BULLETIN NO. 108 15,000 APRIL, 1910

Department of Entomology and Plant Pathology

Oregon Agricultural College
Experiment Station

Insecticides and Fungicides

Brief Directions for their Preparation and Use

BY A. B. CORDLEY

The Bulletins of this Station are sent free to all residents of Oregon who request them.

Oregon Agricultural College Press
Corvallis, Oregon
1910

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION.

Hon J. K. Weatherford, *President*.....Albany, Oregon
Hon. E. E. Wilson, *Secretary*.....Corvallis, Oregon
Hon. B. F. Irvine, *Treasurer*.....Corvallis, Oregon
Hon. F. W. Benson, *Governor and Secretary of State*.Salem, Oregon
Hon. J. H. Ackerman, *State Supt. Public Instruction*.Salem, Oregon
Hon. A. T. Buxton, *Master of State Grange*..Forest Grove, Oregon
Mrs. Clara H. Waldo.....Macleay, Oregon
Hon. J. T. Apperson.....Park Place, Oregon
Hon. C. L. Hawley.....McCoy, Oregon
Hon. William W. Cotton.....Portland, Oregon
Hon. Walter M. Pierce.....Pendleton, Oregon
Hon. J. D. Olwell.....Central Point, Oregon

OFFICERS OF THE STATION

STATION STAFF

W. J. Kerr, D. Sc.....President
James Withycombe, M. Agr.....Animal Husbandry, Director
A. B. Cordley, M. S.....Plant Pathology and Entomology
E. R. Lake, M. S.....Botany
C. I. Lewis, M. S. A.....Horticulture
F. L. Kent, B. Agr.....Dairy Husbandry
E. F. Pernot, M. S.....Bacteriology
James Dryden.....Poultry Husbandry
H. D. Scudder, B. S.....Agronomy
C. E. Bradley, M. S.....Chemistry
H. V. Tartar, B. S.....Assistant in Chemistry
L. A. Bundy, B. S.....Assistant in Chemistry
B. Pilkington, B. S.....Assistant in Chemistry
J. C. Bridwell, M. S.....Assistant in Entomology
C. A. Cole, M. S.....Assistant in Horticulture
E. L. Potter, B. S.....Assistant in Animal Husbandry
G. R. Hyslop, B. Sc.....Assistant in Agronomy
A. L. Peck, B. S.....Floriculture and Landscape Gardening
A. G. B. Bouquet, B. S.....Olericulture
R. W. Allen, B. S.....Assistant in Horticulture
C. C. Vincent, B. S.....Assistant in Horticulture
E. J. Kraus, B. S.....Assistant in Horticulture
F. L. Griffin, B. S.....Assistant in Entomology
H. S. Jackson, A. B.....Assistant in Plant Pathology
Helen L. Holgate, B. S.....Clerk

INTRODUCTION.

This bulletin is in effect a reprint of, and is given the same title as Bulletin No. 75, which has already passed through three editions. In attempting a revision for a fourth edition, so many changes were found desirable, particularly in the treatment of the arsenate of lead and lime-sulphur sprays, in the paging, in numbering formulas and in the "Methods of Treatment," that it is deemed best to designate this edition as Bulletin No. 108.

This edition, like the earlier ones, is open to the criticism that so many formulas may be confusing to the orchardist who is just beginning to spray. I believe, however, that no formula has been included which is not of value for some special purpose, although many of them are used but little, if at all, in orchard practice. Orchardists who understand the range of usefulness of the lime-sulphur spray (No. 25), arsenate of lead (No. 2), and Black Leaf (No. 11), who are equipped with a good spray pump and have the determination to do thorough work are as well fortified as may be against most orchard pests.

None of the crops of orchard, garden or field; none of our domestic animals; practically none of our food products, household effects or wearing apparel but are subject to the ravages of insects or fungi, or both. Even man, himself, is subject to great personal annoyance and even disease by these ever-present agencies.

The financial losses caused by such ravages are enormous. Some years ago, Dr. C. V. Riley, at that time the greatest authority on economic entomology, estimated the average annual loss in the United States from the ravages of insects alone at not less than ten per cent of the total value of all crops grown—a tax upon agriculture much greater than the combined levies for the support of schools and the maintenance of our municipal, county, state and national governments. The estimate is none too high. I have observed that a tax levied by insects or fungi which does not greatly exceed ten per cent of the value of the crop rarely attracts attention. A loss of twenty-five, fifty or seventy-five per cent is necessary to awaken us to a realization of the fact that something is wrong.

Much of this loss can be prevented—the tax levy can be reduced—some of it by proper agricultural practices, some by the selection of resistant varieties of the crops to be grown, some by the intelligent use of insecticides and fungicides.

It is the purpose of this bulletin to give brief directions for the preparation of the most important insecticides and fungicides that have been tested by experiment station workers and found useful, prefacing these directions by such references to the nature of insects and fungi as may be necessary to an understanding of the general principles which underlie the successful use of the various compounds mentioned.

INSECTS AND INSECTICIDES.

To understand the general principle which underlies the selection of the proper remedy to be used for any particular insect, one has only to know that practically all insects may be divided into two great groups.

GROUP I.—This includes all insects that have biting mouth parts—mandibulate insects—and which actually chew and swallow the tissues of the plant or other substance upon which they feed. Grasshoppers, caterpillars, flea-beetles, striped cucumber-beetles, codling moth larvae, etc., are good examples of this group.

GROUP II.—This includes all insects with beak-like sucking mouth parts—haustellate insects—which pierce the plant or animal upon which they feed and suck up its juices or blood but neither chew nor swallow any of the structural tissues. The apple-tingis, woolly-aphis, hop-louse, green apple-aphis, black cherry-aphis, San Jose Scale, etc., are good examples of this group.

In general, insects which belong to Group I may be poisoned by sprinkling or dusting the surface of the plant upon which they feed with some poisonous substance; but insects which belong to Group II cannot be so poisoned since they secure their food from beneath the surface and cannot be made to eat the poison. They must be destroyed by gases, washes, or other substances which act externally upon their bodies.

All insecticide substances may therefore be arranged into two general groups.

GROUP I—FOOD POISONS.—This group includes, principally, the various arsenicals, such as Paris green, London purple, Scheele's green, arsenate of soda, arsenate of lead, etc. These poisons are all valuable against insects which belong to Group I and feed exposed upon the surface of plants, but are practically valueless against those of Group II.

GROUP II—CONTACT INSECTICIDES.—This group includes a great variety of substances which act externally upon the bodies of insects either as mechanical irritants or caustics or to smother them by closing their breathing pores, or to fill the air about them with poisonous gases, or simply as repellants. Soap, sulphur, tobacco, insect powder, kerosene emulsion, crude petroleum, the lime-sulphur wash, resin washes, hydrocyanic acid gas, and carbon bisulphide are some of the most valuable insecticides of this group. These are used successfully not only against sucking insects but many of them are also used against biting insects when for any reason it is undesirable to use poisons; or when it is impossible to apply poisons directly to the food supply, as in the case of insects which work beneath the surface of the soil, or as borers or miners in wood, leaf or fruit, or in stored products, or as animal parasites, or household pests.

FUNGI AND FUNGICIDES.

A fungus is a plant as truly as is the apple tree, the prune tree, the wheat plant or any other plant upon which it may be growing. It differs from the common plants essentially in being much more simple in

structure and in being devoid of chlorophyll—the green coloring matter of plants. Its seeds, which are called spores, are more simple and very much smaller than the smallest seeds of our common plants and are produced in almost inconceivably great numbers. The vegetative portion of the fungus, the part which, in a sense, corresponds to the roots, stems and leaves of ordinary plants, the part which absorbs the food materials and eventually produces the spores, consists of a mass of more or less branched, white or colorless, and very minute threads and is called the mycelium.

Being so small and light, the spores are readily carried long distances by the wind, are washed about by the rains, and are also carried by birds and insects and probably by other agencies. These agencies are thus largely responsible for the spread of fungus diseases from leaf to leaf, plant to plant, or orchard to orchard. Over greater distances the spores may be carried on shipments of infested nursery stock, fresh fruits, vegetables, seeds, etc.

Should a spore fall upon suitable soil, such as the surface of leaf or fruit, and the conditions of heat and moisture be favorable, it will germinate—push out a delicate, slender germ-tube. In the case of most parasitic fungi this germ-tube soon penetrates the epidermis of the leaf or fruit and the mycelium develops in the underlying tissues entirely beyond the reach of fungicides. In some cases, however, the mycelium spreads over the surface of the plant. In other words, fungi, like insects, may be divided into two groups, as follows:

GROUP I—INTERNAL FUNGI.—This includes those fungi in which the germ-tube penetrates the skin of leaf, fruit, branch or root and the mycelium develops entirely within the tissues of the host plant. Apple-tree anthracnose, brown-rot, the grain-smuts and rusts, the downy-mildews, for all practical purposes apple-scab, and many others may be included in this group. The philosophy of spraying for this group of fungus diseases is based upon the fact that they cannot be cured, but can be prevented. This germ-tube must be destroyed before it penetrates the epidermis and to do this the surface of the host must be thoroughly protected by the fungicide during the entire time the spores are germinating.

GROUP II—EXTERNAL FUNGI.—This includes those fungi in which the mycelium spreads over the surface of the host. This group includes but comparatively few serious pests. Perhaps the one that has attracted most attention in this state is the powdery-mildew of gooseberries. The powdery-mildews of the grape and of the rose also belong to this group. These diseases may be prevented by proper fungicidal treatment the same as diseases of Group I and in addition they may also be cured by such treatment. The mycelium being exposed upon the surface of the host may be reached and killed by the proper fungicides.

GROUP I.—FOOD POISONS.

1. Paris Green.

For years this was used more extensively than any other poison. It first supplanted London purple but has, in turn, been supplanted by arsenate of lead and various other compounds of arsenic. Pure, it is among the most reliable of insecticides but has the disadvantage that it is a rather coarse crystalline substance which settles rapidly to the bottom of the spray-tank unless the contents are kept thoroughly stirred. For codling moth, bud moth, tent caterpillars and many other insects of Group I it is generally used as a spray in the following proportions:

Paris green	1 pound
Quick lime	4 to 5 pounds
Water	160-200 gallons

Slake the lime, stir the poison into a thin paste with a little water, add this to the lime, then strain the mixture through a sieve into a tank containing the required amount of water. If it is desired to spray for both fungi and insects, Bordeaux mixture (15 or 16) may be used in place of the water in the above formula. For peach or other tender foliage 300 gallons of water or Bordeaux (17) should be used. *It is necessary to keep this mixture well stirred while spraying.*

2. Arsenate of Lead.

Arsenate of lead is now the chief poison used in spraying for the codling moth, although Paris green gives approximately as good results and is preferred by some. Many brands of commercial arsenate of lead are now to be had and so far as our observations go nearly all are reasonably pure. The various brands may, however, be arranged into two definite groups which may be termed the acid arsenates and the ortho or neutral arsenates. While the evidence is not conclusive, it appears to be true that the acid arsenates have some tendency to injure foliage and cannot so well be used with the lime-sulphur solutions as can the neutral arsenates.

Most manufacturers advise the use of three pounds of arsenate of lead to 50 gallons of water. The Washington Experiment Station has demonstrated that in the dry climate of Eastern Washington one pound to 50 gallons gives equally good results in controlling codling moth. We have found that two pounds are sufficient in the Willamette Valley. It is quite probable that one pound may be sufficient here but since this has not been demonstrated we think it best to advise two pounds to 50 gallons for the more humid portions of this State.

The following table represents the composition of the various commercial lead arsenates which have been examined by the department of chemistry, Oregon Agricultural College:

*COMMERCIAL LEAD ARSENATES.

Name of Brand	Lab. No.	Moisture	Total Lead Oxide	Total Arsenic Oxide	Soluble Impurities	Soluble Arsenic Oxide	Total
		%	%	%	%	%	%
Swift	3652	43.45	34.47	16.68	1.82	.45	96.42
Star	3693	54.02	32.99	10.72	.81	.10	98.04
Grasselli	3712	38.95	43.11	14.85	.16	.39	97.07
Lion	3718	58.40	26.19	12.26	.61	.12	97.46
Sherwin-Williams	3978	49.55	41.00	5.17	2.85	.15	98.57
Sherwin-Williams	4008	51.84	33.11	12.35	1.58	.11	98.88
Bean	4009	41.68	42.19	13.47	1.60	.10	98.94
Hemingway	6006	32.46	42.64	21.45	.93	.31	97.48

Some growers prefer to prepare the arsenate of lead as it is used. This is but little if any more troublesome than to mix the prepared arsenates in water and should be somewhat cheaper. It can be readily prepared after the following formula:

Arsenate of soda	4 ounces
Acetate of lead	11 ounces
Water	15 to 20 gallons

Dissolve the arsenate of soda in two quarts and the acetate of lead in four quarts of warm water in wooden vessels. When dissolved add them to the required amount of water.

This formula is especially valuable for spraying very delicate foliage or for use against insects which are killed only by large amounts of poison, since it can be used upon plants in much stronger solutions than the other food poisons without injury to the foliage.

If it is desired to use a combined insecticide and fungicide, arsenate of lead may be added to Bordeaux or to lime-sulphur solution in the same proportion as when water is used.

DUSTING OR DUST SPRAYING.

It is often convenient to apply poisons by dusting. Dry Paris green may be so applied either pure or adulterated with various substances. If used pure it should be dusted from a cloth sack of suitable texture and only the faintest trace of the poison should appear upon the plants treated. One or two pounds should be sufficient to treat an acre of any low-growing crop.

To avoid using excessive and dangerous amounts of the poison it is usual to adulterate it as follows:

3. PARIS GREEN (FOR DUSTING).

Paris green	1 pound
Wheat flour or finely slaked quick lime	25-50 pounds

Mix the ingredients thoroughly and dust until the plants show a faint trace of white. For dusting only a few plants use a perforated tin can or other sifter. To cover a large acreage use one of the "dust sprayers" which are on the market.

The so-called "dust spray" for orchards is cheaper than spraying with liquids, but results so far obtained indicate that it is less effective for most purposes. Dust spraying has not been tested by this station, but the results of three years' careful work at the Illinois Experiment Station, in

*For discussion of composition of Lead Arsenates see Bulletin 107, Oregon Experiment Station.

testing dust syrays in comparison with liquid sprays, has been summarized as follows:

"With regard to effect upon foliage the results were identical in all orchards and in all seasons. Trees sprayed with liquid Bordeaux and Paris green retained their foliage in healthy working condition throughout the season. Dust sprayed and check trees may be spoken of together, because the behavior of the foliage was the same on both. Leaves began falling from these trees in July and by early September they were practically denuded. The loss of foliage by dust sprayed and check trees was due to apple scab, against which disease the dust spray was entirely ineffective. Differences in fruit was as marked as were differences in foliage. Liquid sprayed trees gave smooth fruit of good size. Dust sprayed and check trees gave small, ill-formed fruit, badly marked by scab and fruit blotch and of very little value even as evaporator stock. Dust spray is 52 per cent cheaper than liquid spray and it is easier to transport about the orchard. This is as far as I can go in an enumeration of its advantages. It is utterly worthless as a means of controlling orchard enemies and money spent in its application is thrown away."*

POISONED BAITS.

Grasshoppers, cut-worms and a few other pests may be destroyed by poisoned baits. These are prepared in various ways. Small bundles of green, succulent vegetation, dipped in a strong solution of any of the above poisons and scattered about the infested field or garden will prove exceedingly tempting to cut-worms, particularly if the field was plowed in early spring and is free from vegetation. Such baits are most effective if used in spring just before the crop to be protected comes up. Poisoned slices of potato or some similar vegetable are used to poison sow-bugs and wire-worms. Cultivated trees and vines may be successfully protected against the ravages of grasshoppers by use of the so-called bran-arsenic-mash, which is made as follows:

4. BRAN-ARSENIC-MASH.

White arsenic	1 pound
Brown sugar	1 to 2 pounds
Bran	6 pounds

Mix the ingredients thoroughly, then add enough water to make a wet mash. A spoonful should be placed at the base of each tree or vine. For cut-worms a still better bait may be prepared by mixing thoroughly Paris green, bran and middlings as follows:

5. PARIS GREEN (DRY BAIT).

Paris green	1 pound
Middlings	15 pounds
Bran	15 pounds

This may be sown broadcast upon the vegetation about the borders of cultivated fields or gardens; or by use of a seed drill it may be sown along the rows of plants to be protected. So used it has been found especially valuable for destroying cut-worms in onion fields.

*Prof. C. S. Crandall, Apple Specialist, January, 1906.

6. Hellebore.

Powdered hellebore, if fresh, is of value for poisoning insects which are injuring small fruits or vegetables which are nearly ready for market and on which it is undesirable to use the arsenical poisons. It may be dusted over the plants when they are moist with dew, or may be used as a spray in the following proportions:

Hellebore	1 ounce
Water	2 gallons

GROUP II—CONTACT INSECTICIDES.

7. Whale-Oil Soap and Quassia.

Strong soap suds made from any good soap are useful for destroying soft-bodied insects like plant lice. It is usual, however, to employ for this purpose special soaps made with fish-oils and sold as whale-oil soaps. These vary considerable in composition, some being made with soda, others with potash lye. The latter are much superior and buyers should insist on having potash soaps.

For scale-insects, whale-oil soap is sometimes used in as concentrated a solution as two pounds of soap to one gallon of water, but only upon dormant plants. As a remedy for the various plant-lice one pound of soap to 8 or 10 gallons of water is usually sufficient. Hop growers are inclined to believe that better results are obtained, when spraying for hop-lice, by adding some quassia decoction to the soap solution, as follows:

Whale-oil soap	10 pounds
Quassia	5 pounds
Water	100 gallons

Place the quassia chips in a sack, cover with 8 or 10 gallons of water and soak 12 to 24 hours. Then bring to a boil, remove the chips, add the soap and boil until it is dissolved. Add water to make 100 gallons. If preferred the grower may prepare his own whale-oil soap after the following formula:

Potash lye	1 pound
Fish-oil	3 pints
Water	2 gallons

Dissolve the lye in the water. When boiling hot add the oil and boil about two hours. Add water to make two gallons. Each pound of the soap thus made should be dissolved in 8 or 10 gallons of water. It will be found a satisfactory remedy for hop-lice and other soft-bodied insects.

8. Kerosene Emulsion.

Kerosene oil, or coal oil, is a powerful insecticide. The undiluted oil is, however, liable to seriously injure plants to which it is applied. This difficulty is overcome by using one of the special spray pumps which have been devised for the purpose of mixing the oil with water in any desired proportion; or by forming an emulsion with some substance that may be readily diluted with water. Soap is most commonly used for this purpose, as follows:

Kerosene oil	2 gallons
Hard soap (preferably whale-oil)	½ pound
Water	1 gallon

Dissolve the soap in the water by boiling. Add the suds, boiling hot,

to the oil. Churn the mixture violently with a spray pump until it becomes a thick creamy mass. If perfectly emulsified, the oil will not rise to the surface even after standing an indefinite time. Such an emulsion may be used immediately or may be kept as a stock mixture. Before using, dilute one part of the stock emulsion with 8 or 10 parts of water.

This will be found to be an efficient remedy for green-aphis, woolly-aphis, red-spider, mealy-bugs, and certain scale-insects.

9. Resin Wash.

This is a favorite spray in California for several of the scales infesting citrus fruits. In this state its chief value is as a spray for the various kinds of plant-lice. For this purpose, it may be used as a substitute for kerosene emulsion or whale-oil soap with good results, particularly in the dry summer months. It can also be used as a summer spray for San Jose scale, but we do not advise such use since summer sprays for this pest are less efficient than the winter spray of lime and sulphur. The resin wash may be made as follows:

Resin	20 pounds
Concentrated lye	4 pounds
Fish-oil	2½ pints
Water	100 gallons

Place the resin, lye and oil in a kettle with sufficient water to cover them to a depth of three or four inches. Boil about two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture which must be diluted to the full amount of 100 gallons when ready for use.

10. Carbolic Acid Emulsion.

Carbolic acid emulsion is used to destroy the eggs and the young maggots which infest radishes, onions and similar garden crops; and occasionally for other insects:

Crude carbolic acid	1 pint
Hard soap	1 pound
Water	1 gallon

Dissolve the soap in boiling water; add the acid and churn as for kerosene emulsion. Use 1 part of emulsion to 30 parts water.

11. Tobacco.

The tobacco waste from cigar factories is of considerable value as an insecticide. In greenhouses, it may be used to destroy plant-lice by simply spreading the waste two or three inches deep over the pipes under the benches, or by burning about one-half pound of moist waste to each 500 square feet of glass. Worked into the soil about young apple trees in the orchard or nursery, it is one of the best remedies for the root form of woolly-aphis. A strong decoction, made by a prolonged steeping of a quantity of stems in enough water to cover them and diluting the liquid to the color of strong tea, is often used as a spray for plant-lice. A still better method is as follows:

Hard soap (preferably whale-oil)	1 pound
Water	8 to 10 gallons
Strong tobacco decoction	1 gallon

Dissolve the soap in boiling water, add the tobacco decoction and dilute to 8 to 10 gallons.

Various tobacco soaps and other tobacco preparations are supplied by the trade both for greenhouse and orchard use. In fact, the most satisfactory spray known, for destroying orchard plant-lice is the Black Leaf Spray which is supplied by the Kentucky Tobacco Product Co., Louisville, Ky. It dilutes readily with water and is efficient when used in the proportion of one gallon of Black Leaf to 60 to 75 gallons of water.

12. Pyrethrum or Insect Powder.

Fresh pyrethrum powder is a valuable remedy for flies, mosquitoes, roaches, ants, fleas and other household pests. It is destructive to insects but not poisonous to the higher animals or to man. It should be kept in an air-tight receptacle. The dry powder may be dusted over the floors, or in the hair of dogs infested with fleas, or about their sleeping quarters; or in other places where noxious insects congregate. It may also be used as a spray in conservatories or on a few plants in the garden, in the following proportion:

Pyrethrum	1 ounce
Water	2 gallons

It is also stated that the flies and mosquitoes in a room may be destroyed by burning a little pyrethrum powder upon some live coals.

13. Bisulphide of Carbon.

Bisulphide of carbon is a colorless liquid with a very disagreeable odor. It is very volatile and its fumes are poisonous to animal and plant life. When mixed with air in the proper proportion they are also very explosive. As an insecticide, it is valuable mainly as a remedy for subterranean insects, borers, or insects infesting stored grains, seeds, etc., and for fumigating buildings which are infested with noxious insects. It is also used extensively for destroying various burrowing animals whose burrows incline downward into the earth. For this purpose pour 2 or 3 ounces of the liquid upon a ball of rags, or other absorbant, place this well down into the burrow and close the opening. Thus used it is an effective remedy for "digger squirrels" and "prairie dogs," but is not effective against moles and pocket gophers which construct long horizontal burrows. Troublesome ants' nests may be destroyed by making a hole in the center of each nest and pouring into it 2 or 3 ounces of the liquid, after which the hole should be tightly closed. For destroying the root form of woolly-aphis of the apple, it is common to make several holes each 6 to 12 inches deep about the tree and pour 1 or 2 ounces of the liquid into each hole, which should be immediately closed.

Borers in the roots of peach or prune trees may be destroyed by simply pouring from 1 to 3 ounces of the liquid, according to the size of the tree, about the base of the tree. If the soil is wet or compact, it is best, first, to excavate a shallow trough about the tree and fill this with loose soil before applying the chemical.

For fumigating grains, seeds, storehouses and other buildings, includ-

ing houses, for the destruction of insects, one pint of the liquid is used for each ton of grain or 1,000 cubic feet of space. The building, bin or other receptacle should be tightly closed and kept closed 24 to 36 hours. *During this time no person should attempt to enter the building, nor should any light be allowed inside, until it has been thoroughly ventilated, since the fumes are both poisonous and explosive.*

14. Hydrocyanic Acid Gas.

This is an extremely poisonous gas which is used in this State principally to fumigate nursery stock. In California it is used to fumigate citrus trees which are infested with scale insects. It has also been used in the East to fumigate scale-infested deciduous fruit trees. Although very efficient the process is so much more expensive than spraying that I do not recommend its use in this State.

Many nurseries now have especially prepared houses, or fumigatoriums, in which to fumigate infested stock. For dormant stock the chemicals are used in the following proportions, for each 100 cubic feet of space inclosed:

Cyanide of potassium (98 per cent)	1 ounce
Sulphuric acid	1 ounce
Water	2 ounces

Place the water in an earthenware or wooden receptacle, add the acid and when all is ready drop in the cyanide of pottassium, close the door and keep it closed for at least 40 minutes. Do not attempt to reenter the house until it has been thoroughly ventilated.

Greenhouses may be fumigated to destroy plant-lice, mealy-bugs, slugs, millipedes, etc., but since there is a wide range in the susceptability of various plants to injury by the gas it is not thought best at this time to give general directions for such work. As a basis for any experimental tests which growers may care to make the above formula is advised for each 350 cubic feet of space to be fumigated, and with the house tightly closed for 15 to 20 minutes. Previous arrangements should be made for opening the ventilators from the outside.

GROUP III.—FUNGICIDES.

15. Bordeaux Mixture for Dormant Plants.

Next to lime-sulphur Bordeaux mixture is perhaps the most generally useful of all spraying compounds. It is the principal remedy for fungus diseases, is of some value as an insecticide, has a beneficial effect upon plants independent of its effect upon their insect and fungous parasites and may be used for most purposes in place of water in the preparation of the arsenical sprays Nos. 1 to 4.

Bordeaux for winter use may be made as follows:

Copper sulphate	6 pounds
Quick lime	6 pounds
Water	50 gallons

This is known as the 6-6-50 formula. It should be used only upon dormant trees.

16. Bordeaux Mixture for Plants in Foliage.

When the trees are in leaf the following 4-4-50 formula is used:

Copper sulphate	4 pounds
Quick lime	4 pounds
Water	50 gallons

17. Bordeaux Mixture for Peach and Other Tender Plants.

For spraying peach foliage it is best to use the still weaker 3-3-50 formula:

Copper sulphate	3 pounds
Quick lime	3 pounds
Water	50 gallons

To prepare Bordeaux mixture dissolve the copper sulphate in hot or cold water in a wooden or earthen vessel. Slake the lime, using only sufficient water to insure slaking. The lime should not be allowed to become dry while slaking nor should it be submerged in water. After the lime is slaked add water and stir until the "milk of lime" is of the consistency of cream. The best results are obtained by diluting the milk of lime and the copper sulphate solution each to 25 gallons and then pouring these two dilute solutions together. The lime solution should always be strained through a sieve to exclude particles that might clog the nozzles. A brass wire sieve, 20-mesh, large enough to fit the head of a barrel or the opening in the spray-tank will prove a great convenience.

When large quantities of Bordeaux are required, it is most convenient to make stock solutions of lime and of copper sulphate, of known strength. A convenient stock solution of copper sulphate is made by dissolving 100 pounds in 50 gallons of water; one of lime, by slaking 100 pounds and diluting with water to 50 gallons. Each gallon of the stock solutions will then contain 2 pounds of lime or of copper sulphate and the amount to be used in preparing any quantity of Bordeaux according to the above formulas can be readily computed.

TESTING BORDEAUX.

There are three simple tests which may be used. First, hold a clean bright knife blade in the Bordeaux, for at least one minute. If it becomes copper-plated more lime should be used. Second, pour some of the Bordeaux into a shallow dish and holding it up to the light blow gently across its surface. If properly made a thin pellicle will form on the surface of the liquid. If this does not form more lime should be added. Third, dissolve one ounce of ferrocyanide of pottassium in 5 or 6 ounces of water. Pour some of the Bordeaux into a white dish and add to it a few drops of the ferrocyanide solution. If sufficient lime has been used no change will be noticed. If a brownish-red discoloration takes place more lime should be added.

18. Copper Sulphate Solution.

A simple solution of copper sulphate is used as a remedy for grain

smuts and sometimes as a spray in place of Bordeaux. For dormant trees use:

Copper sulphate ..... 1 pound
Water ..... 25 gallons

For trees in foliage use:

Copper sulphate ..... 1 pound
Water ..... 250 gallons

For smut of wheat or oats, soak the seed for 10 to 12 hours in a solution of one pound of blue vitriol to 25 gallons of water, then put the seed for 5 or 10 minutes into lime water made by slaking one pound of lime and diluting it with 10 gallons of water.

The treatment with lime water tends to prevent the copper sulphate solution from injuring the seed, but most farmers omit that part of the treatment.

Bordeaux mixture has the disadvantage that it produces an unsightly deposit upon foliage, blossoms and fruit and hence cannot well be used upon florists' plants or upon fruits nearly ready for market. For use under such conditions the ammoniacal copper carbonate, the simple copper carbonate mixture or the copper acetate solution is recommended.

19. Ammoniacal Copper Carbonate.

Copper carbonate ..... 5 ounces
Strong ammonia ..... 3 pints
Water ..... 50 gallons

Mix the copper carbonate into a paste with a little water, add the ammonia and when the copper carbonate is completely dissolved pour the resulting deep blue liquid into the water.

20. Copper Carbonate Mixture.

Copper carbonate ..... 1 pound
Water ..... 50 gallons

Mix the copper carbonate into a paste with a little water before attempting to add it to the 50 gallons.

21. Copper Acetate Solution.

Dibasic acetate of copper ..... 6 ounces
Water ..... 50 gallons

Use finely powdered acetate of copper, mix it into a paste with a little water, then dilute with the full amount of water.

22. Potassium Sulphide Solution.

Potassium sulphide ..... 1 ounce
Water ..... 2 to 3 gallons

Dissolve the potassium sulphide in the water.

Valuable as a spray for mildews.

23. Corrosive Sublimate.

Corrosive sublimate ..... 1 ounce
Water ..... 7 to 8 gallons

This is valuable as a preventive of potato scab. In a wooden vessel, dissolve the poison in one gallon of water, then dilute to the full amount. Place the scabby seed potatoes in a sack, immerse them in the solution and allow them to soak 1 to 2 hours. The solution and the treated potatoes are extremely poisonous.

24. FORMALIN.

Formalin, a 40 per cent solution of formaldehyde gas in water, is being used extensively as a preventive of potato scab and of the grain-smuts, and gives most excellent results. It is cheap, efficient and non-poisonous. For potato scab, soak the seed 2 hours in the following solution:

Formalin	½ pint
Water	15 gallons

For grain-smuts soak the seed for 1 to 2 hours in the following:

Formalin	1 pint
Water	50 gallons

GROUP IV—COMBINED INSECTICIDE AND FUNGICIDE.

25. LIME SULPHUR.

It is often desirable and practicable to use sprays which combine both fungicidal and insecticidal qualities. The time, expense and annoyance of one or more sprayings may frequently be eliminated by such combinations. Thus Bordeaux mixture and Paris green, or arsenate of lead, has long been used as a combined spray for apple-scab and codling moth and the expense of controlling these two important apple pests has thereby been materially reduced. This spray, however, combines only the fungicidal value of Bordeaux and the food poison value of the arsenical. It is of little or no value as a contact insecticide—in other words it is of no value against scale insects, plant-lice and the numerous insects which belong to Group II.

During the past three years we have conclusively demonstrated that the lime-sulphur spray, which has long been known as the most satisfactory winter spray for San Jose scale, has fungicidal qualities nearly or quite equal to those of Bordeaux. We have also conclusively demonstrated that it may be used in combination with arsenate of lead without materially detracting from the value of either; and that when so used it is at once an efficient contact insecticide, food poison spray, and fungicide.

It also has the advantage that when properly diluted it may be used either as a winter or summer spray.

As a winter spray one application of lime-sulphur spray each year will do more for the neglected orchard than can be done in any other way by the same expenditure of cash and energy. It not only destroys San Jose scale, but it also destroys the branch form of woolly-aphis, the eggs of the green-aphis, the pear-leaf blister mite, the hibernating larvae of the prune twig-miner, probably the hibernating larvae of the bud-moth, together with most other insects which may chance to be wintering upon the trees. It is also a good fungicide. If applied in fall it is nearly or quite equal to Bordeaux as a preventive of apple-tree anthracnose; applied to peach trees just before the buds open in spring it is a preventive of peach-leaf curl.

As a summer spray the results of the past three seasons' work at the Oregon Experiment Station prove conclusively that when properly diluted it can be safely used upon the apple, pear, plum and prune, potato, celery and other hardy plants, and that it gives better results in controlling apple scab than does Bordeaux, which has been the standard spray for this disease, and further that it does not produce the disastrous "spray injury" to the fruit which is so common and often serious when Bordeaux is used.

There are two methods of preparing the lime-sulphur spray. The formula which has been most generally used in this State is as follows:

Quick lime	50 pounds
Sulphur	50 pounds
Water	150 gallons

Slake the lime thoroughly, add the sulphur, and boil briskly for at least an hour or until the mixture is of a deep blood-red color with but little free sulphur on the surfacce. Add water to make 150 gallons. Apply with considerable force through a coarse nozzle.

The "stock solution" method which is now most generally used in this State has been developed during the past three years. During that time there have appeared upon the market a number of concentrated lime-sulphur solutions, which have only to be diluted with water to be ready for use. Careful experiments extending over three seasons have demonstrated that these sprays are fully equal to the old home-made lime-sulphur spray in destroying San Jose scale. Whether all of them can safely be used for summer spraying is yet to be demonstrated.

The chief fault to be found with these commercial preparations is that they cost too much. The retail price is $9.00 to $12.00 per barrel of 50 gallons. The lime and sulphur necessary to prepare 50 gallons of stock solution which is equally as efficient costs at present retail prices approximately $3.00. It may be prepared as follows:

Sulphur (best finely ground) one sack	110 pounds
Lime (best grade, unslaked)	55 pounds
Water, sufficient to make	60 gallons

Slake the lime, mix the sulphur into a thin paste with a little water, add it to the lime, add sufficient water to make 60 gallons, bring to a boil and boil vigorously for 30 to 45 minutes. The sediment is then allowed to settle, after which the clear dark amber-colored liquid is drawn off and may be stored in casks for future use.

Every grower who expects to prepare his own spray by the stock solution method should provide himself with a Beaume's Acid Scale Hydrometer. Such an instrument, which should not cost over $1.00, furnishes a very simple and convenient method of testing the strength of the solution. A "stock" solution prepared as above described should test approximately 30° upon such a scale.

If the grower be provided with a hydrometer, it is not at all necessary to obtain stock solutions of uniform strength. The following table gives the proper dilution to be used with stock solutions of various degrees of density, both for winter and summer spraying:

Stock Solution Baume Scale	Dilution Winter Strength	Dilution Summer Strength
32°	1—12	1—30
31°	1—11	1—29
30°	1—10	1—28
29°	1—9½	1—27
28°	1—9	1—26
27°	1—8½	1—25
26°	1—8	1—24
25°	1—7½	1—23
24°	1—7	1—22
23°	1—6½	1—21
22°	1—6	1—20

WHEN TO SPRAY.

General directions as to how many times to spray and when the applications should be made are at best unsatisfactory. The answer to both questions depends not only upon the variety of fruit to be sprayed but also upon the conditions prevailing in the orchard to be sprayed, and the relative importance of the orchard crop to other crops. The orchardist can afford to do more spraying than can the farmer, but usually can obtain satisfactory results with fewer applications—first because he is usually better equipped for the work and has a better knowledge of why he sprays, and second, because his orchard is usually less seriously infested owing to the better care it has received.

An almost universal practice in this State—and a good one—is to spray the orchard, whatever the kind of fruit, with lime-sulphur at sometime while the trees are dormant. While this application is made primarily for San Jose scale I believe there is no other which has such a generally beneficial result. It is the annual "house-cleaning" of the orchards.

The best time for this winter spraying is immediately after the leaves drop in fall—even before they are all off—or just before the buds open in spring. Personally I should prefer the latter were the orchard seriously infested with San Jose scale; the former were it badly infested with anthracnose.

All other sprayings are for special purposes and can best be considered in connection with particular pests.

APPLE.

APPLE SCAB.—Spray with lime-sulphur (1-30); first, when the blossoms are beginning to unfold; second, immediately after the blossoms fall; third, ten days or two weeks later. (If the trees were sprayed with winter strength lime-sulphur solution immediately before the buds started, the first of the above applications may be omitted. If prolonged rainy weather follows the third spraying a fourth two weeks later may be profitable).

CODLING MOTH.—Add arsenate of lead to the second scab spray. Endeavor at this time by the most thorough work to fill the blossom end of every apple with the spray. If this be well done, and if the fruit be again thoroughly sprayed late in June, fairly good results may be obtained without further applications. It is our experience, however, that in

the Willamette Valley at least, it usually pays to spray once or twice for the second brood. The first of these applications should be about August 1; the second some three or four weeks later. While thorough work should be done at all times particular emphasis should be placed upon the two first sprayings. If all of the first brood larvae could be killed there would be none of the second.

SAN JOSE SCALE.—Spray in winter with lime-sulphur, either immediately after the leaves fall or before the buds start in spring. Do thorough work. Soak every part of the tree.

APHIDS OR PLANT LICE (Woolly-aphis, Green-aphis, Brown-aphis, Black-aphis).—The plant-lice rarely if ever become troublesome in orchards which receive an annual winter spraying with lime-sulphur. Dilute kerosene emulsion or Black-Leaf Sheep Dip applied just after the leaf buds start or at any time the aphids become troublesome and before the leaves curl is also effective.

APPLE TINGIS.—Practice clean culture, clean up and burn all rubbish about the orchard. Spray when eggs are hatching in late May or early June with kerosene emulsion or Black-Leaf Sheep Dip.

APPLE TREE ANTHRACNOSE.—Spray with Bordeaux or lime-sulphur soon after fall rains begin or at least as soon as fruit is picked. Spray again with lime-sulphur as soon as leaves have fallen.

BARLEY.—To prevent smut, use 24.

BEANS.—For weevil, fumigate seed with 13.

BEET.—See under Sugar Beet.

BLACKBERRY.—For anthracnose, leaf-spot and rust spray with 15, before leaves start; when leaves are half grown use 16; repeat in two weeks.

CABBAGE AND CAULIFLOWER.—For club-root, rotate crop; destroy all stumps and other waste in fall; apply lime at rate of 80 to 100 bushels per acre and work into soil. For worms, use 1 or 3 when first observed. After plants head, 6 or 12 may be used if preferred. For aphis, use 11.

CARNATIONS.—For rust and other fungous diseases, spray with 22 when disease first appears and repeat at intervals of two weeks. Give good culture, avoid wetting leaves. For red spider or aphis use 11 or 25.

CELERY.—For leaf-spot or leaf-blight use 16 or 25 upon young seedlings and repeat two or three times at intervals of two weeks.

CHERRY.—For brown-rot and leaf-spot, spray with 16 or 25 when blossoms are opening and again when petals fall; after fruit begins to color use 25, 19 or 21. For slugs, use 2 when slugs first appear, or if fruit is ripening dust with air-slaked lime or fine dry dust. For aphis, use 11. For gummosis, cut out gum pockets and wash or spray with 15. For San Jose scale use 25 when trees are dormant.

CUCUMBER.—For striped cucumber-beetle, dust the plants with 3, or spray with 16 plus 1. Plant some early squash as trap plants and when the beetles are feeding on them dust them with pure Paris green. For fungous diseases, spray with 16 when vines begin to form and repeat three or four times at intervals of two weeks.

CURRANT.—For mildew, spray with 25 when buds begin to open and repeat at intervals of 10 to 15 days until fruit is nearly ripe. For worms on leaves use 2 or 6. For fruit worms, destroy infested fruit; allow the poultry the run of the bushes when infested fruit is falling.

GOOSEBERRY.—Same as currant.

GRAPE.—For mildews, dust with sulphur or spray with 25. For rot and anthracnose, spray with 22 or 25 when buds are swelling, when leaves are half grown, just before blossoming, when fruit has set, and repeat once or twice at intervals of two weeks. If later applications are required use 19.

HOP.—For hop-lice, spray thoroughly with 7 in June and repeat if necessary.

HOUSEHOLD PESTS.—For fleas, flies, mosquitoes, roaches, etc., use 12. Garments infested with clothes moths may be inclosed in tight box and fumigated with 13. If house is badly infested with any insect, fumigate with 13.

MUSKMELON. For striped cucumber-beetle, see under Cucumber.

NURSERY STOCK.—For various fungous diseases, spray with 16 when leaves first appear and repeat at intervals of 10 to 15 days until rainy season closes. Fumigate with 14.

OATS.—For loose smut, soak seed in 24.

ONIONS.—For smut, practice rotation of crops; transplanting seedlings; use 100 pounds of sulphur and 50 pounds of air-slaked lime per acre in the drills with the seed. For downy-mildew, try 16 when disease first appears and repeat if necessary. For cut-worms use 4.

PEA.—For mildew, spray with 25 when mildew appears and repeat once or twice, if necessary, at intervals of 10 days.

*PEACH.—For leaf-curl, spray just as buds are swelling with 16 or 25. For blight and fruit-spot spray with 17 or 25 soon after fall rains begin. If brown-rot is severe follow with one or two applications of 21 while fruit is coloring. For San Jose scale, apply 25 while trees are dormant. For twig-borer use 25 just before buds swell. For root-borers, as a preventive wrap base of trunks with paper or cloth or paint them with poisoned whitewash; to kill borers dig them out in fall and spring, or use 13.

°PEAR.—For scab, codling moth and San Jose scale see under apple. For slug, see under cherry. For pear blight cut out and burn all diseased branches. Make cut several inches below where disease extends and sterilize tools frequently by dipping in 23. Paint cut surfaces with 15, strong.

PLUM AND PRUNE.—For twig-borers and root-borers see under peach. For leaf-curl give good drainage, good cultivation and grow leguminous cover crops in winter. For brown-rot, see under cherry. For San Jose scale, see under apple.

*For peach fruit-spot and blight consult Bulletin No. 107, Or. Experiment Station.
°For pear blight consult Circular No. 8, Oregon Experiment Station.

POTATO.—For scab, soak seed potatoes in 23 or 24. For potato dry-rot, rotate crop. For blight, spray with 16 or 25 when plants are 6 inches high and repeat two or three times at intervals of two weeks. For flea-beetles, spray with one of the food poisons, 1 or 2 in 25, whenever they appear. For wet-rot, plant only sound seed, practice rotation of crops, destroy blighted plants as fast as they appear and spray to prevent flea-beetle punctures.

QUINCE.—For leaf and fruit-spot, spray with 16 or 25 when blossom buds begin to open; again when fruit has set, and repeat at intervals of two weeks until rainy season is over.

RASPBERRY.—See under Blackberry.

ROSE.—For mildew, dust with sulphur or spray with 25 whenever it appears. For leaf-spot spray with 16 or 25 when spots first appear and repeat as necessary. For aphis use 11, or wash them off with a stream of water from the garden hose. For rust, burn fallen leaves in fall; spray with 25 before buds start in spring; repeat the application at intervals of 10 or 15 days.

STRAWBERRY.—For crown-miner and root-borer, destroy infested plants before May 1. For leaf-roller burn tops as soon as possible after crop is gathered. For leaf-blight spray with 16 or 25 when new leaves start and repeat every 10 to 15 days until blooms appear. Mow and burn tops as for leaf-roller.

SUGAR BEETS. For leaf-spots or flea-beetles, spray with 25 plus 2 when spots or beetles first appear and repeat two or three times at intervals of two weeks. For cut-worms, if bad, use 5. For aphis, use 11.

TOMATO.—For flea-beetles, spray with 16 plus 2 when they appear, or hang papers from a string stretched just over the plants. For blight, use barn yard compost, plenty of water, close planting, and stocky, vigorous plants.

VIOLET.—For blight, use 16 or 25 when it first appears. Repeat once or twice at intervals of 10 to 15 days, if necessary.

WATERMELON.—See Muskmelon.

WHEAT.—For smut, soak seed in 30. For Hessian fly practice late seeding. For insects in stored grain use 13.

A. B. CORDLEY.