STATION BULLETIN 336 JUNE 1935

Sprays, Their Preparation and Use

Agricultural Experiment Station
Oregon State Agricultural College
CORVALLIS

TABLE OF CONTENTS

Sprays, Their Preparation and Use

By

R. H. Robinson

INTRODUCTION

THE successful production of orchard and certain 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 home-made products, precautions must be closely observed or the effectiveness of the spray is greatly reduced. Likewise, in the use of commercial products, recommendations must be followed in order to obtain best results.

The introduction of 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 that either reduce the efficiency of the spray materials or form a by-product that causes foliage burn or other harmful effects. A study of these 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 home-made and to emphasize the precautions that should be taken in order to insure best results. Also, general information is given regarding physical and chemical properties of the different commercial products. Their stability, compatability with other sprays, and effectiveness are commented upon.

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 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 Agricultural Experiment Station for further detailed information pertaining to specific insect pests and plant diseases.

Sprays should not be allowed to stand in the spray tank. Sprays should be applied immediately after preparation in the spray tank. Most sprays change chemically after dilution, especially combinations of two or more insecticides or fungicides, and the toxic effect may be reduced. It is very important, therefore, that sprays be applied immediately after preparation and not left in the tank during the noon hour or over night.

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. A compatibility chart is given on page 30 showing recommended combinations for the most important fungicides and insecticides used in the State of Oregon. Additional information is given in Station Circular 68, describing specifically how each spray material should be added to the tank in the course of preparation. This is also emphasized and brought up to date in this bulletin.

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 ARSENATES 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 a basic lead arsenate of variable composition, and commonly referred to as neutral or basic lead arsenate. Investigations at the Oregon Agricultural 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 labeled plainly to distinguish it from the lead hydrogen arsenate, commonly known simply as lead arsenate.

High grade lead arsenate must be high in total arsenic for optimum killing efficiency, low in water-soluble arsenic in order that foliage burn may be reduced to a minimum, and free from foreign impurities. Since most manufacturers have perfected their processes for the production of lead arsenate, high grade material is the rule on the market. The chemical analyses of various brands of lead arsenate are given in Table 1.

TABLE 1. ANALYSES OF DIFFERENT COMMERCIAL BRANDS OF LEAD ARSENATE

Name of manufacturer	Arsenic oxide total	Lead oxide total	Arsenic oxide water-soluble
	%	%	%
Acme White Lead and Color Works	32.0	64.5	.08
California Spray Chemical Corp	32.4	65.0	.24
Chipman Chemical Engineering Co	32.0	63.4	.27
General Chemical Co	31.6	63.4	.15
Pittsburg Plate Glass Co. (Corona)	32.4	64.5	.09
The Dow Chemical Co	32.8	64.7	.22
The Grasselli Chemical Co	32.1	64.1	.11
The Latimer-Goodwin Chemical Co	30.2	64.0	.08
The Sherwin-Williams Co	32.2	64.9	.26

The foregoing table indicates 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 brands that are now on the market. We can conclude, therefore, from these and numerous other analyses, that from the standpoint of

their chemical composition all present brands of lead arsenate are high grade and safe for general use. Also, no difference in the control of codling moth or other insects may be anticipated from the use of any particular commercial brand compared with the others.

RECOMMENDED COMBINATIONS

Lead arsenate may be combined with bordeaux mixture, nicotine sulfate, oil emulsions, and lime-sulfur solution or any of the wettable sulfurs. Precautions to observe are as follows:

Lime-sulfur lead-arsenate combination. Fill the spray tank nearly full with water and add the required amount of lime-sulfur solution or other sulfur spray. Then add either (1) about two pounds of lime and two ounces of zinc sulfate* or (2) one-fourth to one-half pound of casein or other recommended spreader and one ounce of zinc sulfate to each 100 gallons of spray in the tank. Mix the lead arsenate with a little water and add the thin paste to the spray tank just before beginning spraying operations.

Nicotine-sulfate lead-arsenate combination. Fill the spray tank nearly full with water and add the required amount of nicotine sulfate. Add one pound of hydrated lime and one-half pound of spreader to each 100 gallons of the spray. Finally, just before beginning spraying operations, make a thin paste of the lead arsenate and pour it into the spray tank.

Nicotine-sulfate lime-sulfur 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-sulfur lead-arsenate* combination.

Bordeaux lead-arsenate combination. Prepare a full tank of bordeaux mixtures as given on pages 15 to 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 agitator and add about 20 gallons of water to 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

The demand for calcium arsenate or some other metallic substitute for lead arsenate may increase materially during the next few years. 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. Eventually, the use of lead arsenate may not be permitted as a spray on fruit and vegetables.

Certain arsenicals cause injury. Calcium arsenate, zinc 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

*See page 29 for sources of supplies.

arsenicals may be applied to some resistant fruits and vegetables without causing injury, yet burning of foliage may occur under favorable climatic conditions. This may be safeguarded to a limited extent by the addition of a mixture of zinc sulfate and lime (1 pound hydrated lime mixed with 4 ounces of zinc sulfate 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 from the Agricultural Experiment Station.

Calcium arsenate and paris green have been found to be very effective poisons in several baits, such as those used for slugs, cutworms, strawberry weevil, etc.

Recommended combinations. Calcium arsenate or zinc arsenite or arsenate may be combined with lime sulfur, nicotine sulfate, bordeaux mixture, or oil emulsions. The order of mixing in the spray tank is the same as given for lead arsenate on page 5, except that the above arsenicals replace the lead arsenate.

LIME SULFUR

Lime sulfur is the most important of the sulfur sprays. It is an efficient contact poison for certain scale insects and an important fungicide for several fungous diseases. When sulfur is combined chemically with calcium under certain conditions it forms calcium polysulfide, the principal active ingredient in lime-sulfur solution. The effectiveness of lime-sulfur solution as a dormant spray is largely due to the ability of the calcium polysulfide to take up oxygen.

COMMERCIAL LIME-SULFUR SOLUTION

Commercial brands of concentrated lime-sulfur 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

TABLE 2. DILUTION TABLE FOR LIQUID LIME SULFUR

Strength of concentrated lime-sulfur solution		To make 100 gallons of dilute spray use the number of gallons of concentrated lime sulfur indicated in the columns below, and add water to make 100 gallons.				
Degrees Baumé	Specific gravity	1. Dormant strength for scale clean-up (5.2° Baumé)	2. Dormant 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

indicated by means of a hydrometer that registers the density or Baumé reading. The different brands of commercial lime sulfur 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-sulfur solution in order that dilutions may be made in accordance with recommendations for specific spraying purposes. The orchardist is advised to test the lime-sulfur solution with a Baumé hydrometer and make dilutions for spraying in accordance with Table 2.

The commercial brands of various dry lime-sulfur and sulfide products are discussed on page 4.

HOME PREPARATION OF LIME-SULFUR SOLUTION

Care should be exercised in the preparation of lime-sulfur solution in order to obtain as complete a reaction as possible between the lime and sulfur and to prevent the formation of excess sludge.

Chemical tests and practical trials have shown that lime and sulfur, when boiled in the proper amount of water, will go into solution best in the proportion of 1 part of lime to about 2 parts of sulfur. For the orchardist who makes his own lime-sulfur solution, the ingredients may be used in the following proportions:

Quicklime (stone lime)	50 pounds
Sulfur (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 different amounts of concentrated lime-sulfur solution.

To prepare small amounts—50 gallons, for example—the following procedure will be found practicable:

1. Place in an 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 bring to a boil.

2. Dump in the required amount of lime (50 pounds) and allow to slake. (The quicklime will slake without burning or drowning provided the water is near the boiling point.)

3. Add the required amount of sulfur (100 pounds), cover with boards, and bring to a boil quickly. Then boil for 45 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.

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

Overboiling or underboiling also 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-sulfur solution. Every orchardist should obtain from the druggist a Baumé hydrometer in order that he may test his lime-sulfur solution, 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. Make dilutions for spraying in accordance with Table 2.

To prepare large amounts. If steam is available, quantities may be prepared limited only by the size of the vessel used. For a 100- to 1000-gallon outfit, a single circular perforated steam coil may be placed near the edge and on the bottom of the tank or other vessel. A mechanical agitator with sweeping arms rotating on a shaft is fitted at the bottom and in the center of the vessel. Over this a half-inch-mesh wire screen cut to fit the vessel is supported by blocks about four inches above the bottom. The agitator revolves between this screen and the bottom of the vessel.

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

1. Run in 300 gallons of hot water and start agitator. Place 550 pounds of the quicklime on the screen and allow to slake.

2. After the lime has slaked turn in more hot water to a thin milk of lime and add 1,000 pounds of powdered sulfur.

3. Add hot water to make a total volume of about 500 gallons, cover, turn on the steam, and boil about 45 minutes or until all of the free sulfur has apparently disappeared. During the boiling process add hot water occasionally, if necessary, to maintain a volume of 500 gallons.

4. The finished product is allowed to cool and after the sludge has settled the clear liquid may be drawn off into storage barrels. This should test about 30° Baumé.

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

RECOMMENDED COMBINATIONS

Lime-sulfur solution, either the home-prepared or the commercial product, may be combined with lead arsenate and nicotine sulfate in accordance with the following directions:

Lime-sulfur, lead arsenate (or other arsenical) combination. Follow directions as given on page 5.

Lime-sulfur, nicotine-sulfate combination. Fill the spray tank nearly full with water and add the required amount of lime-sulfur solution. Add 2 pounds of hydrated lime and ¼ pound of a spreader (if desirable), for each 100 gallons of spray. Dilute the required amount of nicotine sulfate with an equal amount of water and add to the tank.

Nicotine-sulfate, lime-sulfur, lead-arsenate combination. Follow directions as given on page 5.

COMMERCIAL DRY SULFIDE SPRAYS

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

Barium-tetra-sulfide (B.T.S.) has been shown to be a fairly effective contact poison, but it possesses no distinct advantage over the lime-sulfur 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 sulfide. Recent tests by Hurt and Schneiderhan of the Virginia Experiment Station have shown that calcium sulfide is a valuable fungicide for summer spraying. Excellent results were obtained in the control of scab and brown rot on peaches.

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

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

Dry lime sulfur is the product obtained in the dehydration of the concentrated lime-sulfur solution. Apparently there is partial decomposition of the polysulfides during the process of manufacture since the percentage of both free sulfur and thiosulfate sulfur is higher and the polysulfide sulfur is lower than the amounts found in the concentrated lime-sulfur solution calculated on a dry basis. The most recent guaranteed composition of dry lime sulfur at this writing is as follows:

	Per cent
Calcium polysulfide	70.0
Calcium thiosulfate	5.0
Free sulfur	10.0
Inert ingredients	15.0

It may be considered therefore that, for *summer spraying*, about 85 per cent of the dry lime sulfur consists of active ingredients and 15 per cent of inert materials that are of no value as a spray. For dormant spraying, however, the 10 per cent free sulfur also is inert, while the 5 per cent calcium thiosulfate has little or no value.

Summer spraying with dry lime sulfur. The amount of dry lime sulfur to use for summer spraying may be calculated on the basis of the foregoing analysis. For any bad summer infestation, such as scab, the amount of active ingredients present in a gallon of dissolved dry lime sulfur should be equivalent to that present in a gallon of liquid lime sulfur of any recom-

mended strength. An average analysis for lime-sulfur solution, 32° Baumé, is as follows:

	Per cent
Calcium polysulfide	30.5
Calcium thiosulfate	1.5
Water	68.0

A gallon of lime sulfur 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 sulfur is used either for the dormant spray or for the summer sprays it should be applied in amounts equivalent to the liquid lime sulfur in order to obtain equivalent protection. Since each gallon of lime-sulfur solution contains 3.4 pounds of active ingredients it would take, for summer application, 4.0 pounds of a dry lime sulfur having 85 per cent active ingredients to be equivalent to one gallon of concentrated 32° Baumé liquid lime sulfur. Therefore, in making dilutions for the various sprays 4.0 pounds of the dry lime sulfur should be used for each gallon of liquid lime sulfur, 32° Baumé, 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, the smaller amounts recommended by manufacturers may give control.

Dormant spraying with dry lime sulfur. From the composition of dry lime sulfur 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 sulfur should be dissolved in 1 gallon of water to be equivalent to 1 gallon of liquid lime sulfur, 32° Baumé.

For dormant spraying, scale clean-up, dry lime sulfur should be used at the rate of at least 60 pounds to 100 gallons. This amount dissolves with difficulty and more than ordinary care must be exercised in order to bring the maximum amount of the dry lime sulfur into solution. If 10 gallons or more of hot water is used, the dry lime sulfur 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 sulfur 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 to dissolve all of the dry lime sulfur. If these precautions are not taken, solid particles of the dry lime sulfur will 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 above will give control only where light infestations occur.

"WETTABLE SULFUR" FOR SUMMER SPRAYS

Mixtures in which sulfur is the active ingredient have been recognized for some time as the best summer fungicide. Until comparatively recently the self-boiled lime sulfur was the standard spray used. This has been superseded by the "wettable sulfur" 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 crop.

Many commercial brands of wettable sulfur are available on the Oregon market. These are combinations of sulfur mixed with some substance such as casein, starch, lime, or glue that aids in wetting the sulfur when mixed with water. The quality of the different brands of wettable sulfur depends on the grade of sulfur used in the product. Very finely ground sulfur or high-quality dusting sulfur produces the most effective product. In addition to the sulfur, the commercial brands may contain varying amounts of hydrated lime, depending on the purpose for which they are to be used. For use on foliage susceptible to injury, brands containing an excess of lime should be used. For the more resistant foliage very little lime is necessary. If a commercial brand of wettable sulfur is to be used, the orchardist should ascertain for what specific purposes it is intended.

SELF-BOILED LIME SULFUR

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

OREGON COLD-MIX WETTABLE SULFUR

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

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

Formula 1. Oregon cold-mix wettable sulfur

Sulfur (superfine, passing 300-mesh sieve)	8 pounds
Hydrated lime	1 pound
Skim milk	3 quarts

The foregoing amounts may be proportionately increased or decreased depending on the quantity of sulfur needed. Temperature conditions may require the addition of more lime to prevent burn.

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

2. Add an equal amount of water to 2 quarts of skim milk. Pour this onto the sulfur 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 the required amount of water, and the spray is ready for application.

Precaution. In order to produce a good quality of spray, it is important that the sulfur should be ground superfine. Ninety per cent or more should pass through a 300-mesh sieve. If skim milk is not available, whole milk may be used with equal effectiveness. Dry skim-milk powder may also be

substituted for the ordinary skim milk. The powder should be mixed with a little lime and dissolved in water at the rate of 4 ounces to each quart of water. This amount will be equivalent to 1 quart of skim milk.

OREGON WETTABLE SULFUR

Hydrated lime is used in Formula 1, primarily to reduce sulfur burn to 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 sulfur and also increase the deposit per unit area of surface sprayed. Some of the new commercial wetting agents such as Vatsol, Hydralene, and Areskap promote wetting of sulfur and also increase spreading of the mixture. To facilitate dilution with water one of these should be used. Milk powder acts as a binder for the other ingredients.

For the preparation of a stock supply of this dry wettable sulfur mixture, the following formula may be used:

Formula 2. Oregon wettable sulfur

Sulfur, superfine (90 per cent passing 300-mesh sieve)	50 pounds
Bentonite or other filler	10 pounds
Skim-milk powder	3 pounds
Wetting agent	2 pounds

Preparation. 1. Weigh out the proper amounts of the 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 containing about 25 pounds of small stones 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. One of the following methods may be used:

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

2. Enough water is added to the spray tank to cover partially the paddles. With the agitator going, the sulfur mixture is sifted slowly into the tank. The tank 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 sulfur 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.

NEW JERSEY DRY-MIX WETTABLE SULFUR

The New Jersey Experiment Station has developed an excellent wettable sulfur that has given good results in field tests, when sulfur burn

may occur. The mixture is composed of the dry materials, which may be prepared at any time and used when necessary. The formula used for making 50 gallons of spray is as follows:

Formula 3.

Sulfur	8 pounds
Hydrated lime	4 pounds
Calcium caseinate	½ pound

The foregoing amounts may be proportionately increased or decreased, depending on the quantity desired.

Preparation. 1. Weigh out the proper amounts of sulfur, hydrated lime, and calcium caseinate.

2. If necessary, sift both sulfur and lime through a small-mesh sieve in order to remove all lumps.

3. Mix together the three ingredients thoroughly in order to obtain a uniform mixture.

Dilution. The New Jersey Experiment Station recommends that the dry-mix material be used at the rate of 12½ pounds to 50 gallons of water. Any of the following methods may be used for diluting with water.

METHOD 1. Place the proper amount of material in a barrel, or other container which will hold water. Add water slowly, stirring the mixture until the grains of sulfur are wet and a thin solution is obtained that will pass readily through a strainer into the spray tank. Strain the material into the spray tank after filling it at least one-half full of water. This method is recommended particularly for use with hand outfits or where it is not convenient to have the agitator running when the tank is being filled.

METHOD 2. Wash the proper amount of dry-mix lime and sulfur through the strainer into the spray tank with the agitator running. This method can be used to advantage only where a strong flow of water from an overhead pipe or hose is available. The strainer used should not have more than 12 to 14 meshes to the inch.

METHOD 3. Put the proper amount of dry-mix directly into the spray tank after filling it at least one-half full of water. As in Method 2, the agitator should be running when the dry material is added in order to insure a thorough mixture with a minimum amount of settling. Open up the nozzle or spray-gun and drive a stream of the liquid that is being forced through the hose directly into the dry material as it falls upon the surface of the water in the tank.

RECOMMENDED COMBINATIONS OF WETTABLE SULFURS

Any of the sulfur mixtures described above or similar commercial wettable sulfurs may be combined safely with lead arsenate, nicotine sulfate, and bordeaux mixture.

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

DUSTING SULFUR MIXTURES

A sulfur 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 sulfur

Sulfur (superfine dusting, passing 300-mesh screen)	60 pounds
Bentonite, diatomaceous earth, or other superfine filler	40 pounds

(These proportions may be varied to suit any particular purpose.)

Preparation. The ingredients may be weighed out and transferred to an end-over-end-barrel mixer of convenient size. Then add about ½ pound of stones the size of a hen's egg for each pound of dust to be mixed. The barrel should then be turned until the sulfur and inert filler are thoroughly mixed.

If another insecticide or fungicide that needs to 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 amount. For example, when lead arsenate is used this may be added to the mixture to give a dust containing 10 per cent lead arsenate.

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 large extent by sulfur sprays and other materials; yet for certain diseases such as apple-tree anthracnose, peach-leaf curl, peach blight, potato late blight, celery blight, etc., bordeaux is still the most efficient and safest 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 adheres well and has excellent spreading properties. For some uses a spreader may be beneficial, especially when commercial bordeaux is used.

COMMERCIAL BORDEAUX MIXTURE

Laboratory experiments confirmed by field tests have, in the past, shown the superiority of carefully prepared home-made bordeaux over the commercial brands. During the last few years, however, the physical properties of dry bordeaux mixtures have been greatly improved, and recent field tests by the Oregon Station have shown that a few commercial brands possess adhesive qualities comparable to the home-prepared product.

There are on the market several commercial brands of powdered bordeaux mixture, the copper content of which ranges between 10 and 20 per cent. Any 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. 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" bordeaux. Several commercial brands of this type of bordeaux mixture are available on the Oregon market, most of which have given good results.

The two-powder bordeaux consists of two packages. One package contains powdered bluestone or copper sulfate, 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 copper sulfate 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 sulfate 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 unless care is taken to dissolve the bluestone completely. If the contents of the lime package are a left-over from the previous year's stock, a poor grade bordeaux will likewise result.

HOME-MADE BORDEAUX MIXTURE

Carefully prepared home-made bordeaux mixture is unexcelled by any commercial brands available on the market. When properly made, a gelatinous, colloidal suspension of basic copper sulfate 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 home-made bordeaux than for any of the commercial brands tested.

The home-made bordeaux mixture is produced when a solution of copper sulfate (bluestone) and milk of lime are poured together. A chemical reaction takes place between the copper sulfate and the lime which results in the formation of a voluminous precipitate. In order to obtain optimum adhering qualities, the following method 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, the 4-4-50 formula is as follows:

4-4-50 Formula

Copper sulfate (bluestone)	4 pounds
Quicklime (stone lime or process lime)	4 pounds
Water	50 gallons

Other formulas have frequently been advised for specific purposes such as 1-1-50; 3-3-50; 3-6-50; 5-5-50; 6-6-50; 6-8-50; and 8-4-50. The first number indicates amount of copper sulfate to use.

A powdered quicklime or lump lime commonly referred to as "processed lime" is now available. If recently manufactured, it may be substituted for the lump lime. In recent years high-grade hydrated lime has been offered on the market. If properly used, it also may be substituted for the

quicklime. The low-grade hydrated lime commonly used for correcting soil acidity must not be used. The highest-grade hydrated lime available is sometimes referred to as "chemical" hydrated lime in contrast to that used for general plastering and other purposes.

If the chemical grade hydrated lime is not available, however, any other good 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 several hours or over night before using.* When the hydrated lime is used, about one-third more by weight than quicklime should be taken. The 4-4-50 formula then is as follows:

Copper sulfate (bluestone)	4 pounds
Hydrated lime	5½ pounds
Water	50 gallons

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

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

1. Dissolve one-half pound of bluestone in three gallons of water.
2. Slake one-half pound of quicklime and add water to make three gallons.
3. Pour these two solutions together simultaneously into a third vessel. This will make six gallons of 4-4-50 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 sulfate and lime. A convenient concentration of each is one pound to a gallon of water and may be prepared as follows:

(a) **Copper sulfate** (bluestone) in lump form may be dissolved easily by filling a 50-gallon wooden barrel about six inches from 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 ten hours or overnight. If hot water is used the copper sulfate 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 sulfate.

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) **Lime solution.** 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.

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

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 one pound of quicklime to one gallon of water.

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 sulfate 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 using the stock solutions described above. The following quantities are for the preparation of a 50-gallon tank of the 4-4-50 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 four gallons and pour through a 20-mesh strainer into the spray tank.

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

4. Pour four gallons of the stock copper sulfate solution (a) into the *trough* slowly in order that it will be diluted as much as possible by the intake water.

5. The bordeaux is now ready for spraying. It should be applied immediately instead of allowing it to stand.

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. In the preparation of a 300-gallon spray tank of the 4-4-50 bordeaux, 24 gallons of the milk of lime (b) and 24 gallons of the copper sulfate (a) solution will be required. As the last gallon of the copper sulfate solution is being poured into the trough with the intake water, the tank should be nearly filled.

For every 50 gallons of tank capacity, with formulas other than the 4-4-50 formula, use as many gallons of the respective stock solutions as are called for in the formula.

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 several hours before using.

2. Dilute the stock solutions of copper sulfate 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 precipitate that is so essential in the formation of a membrane that causes adherence to the surface sprayed.

The tests of the Oregon Agricultural Experiment Station indicate that ⅛ ounce of sugar should be used for each pound of copper sulfate in the spray. For example, in a 100-gallon tank filled with 4-4-50 bordeaux mixture there were 8 pounds of copper sulfate used. Therefore 8 × ⅛ 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 sulfate is substituted for the copper sulfate.

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

When preparing the combination spray always add any of the foregoing materials to the tank of prepared bordeaux mixture after starting the agitator and just before application.

Oil emulsion should be mixed with two times its volume of water before adding *slowly* to the bordeaux mixture.

BURGUNDY MIXTURE

This spray is sometimes used in place of bordeaux in sprays for small fruits shortly before picking because it does not leave the objectionable deposit on the fruit which 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.

Preparation. 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 sulfate (bluestone)	2 pounds
Sodium carbonate (sal soda)	3 pounds
Water	100 gallons

MINERAL OR LUBRICATING OIL EMULSIONS

The use of mineral or lubricating oil emulsions, both as dormant and summer sprays, has come into prominence within the past few years. Recent investigations have shown that the selection of an oil for specific 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 to be 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, 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 home-prepared and commercial emulsions, is sometimes confusing. For the purpose of differentiation, the home-prepared oil sprays may be classified as either soap emulsions or 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 is less stable and releases most of its oil when the spray strikes the tree. Either casein, bordeaux mixture, or colloidal clay may be used as the emulsifying agent.

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 emulsion, 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 a soluble emulsifier is used and have the appearance of pure oil), jell-type emulsions, flowable emulsions, tank mixed oils and two-package oil emulsion preparations. Since the manufacturers are continually changing their emulsions from year to year, it is impossible to give definite, general information regarding them. Too many brands of the stable, less effective types are on the market and, except for various specific purposes, these are not recommended. 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. A sample of the emulsion should accompany the request.

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 oil should not be applied in summer spraying. 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 sulfonation test may be relatively low—between 50 and 70.

Summer 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), "Light Medium" (viscosity about 60 to 68 seconds), and "Medium" (viscosity about 68 to 75 seconds). One of these grades should be taken for the particular purpose recommended. The sulfonation or purity test should not be lower than 85.

Tank-mix oil sprays. A new 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. Because of limited practical experience with this type of spray, it must be used with care. Further information may be obtained relative to the "tank-mix" oil sprays from Circular 107, Agricultural Experiment Station, and from a bulletin to be issued in the near future covering various phases of the subject.

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 as closely as possible 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 emulsions (large quantities). 1. Put the required amount of water in the spray tank, start pump, and add the ammonia.

2. Sift the casein in slowly, allowing about two 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 two 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 two 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 or 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° F. It is preferable to keep the nozzle submerged below the surface of the emulsion as the latter is pumped into the storage drum.

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

Preparation of emulsions (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 3 tablespoonfuls)

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 two minutes.

3. Add the oil, stirring 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 (*see* Formula 3).

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 slowly adding water and stirring. Continue adding the water until the 2 gallons has been added.

3. Pour this mixture on to the oil and pump it back into itself until a creamy emulsion is obtained.

Precautions. This formula is not recommended for the preparation of large amounts of oil emulsion. Formula 1 may be used with less difficulty when larger amounts are desired.

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 sulfate (bluestone).....½ pound in 1 gallon water
Calcium oxide (quicklime).....½ pound in 1 gallon water

Preparation. 1. Combine the copper-sulfate 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 freshly prepared bordeaux mixture be used, or a poor emulsion will result.

Stock solutions for formula 4. If several tanks of spray are to be used during the day, stock solutions of both copper sulfate 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, or 4.

PRECAUTIONS IN THE USE OF OIL EMULSIONS

The emulsions formed from any of the foregoing formulas are concentrated and must be diluted with water before using. If the emulsions have been prepared properly they will disperse readily in water, mixing evenly throughout 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 in the water but, like oil, will float on top of the water. When this occurs the broken emulsion or reverse emulsion, as the case may be, should be discarded since it would cause severe injury if applied to the tree without being properly emulsified.

Ordinarily any of the above mixed emulsions are fairly stable and if properly made may last for weeks. It is generally advisable, however, to use them immediately after preparation.

RECOMMENDED COMBINATIONS OF OIL EMULSIONS WITH OTHER SPRAYS

With the exception of the home-prepared miscible oil, the different oil emulsions may be combined safely with bordeaux mixture, lead arsenate, and nicotine sulfate, as follows:

Oil-emulsion lead-arsenate combination. For tank quantities of 200 gallons or more, the required amount of oil emulsion should be placed in the tank first, and then, with the agitator going, the water should be turned in. Follow immediately by adding 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.

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 full of bordeaux mixture.

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

PRECAUTION

No oil emulsion should be mixed with a sulfur spray nor follow a lime-sulfur or other sulfur spray within 30 days thereafter. Severe burning may result.

MISCIBLE OIL

The home-prepared "miscible oils" are recommended mainly for dormant sprays *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 for 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.

A concentrated miscible oil results when cresylic acid or cresol and a soft potash soap are mixed with oil in definite proportions. The potash soap should contain about 30 per cent moisture. The soap will then combine with cresylic acid and form a liquid product. This liquid combination may then be dissolved in the oil forming a miscible oil.

Commercial miscible oils. There are available on the market two types of commercial miscible oils: One similar to the home-prepared product, having a cresylic acid-soap mixture as the emulsifying agent, and the other type that uses various emulsifying agents that dissolve in the oil. The latter type may be used for both winter and summer spraying, *provided the proper oil* is used in its preparation. The commercial product may be either stable or quick-breaking. Further information regarding any specific brands may be obtained by writing to the Chemistry department of the Agricultural Experiment Station.

Preparation of miscible oil. A concentrated miscible oil may be prepared from ingredients used in the following proportions:

Formula 5

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

1. The potash soap, (described in Formula 6) or a commercial potash soap containing 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 homogeneous liquid is obtained.

Precautions in making and using concentrated miscible oil. As stated above, potash soap containing about 30 per cent water should be used. Soda soap cannot be used. The potash soap should not contain much free alkali.

Special care should be taken in diluting the concentrated miscible oil, either the commercial brands or the home-made product, for spraying. The amount of miscible oil to be used should be measured out and an equivalent quantity of water added. The water should be added in small amounts at first, with constant stirring. This emulsion of concentrated miscible oil and water may then be poured into the spray tank already filled with water. The agitator of the spray tank should be in motion during the process of adding the diluted miscible oil.

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. If the water is not too hard, two or more pounds of soap may be dissolved in hot water and added to the tank of water *before* the miscible oil is added. This then may be followed by the addition of the diluted miscible oil. 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 may 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 homogeneous mixture is obtained. This is then dissolved in two 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. 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 mis-called 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 70 per cent dry soap, 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 gradually added with vigorous stirring. The mixture is finally heated for a short time with thorough 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 sulfate. There is also the less commonly used nicotine solution, which is composed of 40 per cent free nicotine. The nicotine-sulfate solution is comparatively stable and will last indefinitely if protected from evaporation. The free nicotine, on the other hand, must be tightly sealed or loss will occur by volatilization.

The 40-per cent solution of either nicotine sulfate or free nicotine is used ordinarily at the rate of 1 pint to 100 gallons of water. When used in orchard spraying, a recommended spreader should be added to increase the spreading and wetting action. It is also advisable to add one or two pounds of hydrated lime to each 100 gallons of spray to increase the volatility of the nicotine.

The various commercial proprietary spray mixtures that contain nicotine are often of very little value. Usually they are simply the 40-per cent nicotine-sulfate 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 have been so diluted that they have comparatively little value for the purpose intended.

Nicotine Bentonite. Recently a commercial nicotine compound, called Nicotine Bentonite, has been developed as a stomach insecticide. Most nicotine compounds are used primarily for the control of the soft-bodied insects, such as aphis, and control is attained by contact. Nicotine Bentonite, however, is for control of chewing insects, and functions similarly to such stomach poisons as the arsenicals. Further investigations utilizing this insecticide may disclose new uses for it. As these developments materialize, recommendations will be made accordingly.

Home preparation of nicotine dusts. Nicotine dusts may be home prepared by adding, in the required proportion, either the commercial nicotine sulfate or the solution of free nicotine to carriers such as sulfur, kaolin, hydrated lime, gypsum, or other fillers. The Chemistry department of 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 one-fourth pound of free nicotine solution into about five pounds of either sulfur or hydrated lime and passing the mixture through a ¼-inch-mesh wire screen. Care should be taken to crush all lumps in order that the nicotine may be uniformly mixed throughout the batch. The 40-per cent nicotine-sulfate solution may be used instead of the free-nicotine

solution, but it is somewhat more gummy and forms more lumps. Send for circular of information on control of aphids.

Lead arsenate, dry bordeaux powder, or other dry insecticides or fungicides may be mixed with the foregoing prepared nicotine dust if desired for general garden use. One pound of lead arsenate or commercial bordeaux to 5 pounds of the nicotine dust will be sufficient. It is best to use the nicotine dusts within a short time after they have been prepared.

Nicotine dusts may be used advantageously for the control of aphids and certain other insects in both orchards and gardens. Climatic conditions 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 superior to spraying.

Preparation of nicotine solution from home-grown tobacco leaves. Several inquiries are received annually requesting a method for the preparation of nicotine spray similar to the 40 per cent nicotine sulfate. It is impracticable for the average grower to endeavor to make the concentrated nicotine spray, even though tobacco may be grown successfully in this part of the country. For those who have available home-grown tobacco, however, most of the nicotine may be extracted and the diluted extract used as a spray. The procedure requires drying and crushing or chopping of the green tobacco leaves and then extraction of the nicotine with a hot solution of milk of lime. For more detailed information, write to the Chemistry department of the Agricultural Experiment Station.

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 70° the volatilization is too slow to be effective. The gas is more than five times as heavy as air and consequently it is adaptable for the treatment of soil insects by penetrating downward and laterally under the soil.

Very small amounts only of paradichlorobenzene are necessary to control soil insects. One ounce for young trees, ranging up to 3 ounces for large trees, is sufficient. Larger amounts than this are of no 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 would dissipate throughout a dry and porous soil too rapidly to give good control.

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

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 in the past has been limited, owing mainly to its cost. Recently, however, it has come upon the market in both liquid and dust forms and is recommended for controlling aphids and various other insects. Its future use depends on cost and its relative effectiveness in the control of certain insects. Information regarding the latter will be supplied by the Entomology department of the Agricultural 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. Health officials, however, have established a tolerance of .01 grain fluorine per pound of fruit or vegetable and consequently the use of this insecticide has been limited. It is recommended that whenever possible calcium arsenate be substituted for the fluorine sprays on vegetable crops.

For codling-moth control, certain fluorine compounds have shown promise, but in order to obtain effective results, they must be combined with petroleum or fish oil. Since it is more difficult to remove the fluorine-compound fish-oil residue than lead arsenate, there is no reason why it should be used in preference to the latter. Furthermore, it is necessary to use sodium silicate as the solvent for the removal of fluorine fish-oil residues and most of the washing equipment now used in Oregon is designed primarily to handle acid as the washing solvent.

For certain specific purposes, however, such as poison baits and as a spray or dust on some plants, the fluorine compounds may be used advantageously. Recommendations for these purposes may be obtained from the Entomology department of the Agricultural Experiment Station.

ROTENONE IN DERRIS AND CUBÉ ROOT

Rotenone, the active principle in both derris root and cubé root, is an excellent insecticide for certain insects. It is not poisonous to human beings, and for some purposes has proved a good substitute for the arsenicals. Unfortunately, it breaks down chemically under conditions of sunlight and alkalinity, and consequently will not find wide application until further stabilized.

At present both powdered derris root and cubé root are available commercially. Investigations are under way to determine how these materials may be used most advantageously, and latest information may be obtained by writing the Agricultural Experiment Station.

SPREADERS FOR SPRAY MATERIALS

The effectiveness of some sprays is increased by the addition of a harmless substance that will improve the wetting, spreading, and 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 materials have added value when correctly used in certain combination sprays described in Station

Circular 68. These spreaders also retard the chemical action of combination sprays that destroys the individual components of the spray and diminishes the possibility of foliage injury.

Commercial spreaders. There are available on the Oregon market several commercial spreaders that may be used advantageously for specific purposes. The claims made by some manufacturers of benefits derived from the use of their product are sometimes exaggerated. Furthermore, some commercial spreaders may cause injury to foliage, or may influence the removal of the spray residue. It is therefore important that the orchardist ascertain whether a spreader can be used safely.

The casein spreaders have been on the market for several years. These spreaders consist of a mixture of casein and lime together with small amounts of other material. They may be used without causing injury.

Soap also may be considered one of the best spreading agents. Care must be exercised in the use of soaps, however, since they may react with the spray material and cause foliage injury. On the other hand, when used with certain sprays such as nicotine sulfate, soap materially benefits the combination by increasing the wetting action of the nicotine and liberating the active principle that kills the insect. Recently neutral soaps have been placed on the market, that are recommended for use in combination with lead arsenate to increase spreading and spray load. Since only about ¼ pound of this special neutral soap is recommended for each 100 gallons of spray, chances for injury are reduced to a minimum. Under favorable conditions, however, even these especially prepared neutral soaps cause burning. Other soaps prepared with weak bases and combined with kerosene or a light oil have shown promise by depositing a fluffy, evenly covered load of lead arsenate that has aided materially the control of codling moth. Before using these newer materials, detailed information regarding them should first be obtained from the Chemistry department of the Agricultural Experiment Station.

Another class of material which may find a place as a spreader or wetting agent for insecticides and fungicides is the new wetting agents now used with washing solvents to aid in the removal of spray residue. They are known by the trade names Vatsol, Hydralene (or Detergent E), Areskap, and others. Recommendations for their use will be given as experimental results warrant.

Home-prepared spreaders. A casein-lime spreader similar to the product available on the market may be prepared as follows:

Casein-lime spreader

Casein, powdered	5 ounces
Hydrated lime	10 ounces
Water	100 gallons

The hydrated lime is thoroughly mixed with the casein and then water is slowly added to form a thick paste. Care should be taken not to add too much water at first since lumping will occur. After stirring until all lumps are removed, more water is added to make a very thin paste.

This is sufficient spreader for 100 gallons of spray.

Skim-milk or milk-powder spreader. A satisfactory spreader for some purposes may be prepared by using skim milk. This may be prepared as follows:

Skim-milk spreader

Skim milk	3 quarts
(or milk powder	.5 pound)
Hydrated lime	6 ounces
Water	100 gallons

The hydrated lime is stirred into the skim milk. This mixture is then added to 100 gallons of spray. The skim-milk spreader may be used for most purposes for which the casein-lime spreader is used.

Soap spreader. Soap is an excellent spreader but unfortunately it cannot be used except in certain sprays. It increases the toxic action of the nicotine sprays but will cause severe foliage injury if used in an arsenical spray. It cannot be used with lime-sulfur solution or bordeaux mixture.

For use in combination with nicotine for aphid control of garden crops, the following combination will be successful:

Soap spreader

Fish-oil soap or laundry soap	4 pounds
Water	100 gallons

The soap is shaved into thin strips and dissolved in hot water. This is sufficient for 100 gallons of nicotine spray. (Never use this soap spreader with lead arsenate, lime-sulfur, or bordeaux mixture.)

Precautions in the use of spreaders. When using any spreader material, care should be taken to add the required amount recommended for the purpose intended. When an excess of spreader is used it promotes spray run-off and waste of materials. Consequently, instead of increasing control, poorer results are obtained.

FISH-OIL ADHESIVES

Fish oil is an excellent adhesive for those sprays that consist of solid materials, such as bordeaux mixture, especially the commercial product. It should be classified primarily as an adhesive agent and not as a spreader. Fish oil used in proper amounts increases the spray load on the surface covered, and aids in its retention over a long period of time.

A definite amount of fish oil is used for each specific purpose. For example, if used with 4-4-50 bordeaux mixture, 1 quart is sufficient for 100 gallons of spray. On the other hand, when used with lead arsenate, 2 pounds to 100 gallons, ½ pint of fish oil is sufficient.

When using fish oil, it should be combined with the other spray materials in the following manner: Take the required amount of spray material that is in powder form and add water, stirring to a thin paste. Then add the required amount of fish oil to the paste, whipping thoroughly to incorporate it throughout the mixture. No free oil should come to the surface .

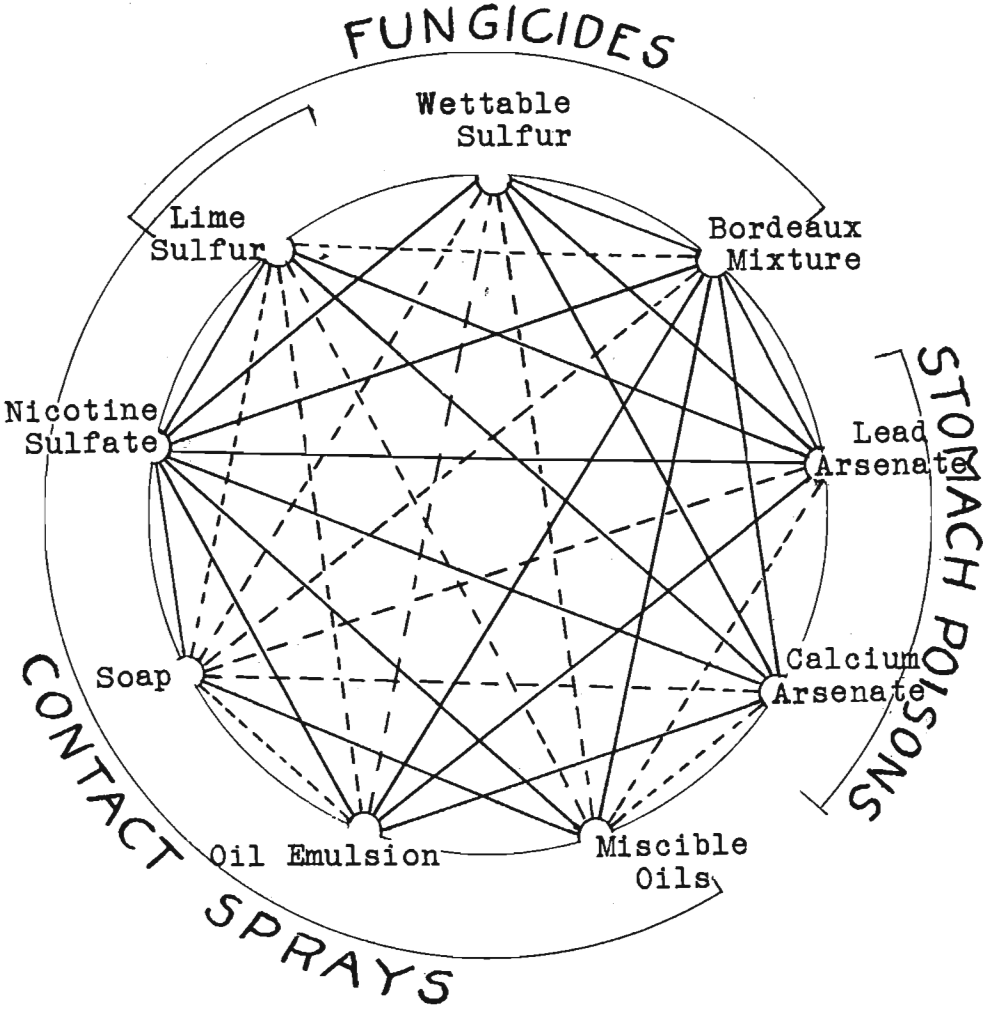
Fish oil should be used only where it is specifically recommended.

SOURCE OF SPRAY MATERIAL SUPPLIES

Most commercial spray materials and spray ingredients that are used for the home preparation of sprays may be obtained locally. In the event some materials are not available, ask your county agent or write to the Chemistry department of the Agricultural Experiment Station regarding a source of supply.

Compatibility Chart

This chart indicates what commonly used insecticides and fungicides may be mixed safely in the spray tank. Materials connected by *dotted* lines should not be combined. Those connected by unbroken lines may be combined safely.



OREGON STATE BOARD OF HIGHER EDUCATION

E. C. Sammons.....*Portland*
Lief S. Finseth.....*Dallas*
B. F. Irvine.....*Portland*
Willard L. Marks.....*Albany*
Herman Oliver.....*Canyon City*
Cornelia Marvin Pierce.....*La Grande*
F. E. Callister.....*Albany*
Beatrice Walton Sackett.....*Salem*
C. A. Brand.....*Roseburg*
W. J. Kerr, D.Sc., LL.D.....Chancellor of Higher Education

STAFF OF AGRICULTURAL EXPERIMENT STATION

*Staff members marked * are United States Department of Agriculture investigators stationed in Oregon*

Geo. W. Peavy, M.S.F.....President of the State College
Wm. A. Schoenfeld, B.S.A., M.B.A.....Director
R. S. Besse, M.S.....Vice Director

Division of Agricultural Economics

E. L. Potter, M.S.....Agricultural Economist; In Charge, Division of Agricultural Economics

Agricultural Economics

W. H. Dreesen, Ph.D.....Agricultural Economist

Farm Management

H. D. Scudder, B.S.....Economist (Farm Management)
H. E. Selby, M.S.....Associate Economist (Farm Management)
G. W. Kuhlman, M.S.....Associate Economist (Farm Management)
A. S. Burrier, M.S.....Associate Economist (Farm Management)

Division of Animal Industries

P. M. Brandt, A.M.....Dairy Husbandman; In Charge, Division of Animal Industries

Animal Husbandry

O. M. Nelson, M.S.....Animal Husbandman
B. W. Rodenwold, B.S.....Assistant Animal Husbandman
A. W. Oliver, M.S.....Assistant Animal Husbandman

Dairy Husbandry

Gustav Wilster, Ph.D.....Dairy Husbandman (Dairy Manufacturing)
I. R. Jones, Ph.D.....Associate Dairy Husbandman

Fish, Game, and Fur Animal Management

R. E. Dimick, M.S.....Assistant in Charge

Poultry Husbandry

A. G. Lunn, B.S.....Poultry Husbandman
F. L. Knowlton, M.S.....Poultry Husbandman
F. E. Fox, M.S.....Associate Poultry Husbandman

Veterinary Medicine

B. T. Simms, D.V.M.....Veterinarian
W. T. Johnson, B.S., D.V.M.....Poultry Pathologist
J. N. Shaw, B.S., D.V.M.....Associate Veterinarian
R. Jay, D.V.M.....Associate Veterinarian, Bureau of Animal Industry*
E. M. Dickinson, D.V.M.....Assistant Poultry Pathologist
F. M. Bolin, D.V.M.....Associate Veterinarian*
O. H. Muth, D.V.M.....Junior Veterinarian*
O. L. Searcy, B.S.....Technician

Division of Plant Industries

G. R. Hyslop, B.S.....Agronomist; In Charge, Division of Plant Industries

Farm Crops

D. D. Hill, M.S.....Associate Agronomist
H. A. Schoth, M.S.....Associate Agronomist; Forage Crops and Disease Investigation*
D. C. Smith, Ph.D.....Assistant Agronomist
B. B. Robinson, Ph.D.....Assistant Plant Breeder, Fiber Flax Investigations*
Grace Cole Fleischman, A.B.....Assistant Botanist, Division of Seed Investigations*

Horticulture

W. S. Brown, D.Sc.....Horticulturist
A. G. B. Bouquet, M.S.....Horticulturist (Vegetable Crops)
E. H. Wiegand, B.S.A.....Horticulturist (Horticultural Products)
H. Hartman, M.S.....Horticulturist (Pomology)
C. E. Schuster, M.S.....Horticulturist (Nut Culture)*
W. P. Duruz, Ph.D.....Horticulturist (Plant Propagation)
G. F. Waldo, M.S.....Assistant Pomologist (Small Fruit Investigations)*
J. C. Moore, M.S.....Assistant Horticulturist (Pomology)
T. Onsdorff, B.S.....Assistant Horticulturist (Horticultural Products)

STATION STAFF—*(Continued)*

Soil Science

W. L. Powers, Ph.D.....Soil Scientist
C. V. Ruzek, M.S.....Soil Scientist (Fertility)
M. R. Lewis, C.E.....Irrigation and Drainage Engineer, Bur. of Agric. Engineering
R. E. Stephenson, Ph.D.....Associate Soil Scientist
E. F. Torgerson, B.S.....Assistant Soil Scientist(Soil Survey)

Other Departments

Agricultural Chemistry

J. S. Jones, M.S.A.....Chemist in Charge
R. H. Robinson, M.S.....Chemist (Insecticides and Fungicides)
J. R. Haag, Ph.D.....Chemist (Animal Nutrition)
D. E. Bullis, M.S.....Associate Chemist (Horticultural Products)
M. B. Hatch, B.S.....Assistant Chemist

Agricultural Engineering

F. E. Price, B.S.....Agricultural Engineer
C. Ivan Branton, B.S.....Assistant Agricultural Engineer

Bacteriology

G. V. Copson, M.S.....Bacteriologist in Charge
J. E. Simmons, M.S.....Associate Bacteriologist
W. B. Bollen, Ph.D.....Associate Bacteriologist
D. B. Charlton, Ph.D.....Assistant Bacteriologist

Entomology

D. C. Mote, Ph.D.....Entomologist in Charge
A. O. Larson, M.S.....Entomologist (Stored Products Insects)*
B. G. Thompson, M.S.....Assistant Entomologist
F G. Hinman., M.S.....Junior Entomologist (Stored Products Insects)*
S. C. Jones, M.S.....Assistant Entomologist
K. W. Gray, B.S.....Field Assistant (Entomology)
W. D. Edwards, B.S.....Field Assistant (Entomology)

Home Economics

Maud M. Wilson, A.M.....Home Economist

Plant Pathology

C. E. Owens, Ph.D.....Plant Pathologist
S. M. Zeller, Ph.D.....Plant Pathologist
B. F. Dana, M.S.....Pathologist (Curley Top Diseases of Vegetables)*
F. P. McWhorter, Ph.D.....Plant Pathologist
F. D. Bailey, M.S.....Associate Pathologist (Enforcement of Insecticide Act)*
P. W. Miller, Ph.D.....Associate Pathologist (Nut Disease Investigations)*
G. R. Hoerner, M.S.....Agent (Hop Disease Investigations)*
T. Dykstra, M.S.....Assistant Plant Pathologist (Potato Diseases)*
Roderick Sprague, Ph.D.....Assistant Pathologist (Cereal Diseases)*
H, H. Millsap.....Agent (Bulb Diseases)*

Publications and News Service

C. D. Byrne, M.S.....Director of Information
E. T. Reed, B.S., A.B.....Editor of Publications
D. M. Goode, B.A.....Associate Editor of Publications
J. C. Burtner, B.S.....Associate in News Service

Branch Stations

D. E. Stephens, B.S.....Supt., Sherman Br. Expt. Sta., Moro; Sr. Agronomist*
L. Childs, A.B.....Superintendent, Hood River Br. Expt. Station, Hood River
F. C. Reimer, M.S.....Superintendent, Southern Oregon Br. Expt. Station, Talent
D. E. Richards, B.S.....Superintendent, Livestock Br. Experiment Station, Union
H. K. Dean, B.S.....Superintendent, Umatilla Br. Experiment Station, Hermiston*
O. Shattuck, M.S.....Superintendent, Harney Valley Br. Experiment Station, Burns
A. E. Engbretson, B.S.....Superintendent, John Jacob Astor Br. Expt. Sta., Astoria
G. A. Mitchell, B.S.....Acting Superintendent, Pendleton Field Station, Pendleton; Assistant Agronomist, Division of Dry Land Agriculture*
Arch Work, B.S.....Acting Supt. Medford Br. Expt. Sta., Medford; Associate Irrigation Engineer, Bureau of Agricultural Engineering*
W. W. Aldrich, Ph.D...Assistant Horticulturist, Bureau of Plant Industry, Medford*
G. G. Brown, A.B., B.S.....Horticulturist, Hood River Br. Expt. Station, Hood River
L. G. Gentner, M.S.....Associate Entomologist, Sou. Or. Br. Expt. Sta., Talent
J. F. Martin, M.S.....Junior Agronomist, Div. Cereal Crops and Diseases, Pendleton*
M. M. Oveson, M.S.....Assistant to Supt., Sherman Br. Experiment Station, Moro
R. B. Webb, M.S.....Jr. Agronomist, Sherman Branch Experiment Station, Moro
R. E. Hutchinson, B.S.....Asst. to Supt., Harney Valley Br. Expt. Sta., Burns