a group of compounds known as wetting or surface-active agents.* These wetting agents also act as spreaders and care must be taken not to use too much since they may cause excess run-off of the spray. Not over 2 to 3 ounces per 100 gallons of sulphur spray should be used. The following procedure is suggested for making 100 gallons of spray:

FORMULA 1, OREGON TANK-MIX WETTABLE SULPHUR

Sulphur (superfine, passing 300-mesh sieve)	6 pounds
Wetting agent*	2 ounces
Lime (as needed to prevent injury)	

Preparation:

1. Dissolve the wetting agent in about 1 gallon of water and stir the sulphur into it.

2. Fill the spray tank with water, pour in the sulphur mixture and the spray is ready for application. (If there is any danger of sulphur burn on account of high temperatures, add about 2 pounds of lime to each 100 gallons of spray.)

Oregon cold-mix wettable sulphur. The preparation of Oregon cold-mix wettable sulphur may be accomplished with very little labor and by means of equipment ordinarily available on the farm. Less care perhaps is required to prepare a stock supply of the Oregon cold-mix lime and sulphur than for any other spray. It should be mixed just before the time of application.

For making 100 gallons of spray, the following ingredients and amounts are recommended:

FORMULA 2. OREGON COLD-MIX WETTABLE SULPHUR

Sulphur (superfine, passing 300-mesh sieve)	6 pounds
Hydrated lime	2 ounces
Skim milk	2 quarts

The foregoing amounts are sufficient for 100 gallons of spray. Temperature conditions may require the addition of more lime (as much as 2 pounds) to prevent burn, especially on susceptible plants.

* Wetting agents available in Oregon include the following: Intramine, Nacconol NR, Tergitol 7, Triton 720, Vatsol, Wetsit, and Duponal.

Preparation:

1. Weigh out the proper amount of sulphur and hydrated lime and mix them together.

2. Add an equal amount of water to 2 quarts of skim milk. Pour this onto the sulphur and lime mixture, stirring until a smooth paste is formed. Add enough water to form a very thin paste and pour through strainer into the spray tank.

3. Fill the spray tank with water, and the spray is ready for application.

Precaution:

In order to produce a good quality of spray, it is important that the sulphur should be ground superfine. Ninety per cent or more should pass through a 325-mesh sieve. If skim milk is not available, whole milk may be used with equal effectiveness. Dry skim-milk powder also may be substituted for the ordinary skim milk. About 3 ounces of the powder should be mixed with an ounce of lime and stirred into a quart of water. This amount will be equivalent to 1 quart of skim milk.

Oregon wettable sulphur. Hydrated lime is used in Formula No. 2, primarily to reduce sulphur burn on sensitive plants in hot weather. For most purposes, however, it is unnecessary to use lime and some inert filler may be substituted in its stead. This filler may consist of Bentonite, diatomaceous earth, Kaolin, or similar material. These materials aid wetting of the sulphur and also increase the deposit per unit area of surface sprayed. One of the commercial wetting agents (see footnote page 14) that promotes wetting of sulphur and increases spreading of the mixture may also be used. Milk powder acts as a binder for the other ingredients. For the preparation of a stock supply of this dry wettable sulphur, the following formula may be used:

FORMULA 3. OREGON WETTABLE SULPHUR

Sulphur, superfine (90 per cent passing 300-mesh sieve)	50 pounds
Bentonite or other filler	5 pounds
Skim-milk powder	2 pounds
Wetting agent	1 pound

Preparation:

1. Weigh out the proper amount of various ingredients, and sift through a small-mesh sieve in order to remove any lumps.

2. Either continue to mix the ingredients thoroughly in a mortar box by hand, or transfer to an end-over-end barrel mixer and turn until a uniform mixture is obtained.

Dilution:

It is recommended that the mixture be used at the rate of 6 to 10 pounds to 100 gallons of spray. Either of the following methods may be used to add the wettable sulphur to the spray tank:

1. The required amount is weighed out in a bucket or other satisfactory container, and water added slowly, with constant stirring, until a thin paste is obtained. This may then be poured through the strainer into the spray tank of water.

2. Enough water is added to the spray tank partly to cover the paddles. With the agitator going, the wettable sulphur is sifted slowly into the tank. The latter is then filled with water and the spray is ready for application.

Modifications:

Formula 2 may be modified to suit other conditions. Where it is to be used on sensitive foliage, 2 to 6 pounds of high-grade hydrated lime may be incorporated into the formula in order to reduce chances for sulphur burn. Also, if it is desirable to apply lead arsenate at the same time, this insecticide may be mixed with the other ingredients in the formula. In like manner, bordeaux mixture in powder form may be used.

Recommended combinations of wettable sulphurs. Any of the sulphur mixtures described above or similar commercial wettable sulphurs may be combined safely with lead arsenate, nicotine sulphate, and bordeaux mixture.

When combined with a liquid spray, such as nicotine sulphate, the wettable sulphur should be mixed in the spray tank as described previously. Then an equal amount of water is added to the nicotine sulphate, stirred thoroughly, and poured into the spray tank.

DUSTING SULPHUR MIXTURES

A sulphur that may be used for dusting purposes should be incorporated in a light carrying agent or filler. The following formula will be found satisfactory:

FORMULA 4. DUSTING SULPHUR

Sulphur (superfine dusting, passing 300-mesh) ..... 80 pounds
Diatomaceous earth, or other superfine filler ..... 20 pounds
(These proportions may be varied to suit any particular purpose. The very fine flotation type sulphur has given better results than the 300-mesh sulphur.)

Preparation:

The ingredients may be weighed out and transferred to an end-over-end barrel mixer of convenient size. The barrel should then be rotated until the sulphur and inert filler are thoroughly mixed.

If another insecticide or fungicide that should be applied at the same time is available in powder form, it likewise may be added to the barrel mixer and incorporated with the other ingredients.

Precaution:

Care should be taken to use the proper amounts of ingredients. For example, when lead arsenate is used this may be added to the mixture to give a dust containing 20 per cent lead arsenate. The quality and fineness of the sulphur also is important for best results.

BORDEAUX MIXTURE

Bordeaux mixture was for a long time the most widely used material for controlling fungous diseases of plants. It has been supplanted to a limited extent by sulphur sprays and other materials; yet for many diseases such as apple-tree anthracnose, peach-leaf curl, peach blight, potato late blight, celery blight, etc., bordeaux is still the most effective and most safe preventive known.

The effectiveness of most protective sprays depends to a large extent on the spreading and adhering properties of the materials. When bordeaux mixture is properly made it forms a bulky, gelatinous precipitate that adheres well and has excellent spreading properties. For some uses a spreader or adhesive may be beneficial when it is essential that the copper function for a long time.

Commercial bordeaux mixture. Laboratory experiments confirmed by field tests have in the past shown the superiority of carefully prepared home-made bordeaux mixture over the commercial brands. The physical properties of dry bordeaux mixtures, however, have been greatly improved and recent field tests have shown that some commercial brands possess adhesive qualities comparable to the home-prepared product when casein spreader or a little petroleum oil is used with it.

There are on the market several commercial brands of powdered bordeaux mixture, the copper content of which ranges between 10 and 20 per cent. Most of these may be used effectively on truck and garden crops, or for other purposes where it is not particularly important that the bordeaux should adhere for long periods of time. To insure best results, it is advisable to use casein spreader wherever the commercial bordeaux is applied.

"Two-powder" commercial bordeaux. In 1922 the Oregon Agricultural Experiment Station recommended for commercial manufacture a bordeaux preparation subsequently referred to as "two-powder" and "instant" bordeaux. Several commercial brands of this type of bordeaux mixture are available on the market, most of which have given good results.

The two-powder bordeaux consists of two packages. One package contains powdered bluestone or copper sulphate, and the other contains hydrated lime. Either one or both of the packages may have mixed with the contents a small amount of casein or starch. When the contents of the copper sulphate package is dissolved and the hydrated lime package is suspended in water and combined in accordance with the directions accompanying the product, an excellent bordeaux mixture is formed.

It has been found that some brands of the two-powder bordeaux mixture produce a poor grade bordeaux owing to the coarse particles present in the copper sulphate package. If coarse particles can be felt when tested by rubbing the powdered bluestone between the thumb and finger, a poor quality bordeaux will result that will not adhere well to foliage. If the contents of the *lime* package are a left-over from the previous year's stock, a poor grade bordeaux will likewise result.

Other commercial copper compounds. During the past few years many new copper compounds have been developed for fungicidal purposes and are now available. Among them are the copper oxychlorides, cuprous oxides, basic copper sulphate, copper silicates, copper zeolite, copper phosphate, copper oxalate, and copper resinate. When carefully prepared some of these products adhere as well as bordeaux mixture and are less injurious to the copper sensitive plants. On the other hand the more stable compounds such as copper phosphate do not give as effective disease control. Efforts are being made to reduce plant injury by incorporating in the more active copper compounds, safening and conditioning agents, and with the aid of compatible spreaders, to make the various compounds safer and more effective specifics.

Preparation of home-made bordeaux mixture. Carefully prepared homemade bordeaux mixture is unexcelled by any commercial brands available on the market. When properly made, a gelatinous, colloidal suspension of basic copper sulphate is formed which, if applied to the tree *immediately* after mixing, will adhere to the surface sprayed in appreciable amounts for several months. Field tests by the Oregon Agricultural Experiment Station have shown that more of the active ingredient, copper, adheres to the surface sprayed with homemade bordeaux than for any of the commercial brands tested.

The homemade bordeaux mixture is produced when a solution of copper sulphate (bluestone) and milk of lime are poured together. A chemical reaction takes place between the copper sulphate and the lime which results in the formation of a voluminous precipitate. In order to obtain optimum adhering qualities, the following methods of preparation should be carefully observed. Otherwise a poor product will result.

Formulas are generally designated by the proportion of the material used. For example, in the 8-8-100 formula, the first number refers to the amount in pounds of copper sulphate to use; the second number, the amount of lime; and the third number, the gallons of water necessary.

8-8-100 FORMULA

Copper sulphate (bluestone)	8 pounds
Quicklime (stone lime or process lime)	8 pounds
Water	100 gallons

Other formulas have frequently been advised for specific purposes such as 2-2-100; 6-6-100; 6-12-100; and 12-12-100.

A powdered quick lime commonly referred to as "processed lime" is now available. If recently manufactured, it may be substituted in equal amounts for the lump lime. High-grade hydrated lime may also be substituted for the quick lime, using one-third more by weight. The highest grade hydrated lime available is sometimes referred to as "chemical" hydrated lime in contrast to that used for general plastering purposes.

If the chemical lime is not available, however, ordinary hydrated lime may be used. Tests have shown that when hydrated lime is used, the milk of lime formed after the addition of water *should be allowed to stand a half hour or more before using* to produce the best bordeaux. When the hydrated lime is used, the above 8-8-100 formula then is changed as follows:

Copper sulphate (bluestone)	8 pounds
Hydrated lime	10½ pounds
Water	100 gallons

Other formulas likewise require one-third more of the hydrated lime than of the quicklime.

Preparation of small quantities. If only a small amount of bordeaux mixture is needed, it may be prepared as follows:

1. Dissolve ½ pound of bluestone in 3 gallons of water.
2. Slake ½ pound of quicklime and add water to make 3 gallons.
3. Pour the bluestone solution into the milk of lime suspension. This will make 6 gallons of bordeaux mixture ready for use.

Preparation of larger quantities using stock solutions. If large quantities of bordeaux are to be used, it is best first to prepare concentrated stock solutions of both copper sulphate and lime. A convenient concentration of each is 1 pound to a gallon of water and may be prepared as follows:

(a) *Copper sulphate* (bluestone) when in lump form may be dissolved easily by filling a 50-gallon barrel within 6 inches of the top with water and suspending near the surface of the water 50 pounds of bluestone in a burlap sack. The bluestone will dissolve completely after standing about 8 hours or overnight. If hot water is used the copper sulphate will dissolve in a comparatively short time. Good presoaked wooden barrels should be used. Iron containers can not be used, since they are soon dissolved by the copper sulphate.

Finely powdered bluestone is now available and will dissolve in water much more quickly than the crystalline or lump form. The powder form may be weighed out and dumped directly into the water. It should then be stirred with a wooden paddle until completely dissolved. Hot water will dissolve it much more rapidly.

(b) To prepare the milk of lime, slake 50 pounds of quicklime in a barrel by the addition, with constant stirring, of enough water to prevent "burning" or drying of the lime. When thoroughly slaked, add water to make 50 gallons. (When hydrated lime is used instead of quicklime, weigh out 66 pounds and add enough water to make 50 gallons. This will contain the equivalent of 1 pound of quicklime to 1 gallon of water.)

The stock solutions (a) and (b) will each contain 1 pound of material to 1 gallon of water. If covered to prevent evaporation they will keep indefinitely.

Method of preparation:

Bordeaux mixture may be made in a satisfactory manner by several different methods. Whatever method is used it is most important that both the copper sulphate solution and the milk of lime be as dilute as possible before combining to form the bordeaux. The stock solutions must *never* be mixed without first diluting with a large amount of water. The following method will give good results when using the stock solutions described above and enough material for a 100-gallon tank of the 8-8-100 formula.

1. Fill the spray tank about half full of water and *start the agitator.*

2. Stir up the stock solution (b) of milk of lime thoroughly. Dip out 8 gallons and pour through a 20-mesh strainer into the spray tank.

3. Arrange a water inlet to the spray tank so that the water runs down a trough into the tank. Turn on the water full force in order to fill the tank as soon as possible.

4. Pour 8 gallons of the stock copper sulphate solution (a) into the inlet water as it flows down the trough into the spray tank.

5. The bordeaux is now ready for spraying. It should be applied immediately and not allowed to stand even over the noon hour.

When larger quantities are to be prepared, such as enough to fill a 300-gallon tank, multiple amounts of the milk of lime and bluestone are measured out, and the same procedure followed as described above. It is most important that the bluestone stock solution be poured into the intake water as it runs down the trough into the tank, so that, as the last gallon of the copper sulphate solution is being poured into the intake water, the tank should be nearly filled.

Precautions:

1. Use fresh quicklime or hydrated lime of highest purity. If hydrated lime is used, add water and allow the milk of lime to stand at least one-half hour before using.

2. Dilute the stock solutions of copper sulphate and milk of lime in the manner described above.

3. Strain the milk of lime through a 20-mesh copper wire strainer before using.

4. Bordeaux mixture will attack iron. Rinse out spray tank, hose, and rod or gun with clean water immediately after using.

5. If bordeaux mixture is not applied immediately after preparation, add 1 ounce of sugar to each 100 gallons as described below.

Preservative for bordeaux mixture. Bordeaux mixture must be applied immediately after preparation. If it is not possible to use all in the tank within an hour after it is made, the bordeaux may be preserved by the addition of a very small amount of ordinary sugar. The sugar retards the breaking down of the gelatinous bordeaux precipitate that is so essential for adherence to the surface sprayed.

The tests of the Oregon Agricultural Experiment Station indicate that $\frac{1}{8}$ ounce of sugar should be used for each pound of copper sulphate in the spray. For example, in a 100-gallon tank filled with 8-8-100 bordeaux mixture there are 8 pounds of copper sulphate. Therefore 8 × $\frac{1}{8}$ ounce or 1 ounce (1 heaped tablespoonful) of sugar should be used. The required amount of sugar is added after first dissolving it in a little water.

Zinc bordeaux or zinc-lime is recommended for some purposes. This may be prepared in the same manner as outlined for ordinary bordeaux except that zinc sulphate is substituted for the copper sulphate.

Recommended combinations with other sprays. Bordeaux mixture may be combined safely with lead arsenate, calcium arsenate, paris green, certain oil emulsions, and nicotine sulphate preparations.

When preparing the combination spray always add any of the foregoing materials to the full tank of bordeaux mixture and apply immediately.

Oil emulsions should be mixed with an equal volume of water before adding *slowly* to the bordeaux mixture with agitator going.

BORDEAUX PAINT AND BORDEAUX PASTE

Bordeaux mixture properly prepared in concentrated form may be used as wound dressing (see Oregon Extension Bulletin 485). A temporary dressing called *bordeaux paste* may be prepared by the addition of water to a commercial bordeaux powder to the consistency of paint, or by mixing bluestone and lime to form a thick bordeaux mixture. A permanent dressing called *bordeaux paint* may be prepared by the addition of linseed oil to dry bordeaux until a thick, smooth paint is formed.

Bordeaux paste. Dissolve about $\frac{1}{2}$ teaspoonful of sugar in 1 pint of water. Stir in any commercial dry bordeaux powder until a smooth paste consistency is formed. This may be applied to the tree wounds with a paint brush. This temporary dressing may be prepared also from bluestone and lime as follows: Dissolve about $\frac{1}{2}$ teaspoonful of sugar in 1 pint of water and add 3 ounces of hydrated lime. Then dissolve 3 ounces of bluestone in 1 pint of water and add this solution to this suspension of lime to form a concentrated bordeaux mixture.

Bordeaux paint. A permanent dressing for wounds has been perfected and tested by S. M. Zeller, Pathologist of the Oregon Experiment Station, that is unsurpassed for the purpose by any commercial product. It should not be applied to fresh cuts because the oil used may injure the exposed cambium. If applied after the callus begins to form it makes a close union with the wood,

yet is not hard or thick enough to prevent free callus formation. Properly made it forms a skin-like coating, although sufficiently air porous that pockets will not form beneath it. This bordeaux paint is easily made and applied and will last for several years.

Preparation of bordeaux paint. Put into a tin can or other suitable container 1 pound of commercial bordeaux powder. Then add slowly while stirring about 1½ pints of raw linseed oil. Continue stirring thoroughly until a thick, smooth paint is formed. Depending upon the brand of commercial bordeaux used, it may take slightly more or less of the linseed oil than specified above for each pound of bordeaux used. The final product should have a consistency that will permit brushing to a thin, smooth coat. If kept in an airtight container, it may be stored for future use.

BURGUNDY MIXTURE

This spray is sometimes used in place of bordeaux in sprays for ornamental shrubs and on small fruits shortly before picking, because it does not leave the objectionable deposit on the fruit that comes from applying bordeaux at such a time. Like bordeaux, the active principle is copper but the mixture does not adhere as well as bordeaux.

Precaution:

Burgundy mixture may be prepared in the same manner as bordeaux except that sodium carbonate is substituted for quicklime. The following formula is commonly used:

Copper sulphate (bluestone)	2 pounds
Sodium carbonate (sal soda)	3 pounds
Water	100 gallons

PETROLEUM OR MINERAL-OIL EMULSIONS

Petroleum oil emulsions are now used extensively as insecticides and ovicides both as dormant and summer sprays. They also serve as adhesive agents and as deposit builders, in flocculated spray mixtures. Recent investigations have shown that the selection of an oil for the various purposes is important. An oil suitable for dormant spraying may cause severe injury if used as a summer spray. Some summer oil sprays may cause injury to the fruit in one locality while they may be used safely in another. Latest recommendations, therefore, should be obtained from the Agricultural Experiment Station regarding the different brands of commercial oil emulsions available and what oils may be used with safety in the various fruit districts of the state.

When oil sprays are home-prepared it is likewise very important that the orchardist learn what kind and grade of oils may be used safely for the purpose intended.

PREPARATION OF OIL SPRAYS

It is generally known that oil and water alone will not mix. In order to break up the oil mass into globules that will disperse throughout the water an "emulsion" is made with the help of a third substance. This substance is referred to as an emulsifying agent. Among the emulsifying agents are included soap, ammonium caseinate, calcium caseinate, bordeaux mixture, wetting

agents, gums, colloidal clay, and others. When a definite amount of the oil, emulsifier, and water are mixed as described below, the oil emulsion is formed. If properly prepared, the emulsion may then be added to the spray tank and dispersed in water in a manner similar to the mixing of other sprays.

Quick-breaking and stable oil emulsions. *The terminology* commonly used when referring to the various types of oil sprays, both the home prepared and the commercial emulsions, is sometimes confusing. For the purpose of differentiation, the home prepared oil sprays may be classified as soap emulsions and quick-breaking emulsions. The soap emulsion, that is, one in which soap is the principal emulsifier, is a very "stable" or "tight" emulsion. The "quick-breaking" emulsion in which casein is the emulsifying agent is less stable and releases most of its oil when the spray strikes the tree.

The *"stable soap emulsions"* have a low oil-depositing quality, since the oil is not released from the emulsion very easily. Consequently, a large percentage of the oil is lost in the spray run-off. This is an undesirable quality and the soap emulsions, therefore, should be used only for those specific purposes for which they are recommended.

The *"quick-breaking"* type of oil emulsions in contrast to the soap emulsions deposit a comparatively heavy film of oil on the surface sprayed and the spray run-off is mainly water. Most of the oil, therefore, is released to be effective for the purpose intended. The home-prepared casein-ammonia oil emulsion (described below) is quick-breaking and may be used for the preparation of both dormant and summer oil emulsions.

Commercial oil emulsions. All types of oil emulsions are available on the market. These include quick-breaking emulsions of varying degrees of stability, miscible oils (oils in which an oil-soluble emulsifier is used and has the appearance of pure oil), jell type emulsions, flowable emulsions, tank-mix oils and "separate-package" emulsifier preparations. Since some manufacturers change the ingredients in their emulsions from year to year, it is impossible to give general information regarding them. The only way the orchardist or other user of oil emulsions can be sure regarding any particular commercial brand is to write to the Chemistry Department of the Agricultural Experiment Station, asking for latest information regarding it.

Selection of oils for dormant and summer emulsions. Oils of very definite specifications should be selected for different purposes, depending largely upon the purpose for which they are to be used. Dormant spray oils should not be applied in summer. These oils are of comparatively low purity and high viscosity, either of which may cause severe injury to both foliage and fruit.

Dormant oil specifications: Straight cut oils should be used, having a viscosity between 100 and 120 seconds Saybolt. The purity or sulphonation test may be relatively low; namely, between 50 and 70.

Summer or foliage oil specifications: Straight, close-cut oils of proper viscosity and purity should be selected. For all practical purposes the viscosity or flow may be expressed by the terms "Light" (viscosity about 50 to 60 seconds Saybolt), "Light Medium" (viscosity about 60 to 68), and "Medium" (viscosity about 68 to 75). One of these grades should be satisfactory for the particular purpose recommended. For most summer oils the sulphonation or purity test should not be lower than 85.

Tank-mix oil sprays. A special type of home-prepared oil spray is the "Tank-Mix" form, perfected by the California Experiment Station. This is a mechanical mixture that may be prepared in the orchard immediately before spraying. Success in using this type of oil spray depends upon the use of a modified high speed agitator in the spray tank and an effective dispersive agent. Especial care must be exercised whenever it is used. Further information may be obtained relative to the "tank-mix" oil sprays from a bulletin that will be issued in the near future covering various phases of orchard tests.

METHODS OF PREPARATION

In the preparation of various emulsions according to the following formulas, care should be taken to measure carefully the amounts of the different ingredients specified. The directions should be followed closely in order to obtain a good product.

Casein-ammonia emulsion. Among the several quick-breaking oil emulsions, one known as a casein-ammonia emulsion is perhaps easiest to prepare. Either dormant or summer oils may be used in the formula.

For a large or stock supply, the ingredients used are in the following proportions:

FORMULA 1

Oil	100 gallons
Water	33 gallons
Casein (finely powdered)	3 pounds
Ammonia (28 per cent solution)	1 quart

Preparation of emulsion (large quantities):

1. Put the required amount of water in the spray tank, start agitator, and add the ammonia.

2. Sift the casein in slowly, allowing about 2 minutes for it to dissolve.

3. Let the oil run into the tank *slowly* from the drum through the inch bung hole.

4. After the mixture has been thoroughly stirred by the agitator for about 2 minutes, pump it through the spray nozzle (opened up wide) at about 250 pounds pressure, into empty drums for storage until it is to be used. A second pumping is advisable if it is to be stored longer than 2 weeks.

Precautions:

The oil should not be added too rapidly or a "reverse" emulsion may form. This will not mix with water and must not be used.

Emulsions should not be made during freezing weather, lest the "reverse" type of emulsion may form. Best emulsions are made when the water and oil are maintained at a temperature between 60° and 70° Fahrenheit. It is preferable to keep the nozzle submerged below the surface of the emulsion, as it is pumped into the storage drum.

Care should be taken to obtain the proper dormant oil for dormant spraying and a summer oil of definite specifications for summer spraying.

Small quantities. When only a few gallons of oil emulsion are needed, the following formula will be found satisfactory:

FORMULA 2

Oil	5 gallons
Water	2 gallons
Casein	3 ounces
Ammonia	2 fluid ounces (about 4 tablespoonfuls)

Preparation of emulsion (small quantities):

1. Pour the water into a half-barrel, small spray machine, or other container and add ammonia.

2. Sift the casein in slowly and stir for about 2 minutes.

3. Add the oil and stir vigorously for a minute or more.

4. Pump the mixture back into itself using either a bucket pump or the spray machine pump.

Casein spreader emulsion. A commercial casein spreader may be substituted for the casein and ammonia in Formula 2. The formula is as follows:

FORMULA 3

Oil	5 gallons
Water	2 gallons
Casein spreader	½ pound

Preparation:

1. Pour the oil into a half-barrel or other convenient vessel.

2. Make a smooth paste out of the casein spreader by adding water slowly and stirring. Continue adding the water until 2 gallons has been added.

3. Pour the oil into this mixture, stirring vigorously, and pump it back into itself with a bucket pump until a creamy emulsion is obtained.

Precautions:

Formula 3 is not recommended for the preparation of large amounts of oil emulsion since Formula 1 may be used with less difficulty.

One-half pound of skim-milk powder mixed with 2 ounces of hydrated lime may be substituted for the casein spreader.

Bordeaux emulsion. A freshly prepared bordeaux mixture may also be used to emulsify oil. The following formula will be found satisfactory:

FORMULA 4

Oil	4 gallons
Copper sulphate (bluestone)	½ pound in 1 gallon water
Calcium oxide (quicklime)	½ pound in 1 gallon water

Preparation:

1. Combine the copper sulphate solution and milk of lime by pouring them together, simultaneously, into spray tank or other vessel, thus forming a freshly prepared bordeaux mixture.

2. Pour the oil slowly into the bordeaux mixture, stirring vigorously.

3. Pump the mixture back into itself or into another container until a smooth emulsion is formed.

Precaution: It is important that fresh bordeaux mixture be used prepared as outlined under page 24.

Stock solutions for Formula 4. If several tanks of spray are to be used during the day, stock solutions of both copper sulphate and lime will facilitate the preparation of the oil emulsion. The stock solution may be prepared as directed under bordeaux mixture, except that ½ pound of each material is dissolved in 1 gallon of water.

Kerosene emulsion. A kerosene emulsion may be prepared by substituting kerosene for the oil in any of the formulas 1, 2, 3, 4 or 5.

PRECAUTIONS IN THE USE OF OIL EMULSIONS

The emulsions formed from any of the foregoing formulas are oil concentrates and must be diluted with water before being used. If the emulsions have been prepared properly they will disperse readily in water, mixing evenly very much as milk mixes with water.

If the emulsion is not properly made or if a "reverse" emulsion is formed, it will not disperse permanently in the water but, like oil, will rise to the top. When this occurs either the broken emulsion or the reverse emulsion, as the case may be, should be discarded, since the oil would cause severe injury if applied to the tree in either condition.

Ordinarily the cold-mixed emulsions are fairly stable and if properly made may last for 2 weeks or longer. It is generally advisable, however, to use them immediately after preparation.

RECOMMENDED COMBINATIONS OF OIL EMULSIONS WITH OTHER SPRAYS

The different oil emulsions prepared by any of the above formulas and most of the commercial emulsions may be combined safely with bordeaux mixture, lead arsenate and nicotine sulphate. For dormant spraying (before any buds show green) the oil emulsions may also be combined with sulphur sprays.

Oil-emulsion lead-arsenate combination. Fill the spray tank about one-third full with water and add the required amount of oil emulsion. Then add ¼ pound of a recommended spreader (for some hard waters, ½ pound may be needed) to each 100 gallons of spray. Finally, when the tank is nearly filled with water, add the required amount of lead arsenate (made to a thin paste with a little water) just before beginning to spray. (For flocculated oil-lead arsenate mixtures, see spreaders.)

Oil-emulsion bordeaux combination. Prepare the bordeaux mixture in the spray tank as described under that title in this bulletin. Mix the required amount of oil emulsion with an equal amount of water, and add slowly to the tank of bordeaux mixture.

Oil-emulsion bordeaux-mixture lead-arsenate combination. Prepare and mix the bordeaux and oil emulsion as described above, and just before beginning to spray, add the required amount of lead arsenate first made to a thin paste with a little water.

Lime-sulphur dry lime-sulphur or other sulphur sprays and oil emulsion combination. Recent experimental orchard tests indicate that sul-

phur sprays may be combined with oil emulsion for dormant spray applications, especially for the control of scale. This combination should never be used in the advanced delayed dormant stage of bud development and never after any leaves are out. Recommendations will be made later if experimental results warrant the use of this combination. If used, the combination may be mixed in the spray tank as follows: cover the agitator with water and while running add the oil emulsion slowly. Fill tank with water and then pour in the lime sulphur solution or other sulphur sprays. Apply immediately.

PRECAUTION

After the dormant period, no oil emulsion should be mixed with any sulphur combination nor follow a lime-sulphur or other sulphur spray within 30 days thereafter. Severe burning may result.

COMMERCIAL EMULSIVE OILS

Emulsive oils are products that contain an oil-soluble emulsifier. There are available on the market two types of commercial emulsive oils. One type is similar to the home-prepared product commonly known as "miscible oil" and contains the cresylic-acid soap mixture as the emulsifying agent; the other type, which contains an oil-soluble emulsifier, is clear and cannot be distinguished by the eye from oil of similar color. The stability of these commercial oil products may vary, depending upon the emulsifier used. Further information regarding any specific brand may be obtained by writing to the Agricultural Experiment Station.

The home-prepared "miscible oils" are recommnded mainly for specific purposes and especially *during the critical period of bud development.* Plants are very susceptible to oil injury at this time and the thin film of oil deposited by the miscible type reduces the chance of injury to a minimum. The home-prepared product should not be used in summer sprays, since the emulsifying agent, cresylic-acid soap, will react with lead arsenate or other arsenical and cause foliage injury.

Preparation of miscible oil:

A miscible oil results when cresylic-acid or cresol and a soft potash soap are blended and then mixed with oil in definite proportions. A dark colored, clear product is obtained that mixes readily with water in all proportions. The concentrated miscible oil may be prepared from the following formula:

FORMULA 5

Oil	5 gallons
Cresylic acid	1 quart
Potash fish-oil soap	2 pounds

1. The potash soap (described in Formula 6) which should contain about 30 per cent moisture, is added to the cresylic acid and thoroughly mixed, using heat if necessary.

2. The mixture is then poured into the lubricating oil and stirred until a homogenous liquid is obtained.

Precautions in making and using concentrated miscible oil. As stated above, the potash soap should contain about 30 per cent water. A soda soap must not be used.

Special care should be taken in diluting concentrated miscible oils, including the commercial brands. The required amount of miscible oil should be measured out and an equal quantity of water added. The water should be added slowly with constant stirring. With the agitator going, this emulsion may then be poured into the spray tank filled with water.

The home-prepared miscible oil may be used successfully where soft water is available. If the water is hard, it may cause a breaking of the emulsion, resulting in the oil separating and floating to the top of the water. For hard water about 2 pounds of soap may be dissolved in hot water and added to the tank of water *before* the miscible oil is added. If the water is very hard, one of the other oil emulsions, previously described, should be used instead of the miscible oil.

Preparation of miscible oil emulsion. Instead of preparing a concentrated miscible oil, as described above, an emulsion containing a larger amount of water can be more easily made, using the same formula as No. 5. The procedure is as follows:

1. Stir the commercial cresylic acid and soap together by warming slightly until a homogenous mixture is obtained. This is then dissolved in 2 gallons of water.

2. Pour the oil into the spray tank, half barrel, or other container, and add the cresylic acid and soap mixture.

3. Stir thoroughly and then pump the mixture back into itself until a smooth, creamy emulsion is obtained. This emulsion may then be diluted with water without taking the extraordinary precaution necessary in diluting concentrated miscible oil.

FISH-OIL SOAPS

Fish-oil soap, often miscalled whale-oil soap, is used extensively in agriculture both as an insecticide and as a spreading agent for certain spray materials. While a pure whale-oil soap may be obtained commercially, most of these soaps are prepared from oil extracted from the refuse of fish canneries. Whale-oil soap is not superior in any way to fish-oil soap.

The commercial fish-oil soap is available both as the potash and as the soda soap. A potash fish-oil soap, containing about 30 per cent moisture, is soft and jelly-like. The soda fish-oil soap, on the other hand, is hard and is usually wrapped in paper like laundry soap.

Potash fish-oil soap. The potash fish-oil soap may be prepared from the following formula:

FORMULA 6

Fish oil	1 gallon
Caustic potash (potassium hydroxide)	1½ pounds
Water	3 pints

The caustic potash is dissolved completely in the water by warming. The fish oil is then added gradually with vigorous stirring. The mixture is finally heated for a short time, stirring until the mass is uniformly smooth.

COMMERCIAL NICOTINE COMPOUNDS

Nicotine compounds for insecticidal purposes are available on the market in numerous forms. Many nicotine dusts and proprietary mixtures are compounded

for special purposes. The most important commercial product, however, is a water solution containing 40 per cent of nicotine as nicotine sulphate. There is also the less commonly used nicotine solution, which is composed of 40 or 50 per cent alkaloid nicotine. The nicotine-sulphate solution is comparatively stable and will last indefinitely if protected from evaporation. The alkaloid nicotine, on the other hand, must be tightly sealed or loss will occur by volatilization.

The 40 per cent solution of either nicotine sulphate or alkaloid nicotine is used ordinarily at the rate of 1 pint to 100 gallons of water. When used in orchard spraying, an alkaline spreader should be added to increase the spreading and wetting action. It is also advisable to add 1 pound of hydrated lime to each 100 gallons of spray to increase the volatility of the nicotine.

Some proprietary spray mixtures that contain nicotine are often of very little value. Usually they are simply the 40 per cent nicotine-sulphate solution diluted with water and combined with small amounts of other spray ingredients. When such mixtures are diluted in accordance with recommendations on the package for spraying purposes, the active ingredients may or may not be too dilute to give effective results.

Nicotine bentonite. A commercial nicotine compound, called Nicotine Bentonite, has shown promise as a stomach insecticide. Most nicotine compounds are used primarily for the control of the soft-bodied insects, such as aphis, and control is obtained by contact. Nicotine Bentonite, however, is recommended for the control of chewing insects and functions similarly to such stomach poisons as the arsenicals.

Home preparation of nicotine dusts. Nicotine dusts may be home-prepared by adding, in the required proportions, either the commercial nicotine sulphate or the solution of alkaloid nicotine to carriers such as sulphur, hydrated lime, gypsum, or other fillers. The Oregon Agricultural Experiment Station will give details regarding the procedure to follow in compounding these dusts and other information pertaining to mixing machines and machinery available for making dust for orchard dusting.

Small amounts of nicotine dusts for garden use may be prepared by simply stirring ¼ pound of a 40 per cent nicotine solution into about 5 pounds of either sulphur or hydrated lime. Care should be taken to crush all lumps in order that the nicotine may be uniformly mixed throughout the batch.

Lead arsenate, dry bordeaux powder, or other dry insecticides or fungicides may be mixed with the home-prepared nicotine dust if desired for general garden use. It is best to use the nicotine dusts within a few weeks after they have been prepared, especially if lime is present in the mixture.

Nicotine dusts may be used advantageously for the control of aphids and certain other insects in both orchards and gardens. Climatic conditions and severity of the infestation in each locality should determine the practicability of using the nicotine dust on a large scale in orchard practice. For the control of insects in the truck gardens, however, the dusting method is often easier than spraying.

Preparation of nicotine spray from home-grown tobacco. Requests are frequently received for a method to make nicotine spray from home-grown tobacco. The preparation of a concentrated nicotine solution similar to the commercial 40 per cent nicotine sulphate requires expensive equipment and cannot, therefore, be home prepared. A dilute water extract of tobacco leaves may be made, however, that contains about the same amount of nicotine as the

commercial product when diluted at the rate of 1 pint to 100 gallons. For this purpose a variety of tobacco, such as nicotiana rustica, should be used that contains on the air-dry basis 2.5 per cent nicotine or higher. This extract may be prepared as follows:

Put into a 50-gallon barrel, 8 pounds of air-dried tobacco (or 40 pounds of the ripe undried plant) and sift over it about ¼ pound of hydrated lime. Then pour in 10 gallons of hot water and stir thoroughly several times during a half hour. Finally add 40 gallons of cold water and stir at intervals for half a day, or about 5 hours. The water infusion may then be strained off and can be used immediately as a spray without further dilution. A suitable spreader such as casein-lime, soap, or wetting agent should be used with all nicotine sprays.

PARADICHLOROBENZENE

Paradichlorobenzene is an excellent soil insecticide and fumigant. In orchard practice it has found wide use for the control of the peach and prune tree root-borers. On account of its physical and chemical properties, caution must be used in order to obtain satisfactory results and to avoid injury to the tree.

Paradichlorobenzene is a white crystalline chemical that is comparatively volatile at 70° to 80° F. It vaporizes more slowly at lower temperatures and if much below 60°, the volatilization is too slow to be effective. The gas is more than five times as heavy as air and consequently is adaptable for the treatment of soil insects by penetrating downward and laterally under the soil.

Very small amounts of paradichlorobenzene are necessary to control soil insects. One ounce is sufficient for full grown trees while only ½ to ¾ ounce should be used on trees 2 to 6 years old. Larger amounts than this are of no increased value and may cause injury, especially if placed too close to the trunks of the trees. In order to obtain best results, the soil should be moist but not water soaked, since the gas will not penetrate a water-soaked soil. On the other hand, the gas will dissipate throughout a dry and porous soil too rapidly to give good control.

Station Circular 109 describes the methods of control of the peach and prune root borer.

Paradichlorobenzine-cottonseed-oil emulsion. The New York Experiment Station reports that an emulsion of paradichlorobenzine in cottonseed oil properly diluted and applied as a spray around the base of the tree gives effective control of the western prune root borer. A stock emulsion may be prepared from the following formula:

Cottonseed oil	1 gallon
Paradichlorobenzine	2 pounds
Potash fish oil soap	1 pint
Water	1 gallon

Preparation. 1. Warm the cottonseed oil to about 90° F. and stir in the paradichlorobenzine until entirely dissolved.

2. Stir the above mixture in the potash fish oil soap until a smooth blend is obtained.

3. Finally, stir in the water until a smooth emulsion is obtained. Before being used the stock emulsion should be stirred thoroughly and then diluted with water at the rate of one part of the emulsion to three parts of water. This diluted emulsion is sprayed on the lower part of the trunk of

the tree and on the ground around the base. One-fourth to 1½ pints of the emulsion is applied to each tree depending upon its age. Further information on the application of this emulsion should be obtained from the Entomology Department of the Experiment Station.

ETHYLENE DICHLORIDE EMULSION

Ethylene dichloride emulsion also is an excellent insecticide for the control of peach and prune tree root borers and has a number of advantages over paradichlorobenzene. It is more effective at lower temperatures and can be used in late fall and early spring. It may be sprayed or poured around the base of the tree without much preparation of the soil. Cupping of the soil around the tree, however, may be necessary to prevent runoff. Different amounts of the dilute ethylene dichloride emulsion must be applied depending upon the age and size of the tree. For information and directions for use write the Experiment Station for latest bulletin.

Ethylene dichloride is a colorless liquid very slightly soluble in water and must be emulsified before being used. The emulsion is available commercially or a stock supply may be home prepared by the following formula:

Ethylene dichloride	1 gallon
Water	1 gallon
Wetting agent (*p 14)	2½ oz.

Preparation. Dissolve the wetting agent in the water and pour in the ethylene dichloride slowly, stirring vigorously. A better and safer emulsion is obtained if the mixture is pumped back into itself by means of a bucket pump. This makes a 50 per cent emulsion that may then be diluted further with water and applied immediately according to directions.

Precautions: Stir the stock emulsion thoroughly just before using it, since the ethylene dichloride tends to separate and come to the top. Keep covered to avoid loss by evaporation.

PYRETHRUM

Pyrethrum is a potent insecticide that is very toxic to many insects. It is the active ingredient of many of the household fly sprays and dusts. The use of pyrethrum has been limited, owing mainly to its cost. It is available commercially, however, in both liquid and dust forms and is recommended for controlling aphids and various other insects. Information regarding the latter will be supplied by the Entomology Department of the Experiment Station.

FLUORINE COMPOUNDS

Numerous fluorine compounds comprising several fluorides, sodium fluosilicate, cryolite, barium fluosilicate, and others have been used successfully as insecticides under certain conditions. However, health officials have established a tolerance of .02 grains fluorine per pound of fruit or vegetable, and consequently the use of this insecticide has been limited. It is recommended that whenever possible a nontoxic material such as the rotenone sprays and dusts or, when necessary, calcium arsenate, be substituted for the fluorine on vegetable crops.

For codling moth control, the fluorine compound, cryolite, either natural or synthetic, has given effective results comparable with lead arsenate. For heavy infestations it is necessary to combine with cryolite, 1 pint of fish or petroleum oil. Fruit washing tests, however, show that it is very difficult to remove the cryolite-oil combination and consequently this mixture is not recommended in Oregon. If the cryolite is used with a neutral spreader such as blood albumen, two or three cover sprays may be applied advantageously without residue complications.

ROTENONE IN DERRIS, TIMBO AND CUBÉ ROOTS

Rotenone, the main active principle in derris, timbo, and cubé roots, is an excellent insecticide for various insects. It is not poisonous to human beings, and for many purposes has proved a good substitute for the arsenicals. Unfortunately, it loses its toxicity rapidly under conditions of sunlight and alkalinity, and consequently must function within a few hours after application. When mixed with certain vegetable oils, the effectiveness of rotenone products is increased materially.

Several grades of powdered derris, timbo, and cubé root are available commercially that may be classified according to their guaranteed rotenone content. The rotenone dusts are prepared by mixing a diluent such as diatomaceous earth, with the powdered root to give a desired rotenone content. Investigations continue in order to learn for what purpose and how these materials may be used most advantageously. Latest information may be obtained by writing the Entomology Department of the Agricultural Experiment Station.

DINITRO ORTHO CYCLOHEXYLPHENOL

Dinitro-O-Cyclohexylphenol, commonly referred to as DN, and its dicyclohexylamine salt incorporated in a proper carrier, have been found very effective for the control of spider mites on hops and nursery stock. As a toxicant in oil these organic compounds have also shown promise for various other insecticidal purposes. Unfortunately, however, they cause very severe injury in comparatively small amounts. When dissolved in oil the combination spray can be used only in the fully dormant stage; when used incorporated in a dust it should be applied only on those plants for which definite recommendations have been made. Further experimental field studies will reveal for what purposes and on what plants these new organic compounds may be safely applied.

SPREADERS FOR SPRAY MATERIALS

The effectiveness of some insecticides and fungicides may be increased by the addition of a spreader that improves the wetting, spreading, or adhering properties of the spray material. Some plant surfaces and certain insects are wetted with difficulty, but if the proper kind of spreader is added to the spray a continuous film of the poison is deposited on the surface to be covered. For general use the home-prepared casein-lime spreader or the skim-milk spreader is recommended. These spreaders also retard the chemical action of some combinations that destroys the individual components of the spray and diminish the possibility of foliage injury.

Commercial spreaders and deposit builders. There are available on the Oregon market many commercial spreaders that may be used advantageously

for specific purposes. Most of them increase the spreading and wetting power of the spray material, but frequently do not increase the fungicidal or insecticidal value and no benefit is derived from their use. Some sprays, however, need to be supplemented by a spreader and their use is advantageous. Since some spreaders may cause foliage injury or may not be designed for a particular purpose, it is important that the orchardist learn when a spreader should be used and the proper procedure for handling it. When improperly used they may be detrimental by causing excessive spray run-off or fruit and foliage injury.

The group of spreaders known as casein spreaders have been on the market for years. These consist mainly of casein and lime together with varying amounts of other ingredients. For most purposes they should be used at about one-third of a pound to 100 gallons of the spray.

Another class of materials now used as spreaders are the various wetting agents mentioned in the footnote on page 14. Very small amounts of these materials should be used, since a slight excess promotes run-off of the spray. Two ounces of the material in 100 gallons of spray generally will suffice. Recommendations should be followed carefully where these spreaders are used.

Soap has long been known as one of the best spreading agents. Care must be exercised in the use of the soaps, however, since they react with many spray materials, especially the arsenicals, and cause foliage injury. On the other hand, when used with the nicotine compounds, soap materially benefits the combination by increasing the wetting action of the nicotine and liberating the active principle that kills the insects.

The group of commercial compounds commonly known as "deposit builders" are not strictly spreaders. Instead they react with the spray material, flocculating it in such a manner that when sprayed the solid is deposited in an even granular state. These materials must be handled very carefully and in accordance with the directions given by the manufacturers. Some deposit builders function only in waters of a certain degree of hardness while others may be effective in either hard or soft water. These deposit builders may be in liquid form and are added directly to the spray tank. Others are dry powders that require the use of a small amount of stove oil, kerosene, or a heavier petroleum oil. Soaps may also be used in combination with a small amount of kerosene or light petroleum oil to increase deposition by flocculation of the lead arsenate in codling-moth control. Again care must be taken in preparing the spray, since the water available may prevent the use of this combination. Your local spray authority should be consulted in the use of any of the above mentioned deposit builders.

HOME PREPARED SPREADERS

Casein spreader. A casein-lime spreader similar to the commercial product may be prepared easily from the following formula:

CASEIN SPREADER

Casein, powdered	1 pound
Hydrated lime	2 pounds

The casein and hydrated lime are thoroughly mixed and then the required amount; namely, 3 to 8 ounces, should be used for each 100 gallons of spray. It is best to make the mixture into a thin paste before adding to the spray tank.

Skim-milk or milk-powder spreader. A satisfactory spreader for some purposes may be prepared by using either skim milk or skim-milk powder. This may be prepared from the following formula:

SKIM-MILK SPREADER

Skim milk	2 quarts
(or milk powder)	½ pound
Hydrated lime	4 ounces

Add the hydrated lime to the skim milk or mix it with the milk powder. This is sufficient spreader for 100 gallons of spray.

Soap spreader. Soap is an excellent spreader but unfortunately it cannot be used safely in combination with many insecticides and fungicides. It may be used advantageously, however, with nicotine sprays and should be added at the rate of 2 to 4 pounds per 100 gallons of spray. The soap should first be dissolved in hot water by shaving into thin strips and stirring until dissolved.

Ammonium-oleate soap spreader and deposit builder. Ammonium oleate is a soap containing a weak base and is less reactive with lead arsenate than sodium or potassium soaps. It may be used as a spreader wherever soap is recommended. Also, properly combined with either kerosene or stove oil, it may be used as a deposit builder and spreader for lead arsenate on apples and pears. Ammonium oleate may be home-prepared from the following formula:

AMMONIUM-OLEATE SOAP SPREADER

Water	3¼ gallon
Ammonium hydroxide, 28 per cent ammonia	⅓ pint
Oleic acid (commonly known as Red oil)	2¾ pint

It is very important that all of the above ingredients be measured out very accurately in order to obtain a soap with a very slight excess of oleic acid. Then proceed as follows:

Preparation: Add the ammonium hydroxide to the water and then pour in the oleic acid very slowly, stirring and whipping the mixture vigorously with a wire whip. Each quart of the mixture will contain ¼ pound of ammonium oleate soap.

PRECAUTIONS IN THE USE OF SPREADERS

It is most important when using any spreader material that care be taken to add the required amount recommended for the particular purpose and for the combination of spray materials to be used. An excess of spreader promotes spray run-off and waste of material.

OIL ADHESIVES

Petroleum, fish, and vegetable oils are excellent adhesives for those spray materials that consist of solid materials such as lead arsenate, bordeaux, rotenone dusts, and similar commercial products. When oils are used in this manner primarily to increase the spray load on the surface covered, they should be classified as adhesive agents and not as spreaders. For this purpose a small amount, only, is necessary, usually 1 pint to 1 quart of the oil to 100 gallons of the spray.

When using oils as an adhesive, the mixture should be prepared in the following manner: Take the required amount of spray material that is in powdered form and add sufficient water to make a thin paste. Then add the oil, whipping thoroughly to incorporate it throughout the mixture. No free oil should come to the surface. Finally, pour into the spray tank of water, and the spray is ready for application.

WHITEWASH

Whitewashing of trees is widely practiced in order to prevent sunburn or winter injury of young trees and for the protection of exposed older trees. A formula tested by O. T. McWhorter, Extension Horticulturist, is as follows:

Powder casein	4 ounces
Quicklime	4 pounds
Skim milk	1 quart

Preparation. 1. Soak the casein in about 1 quart of hot water for 2 hours. Slake the quicklime carefully using about 3 quarts of water. Let stand also for 2 hours.

2. Then add the casein to the quicklime suspension and stir thoroughly for about 5 minutes. Then stir in the skim milk, and the whitewash is ready for application.

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