UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BULLETIN 216

Spraying Missouri Fruits

Applying the third summer spray on apple trees.

COLUMBIA, MISSOURI
JULY, 1924

CONTENTS

Spraying Missouri Fruits

T. J. TALBERT

Abstract.—In this bulletin the importance of timely and thorough spraying is emphasized. The essential factors to be considered in the control of fungous diseases and insect pests injurious to fruits under Missouri conditions are carefully considered. A complete spraying schedule for all the fruits commonly grown in the State is included. The standard spraying mixtures, formulas and preparation, together with a description of modern spraying equipment and accessories are carefully set forth. The making and application of Missouri cold lubricating oil emulsions and boiled oil soap emulsions as sprays for deciduous fruit trees are given special attention. Many illustrations are presented to make clear the identification of important fungous diseases and insect pests harmful to fruit plants.

Spraying is the most important orchard practice. It is the cheapest insurance against failure. The cost of spraying is so small when compared with the returns it will bring that the orchardist can well afford to give the practice major consideration. The fruit grower who fails to spray thoroughly, properly, and at the right time will not succeed; even though he may use the best known cultural practices, pruning methods and fertilization systems.

The various sprays are applied to fruit trees and plants to prevent damage from the insects and fungous diseases injurious to orchards, vineyards and small fruit plantations. For practical purposes all the fungous diseases and insect pests may be grouped under the following three heads: (1) fungous diseases, (2) biting and chewing insects, and (3) sucking insects.

The fungous diseases are controlled by spraying the fruit trees and fruit plants with such mixtures as lime-sulphur and bordeaux. Some of the most common diseases of fruits requiring sprays for their control are: apple blotch, peach leaf curl, black rot of grapes, and brown rot of the stone fruits.

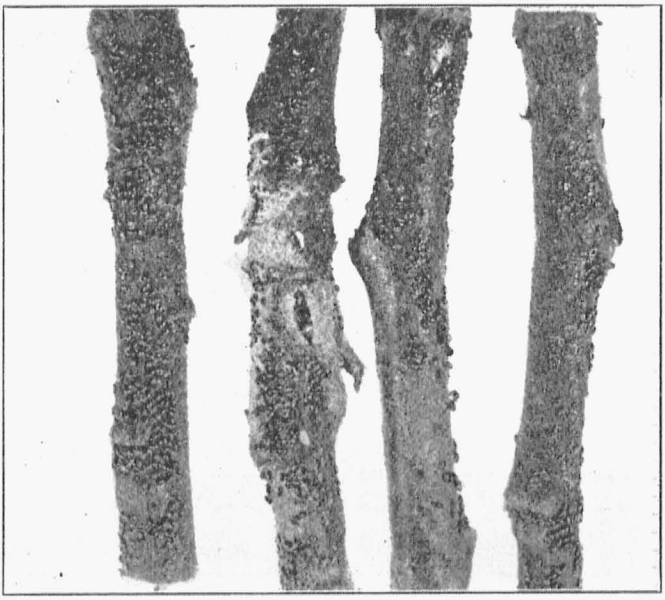
The fruit grower should keep in mind the fact that the fungicidal sprays such as lime-sulphur and bordeaux prevent the diseases instead of curing the plants of them. It is highly important, therefore, that the sprays be applied at the right time, to prevent the spores or seeds of the fungus from germinating and growing. Fungous diseases are spread by such agencies as the wind and rain. Once such growth or infection is started in the leaf or fruit, the sprays are valueless because they do not penetrate the surface of the plant tissues.

A protective spray or dust applied as a covering on the susceptible parts kills the fungous spores alighting on the coating before they have an opportunity to cause infection. In all spraying operations, it is important that all susceptible parts of the plant be kept thoroughly covered and that the new growth be sprayed often enough to prevent the germination of fungous spores and later injury.

One of the most important essentials in spraying is thoroughness of application. The spray may be applied at the right time, in the right way and with the right materials, but if it does not entirely cover the parts of the plant needing protection, it is not likely to be effective.

INSECTS

The chewing and biting insects like the codling moth, plum curculio, and canker worm, actually eat portions of the fruits, stems, and leaves. These insects and all others that feed in this manner may usually be destroyed by spraying the plants upon which they are feeding with an arsenical or stomach poison. Arsenate of lead is the standard arsenical used. In spraying the purpose is to cover completely the surface of the fruit and foliage with a thin film



Aphid eggs hatching on apple twigs in the spring just as growth is starting. A delayed dormant spray of oil emulsion diluted 1½ to 50, or nicotine sulphate ¾ pint in 100 gallons of lime sulphur, summer dilution, will control the pest if applied immediately after most of the eggs have hatched.

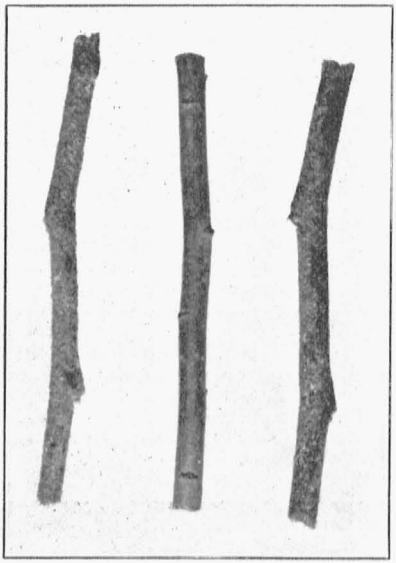
of the poison. The sprays should be repeated often enough to keep all new growth thoroughly covered. In so doing the insects are forced to feed upon poisoned food which kills them.

A contact spray is required for the control of sucking insects such as San Jose scale and the aphids. Examples of contact sprays are strong lime-sulphur solution and oil emulsions, when used to control San Jose scale. Nicotine sulphate is also a contact spray when used in summer sprays to control aphids. They are called contact sprays because they must be applied in such a manner as to come in contact with the body of the insect. The secret of success, therefore, is thoroughness. Every insect must be hit and wet with the spray; otherwise it will not be destroyed.

Fortunately for the fruit grower, it is not necessary to apply a separate spray for the control of each insect pest and fungous disease. It is possible to use combination sprays which will control the different kinds of insects and fungous diseases present at one application. In the first summer spray, for example, we may add to the lime-sulphur solution arsenate of lead and nicotine sulphate, making a combination spray capable of controlling biting and chewing insects like curculio, sucking insects like aphids, and fungous diseases like apple scab. The lime-sulphur acts as the fungicide, preventing the germination of the spores of the scab fungus; the arsenate of lead poisons the curculio; while the nicotine sulphate paralyzes and kills the aphids when applied to their bodies.

AMOUNT OF SPRAY REQUIRED

The actual number of gallons needed for each tree or plant will depend upon a number of factors, some of which are as follows: Size of trees or plants, thoroughness of application, spraying equipment, pest to be controlled and velocity of the wind at the time of of spraying. In general, the number of gallons needed per tree for apple, pear, peach, plum and cherry trees does not differ widely until the trees reach an age of about 10 years. After this age, the apple trees, mainly on account of being larger, need from 1 to 6 or 7 gallons more spray per tree than pear, peach, plum or cherry trees.



San Jose scale. The apple branches on the left and right of the center branch are infested badly by San Jose scale. The branch in the center is non-infested.

Average sized trees from 1 to 3 years old will require approximately ¼ to 1 gallon each; trees 3 to 5 years, ½ to 2 gallons each; trees 5 to 7 years, 2 to 3 gallons each; trees 7 to 10 years, 3 to 4½ gallons each; trees 10 to 14 years, 4 to 6 gallons each ; trees 14 to 18 years, 6 to 9 gallons each; trees 18 to 24 years, 9 to 12 gallons each; trees 24 years old or over may require from 12 to 20 gallons each. One may roughly estimate the number of gallons required for one application to a mature apple tree by dividing the age of the tree in years by two.

HOW TO CALCULATE AMOUNT OF SPRAY MATERIAL TO BUY

Dormant Spray, Lime-Sulphur.—To determine the amount of lime-sulphur solution to purchase, multiply the number of trees about the same age by the amount per tree as estimated above. Then multiply this by the number of sprays to be made, which is usually one, and divide the total by 350. The result will be the number of 50-gallon barrels of concentrated lime-sulphur solution that should be purchased. A 50-gallon barrel of lime-sulphur solution diluted at the rate of 1 gallon of the concentrated solution to 7 gallons of water will make approximately 350 gallons of spray.

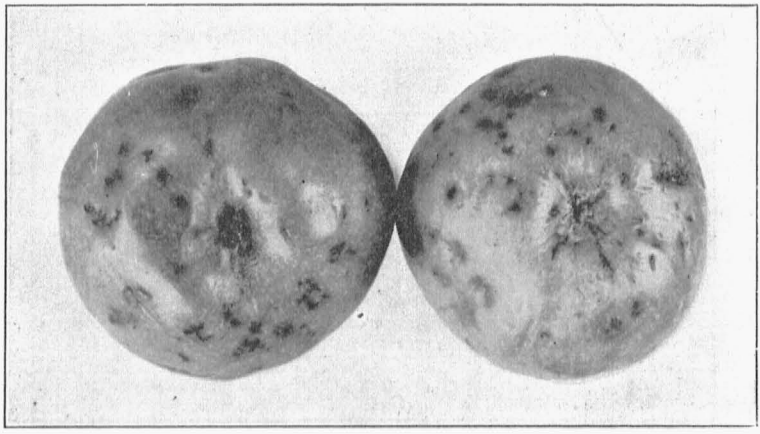
SPRAY SCHEDULE FOR APPLES

No. and Name of Spray, and When to Spray	What to Spray For	What to Use
I.—Dormant or Delayed Dormant Any time after the leaves drop in the fall and until the blossom buds begin to open in the spring. Generally most satisfactory just as buds are swelling.	San Jose scale and other scale insects.	Lime-sulphur 1 to 7, or lubricating oil emulsions, cold or boiled oil soap emulsion, 1½ to 50. Proprietary miscible oils at dilution marked on containers.
Special Spray When buds are opening and aphid eggs are hatching.	Plant lice (aphids). Only when serious.	Oil emulsion 1½ to 50, or nicotine sulphate ¾ pint in 100 gallons lime-sulphur diluted 1½ gallons to 50.
II.—First Summer Spray (Cluster Bud) When individual flower buds in the cluster begin to separate, but before they open.	Plant lice (aphids), Apple scab, Leaf spot, Curculio, Canker worm.	Lime-sulphur 1½ to 50 plus 1 lb. of arsenate of lead. When aphids are abundant, add nicotine sulphate ¾ pint to 100 gal. of spray mixture.
III.—Second Summer Spray (Calyx) Start when bloom is two-thirds off and finish before the blossom ends close. Most important single summer spray. Should be applied within a week after petals fall to be most effective.	Codling moth, Plant lice (aphids), Apple scab, Leaf spot, Curculio, Canker worm, Lesser apple worm.	Lime-sulphur 1¼ to 50, plus 1 lb. of arsenate of lead. When aphids are serious add nicotine sulphate ¾ pint to 100 gal. spray mixture. On account of danger of injury to fruit, bordeaux should not be used earlier than 12 to 14 days after the calyx spray.
IV.—Third Summer Spray Within 12 to 14 days after calyx spray. (If curculio injury is severe apply within 6 or 7 days after calyx spray, using lime-sulphur 1¼ to 50 and 1½ lb. of arsenate of lead.)	Apple blotch, Curculio, Codling moth, Lesser apple worm, Apple scab, Leaf spot, Phoma spot.	Lime-sulphur 1¼ to 50 plus 1 lb. of arsenate of lead. Where apple blotch or phoma spot is serious, use bordeaux mixture (3-4-50) instead of lime-sulphur.
V.—Fourth Summer Spray Apply 12 to 14 days after the preceding summer spray or No. IV.	Apple blotch, Curculio, Codling moth, Lesser apple worm, Sooty blotch, Phoma spot.	Lime-sulphur 1¼ to 50, plus 1 lb. of arsenate of lead. If apple blotch or phoma spot is serious. Use bordeaux (3-4-50) instead of lime-sulphur.
VI.—Fifth Summer Spray Apply about 12 to 14 days after No. V.	Codling moth, Lesser apple worm, Apple blotch, Bitter rot, Sooty blotch, Curculio, Phoma spot.	Lime-sulphur 1 to 50, plus 1 lb. of arsenate of lead. If apple blotch bitter rot, or phoma spot is serious use bordeaux (3-4-50) instead of lime-sulphur.
VII.—Sixth Summer Spray Apply about 12 to 14 days after No. VI. Make later sprays at intervals of 10 days to 2 weeks, where apple blotch, bitter rot, or phoma spot is serious.	Codling moth, Lesser apple worm, Apple blotch, Bitter rot, Sooty blotch, Curculio, Phoma spot.	Same materials in the same proportions as for the fifth summer spray.

Dormant Spray, Lubricating Oil Emulsion.—A 50-gallon barrel of the cold emulsion or the oil-soap emulsion diluted at the rate of 1½ gallons to 50 gallons of water will make approximately 1,650 gallons of spray. To find the quantity of oil emulsion required, calculate as indicated above by multiplying the number of trees about the same age by the amount estimated per tree. Then multiply by the number of sprays to be applied, which is usually one, and divide by 1,650. This will give the number of 50-gallon barrels to be purchased or made for the dormant or scale spray if oil is used.

Lime-Sulphur Solution for Summer Sprays.—Since a 50-gallon barrel of lime-sulphur solution used at summer strength, 1½ gallons to 50 gallons of water, will make approximately 1650 gallons of spray, calculate the number of barrels of the concentrated solution needed in the manner indicated for Lubricating Oil Emulsion.

Arsenate of Lead.—Multiply the number of trees of the same age by the estimated amount of spray needed for each tree, then multiply this by the number of sprays to be made and divide by 50. This will give the number of 50-gallon lots required. Now multiply this by 1, 2 or 3, depending upon the pounds of dry arsenate of lead or paste arsenate of lead you expect to use for each 50 gallons of spray. The product obtained will give the number of pounds arsenate of lead to purchase.

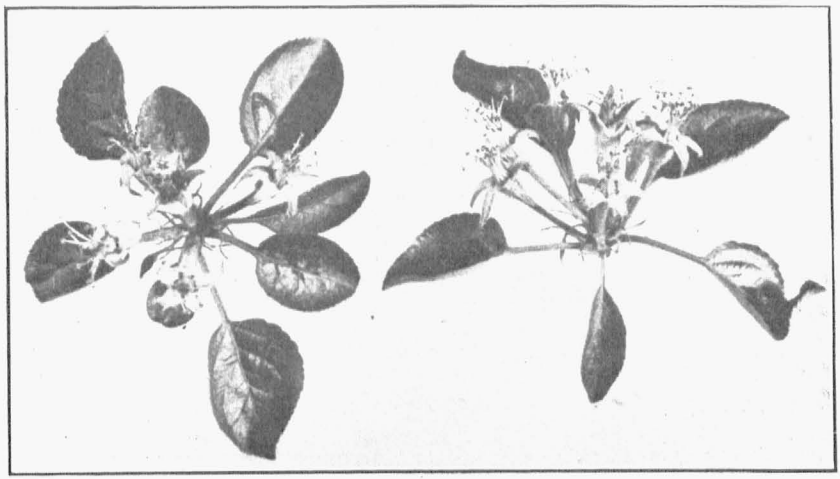


Phoma Spot injury on Jonathan apples. Bordeaux sprays applied at intervals of about 14 days from the time of the third application until mid-summer should control the disease.

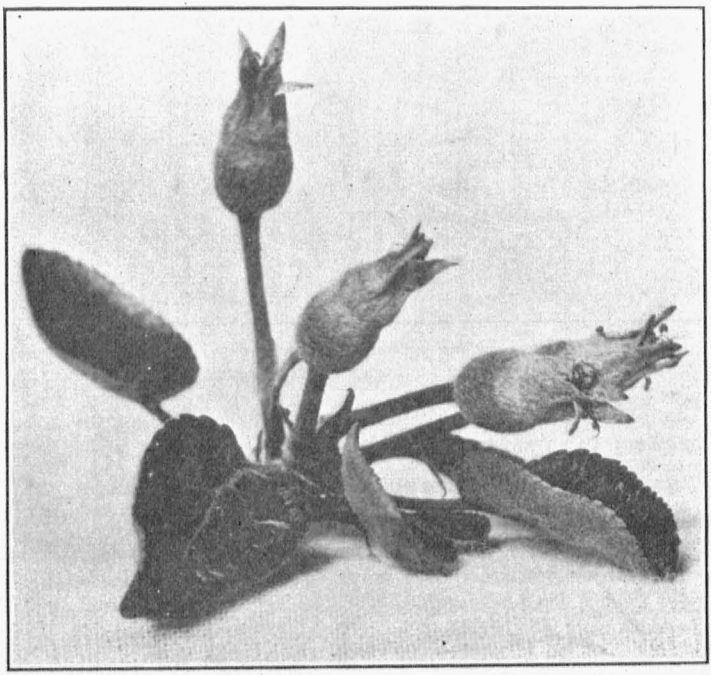
EXPLANATION OF SPRAY SCHEDULE FOR APPLES

If the orchard is practically free from apple blotch, bitter rot, and phoma spot, lime-sulphur (1¼ to 50) may be used instead of bordeaux in Nos. IV and V. All of the above sprays are not likely to be needed except in South Missouri. A study of the insects and fungous diseases common in the orchard will help the grower arrange a schedule adapted to his particular needs. The sprays ordinarily needed are I, II, III, IV, and V in the northern half of the State, while in the southern half, sprays VI and VII may be necessary.

Lime-Sulphur.—As referred to in the spray calendar, lime-sulphur means the concentrated commercial solution testing about 33 degrees Baume.



Time for the second summer or calyx-cup spray, the most important summer application. The blossoms or petals have just fallen and the calyx cups are wide open.

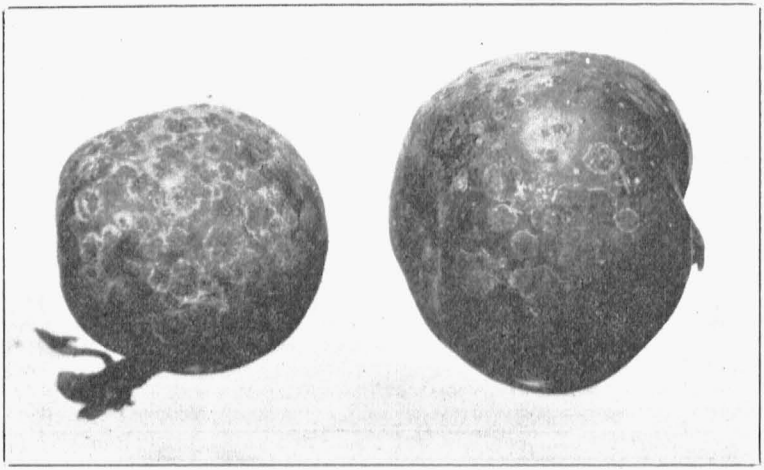


Too late for calyx-cup spray to be effective in controlling codling moth, as the calyces of the young apples have closed.

Bordeaux.—Bordeaux has reference to bordeaux mixture made according to the 3-4-50 formula (3 lbs. bluestone, 4 lbs. quick lime to 50 gallons of water).

Arsenate of Lead.—In the spray schedules the quantities given refer to the dry form, although the paste form of arsenate of lead may be used. For all practical purposes, one form is as effective as the other. Since the arsenate of lead paste is 50 per cent water, use twice the amount recommended for the dry form. Most orchardists now prefer to use the dry lead arsenate because it does not dry out when containers are opened and it is easier to store and handle.

Designation of Sprays.—The sprays beginning with the cluster-bud application are generally known as the first summer spray, second summer spray, third summer spray, etc. Since practically all fruit growers who spray their orchards never omit the calyx-cup or second summer spray, the time for applying the later applications may be based upon the date of the calyx-cup



Apples showing the characteristic spots of apple scab injury.

spray. If the date of each spray is based on a certain number of days following the last application it is usually less difficult to determine and keep in mind the dates of future sprays. This plan has been followed in the spray schedule.

Amounts of Spraying Chemicals.—The recommendations are to use 1 to 1½ gallons of lime-sulphur to 50 gallons of water and 1 pound of dry arsenate of lead for summer applications. In reality, 1 or 1½ gallons of lime-sulphur is to be used in 49 or 48½ gallons of water. At this proportion, a spray tank of 100 gallons capacity would require 2 or 3 gallons of lime-sulphur and 2 pounds of dry arsenate of lead, while a spray tank of 200 gallons capacity would require 4 or 6 gallons of lime-sulphur and 4 pounds of dry arsenate of lead.

Sprays Required.—Additional sprays may be necessary to control insects or fungous diseases requiring special attention. When the fruit crop is in danger spray without delay, using the proper spraying mixture. Where the grower applies sprays at intervals of 12 to 14 days from the time of the calyx spray until about the middle of July or later, his crop is usually protected.

Pears and Quinces.—The dormant spray and three summer sprays may be sufficient to prevent injury to pears and quinces in Central and North Missouri. In South Missouri, two additional fruit and foliage sprays, applied at intervals of from 14 to 18 days, may be required on account of the longer growing season.

The quince blooms considerably later than the pear. For this reason the pear will require earlier spraying than the quince. The same materials in the same proportion and applied according to the same schedule as for the pear should prove satisfactory.

SPRAY SCHEDULE FOR PEARS AND QUINCES

No. and Name of Spray, and When to Spray	What to Spray For	What to Use
I.—Dormant or Delayed Dormant		
Any time after the leaves drop in the fall and before the buds open in the spring. Generally most satisfactory just as buds are swelling.	San Jose scale and other scale insects.	Lime-sulphur 1 to 7 or lubricating oil emulsions cold or boiled oil-soap emulsions, 1½ to 50. Proprietary miscible oils at dilution marked on containers.
When buds are opening and aphid eggs are hatching.	Plant lice (aphids). Only when serious.	Oil emulsion 1½ to 50 or nicotine sulphate ¾ pint in 100 gallons lime-sulphur diuted 1½ gallons to 50.
II.—First Summer (Cluster Bud)		
When individual flower buds in the pear cluster begin to separate but before they open, and before solitary quince flowers open.	Plant lice (aphids), Pear scab, Curculio, Canker worm, Other diseases and chewing insects.	Lime-sulphur 1½ to 50, plus 1 lb. of arsenate of lead. When aphids are abundant, add nicotine sulphate ¾ pint to 100 gallons of spray mixture.
III.—Second Summer (Calyx)		
As soon as most of the petals have fallen.	Codling moth, Curculio, Pear scab, Other diseases and chewing insects.	Lime-sulphur 1¾ to 50 plus 1 lb. of arsenate of lead. When aphids are abundant add nicotine sulphate ¾ pint to 100 gal. spray mixture.
IV.—Third Summer		
About 14 days after the calyx spray.	Codling moth, Curculio, Sooty blotch.	Same materials in the same proportions as for the calyx spray.
V.—Fourth Summer		
About 18 days after the third summer spray.	Codling moth, Curculio, Sooty blotch.	Same materials in the same proportions as for the third summer spray.

Peaches.—Where San Jose scale and peach leaf curl are absent, sprays No. II and III will generally be adequate for early peaches. For the best protection of the fruit on varieties like Elberta Heath Cling and Krummel, two or three additional sprays applied at intervals of about 12 to 14 days may be required. This will be particularly true during wet seasons. It is important, however, that the spraying work be discontinued about three weeks before picking time to prevent marring the appearance of the fruit and having it discriminated against upon the markets.

Self-boiled lime and sulphur is one of the best and safest sprays for peaches. This is a special spray for peaches and Japanese plums. It should not be made up until it is desired to begin the spraying work. Self-boiled lime and sulphur should not be confused with commercial lime-sulphur or the home made lime-sulphur. The only heat used in making the self-boiled lime and sulphur is that produced by the slaking of the stone lime.

SPRAY SCHEDULE FOR PEACHES

No. and Name of Spray, and When to Spray	What to Spray For	What to Use
I.—Dormant Spray Any time after the leaves drop in the fall and before the buds swell in the spring.	San Jose scale, Peach leaf curl.	Lime-sulphur 1-7, or oil emulsion cold or boiled at the rate of 1½ to 50 in 5-5-50 Bordeaux.
Special Spray Before the buds swell in the spring.	If scale is absent, for peach leaf curl	Bordeaux 5-5-50 or Lime-sulphur 5-50.
II.—First Summer Spray Just as the husks fall from the young fruit or about 7 days after the bloom drops. *Special Spray* If curculio is serious repeat this spray in a week.	Curculio, Brown rot.	One pound of arsenate of lead and 3 pounds of freshly slaked lump lime to 50 gallons of water or if brown rot has been serious use 8-8-50 self-boiled lime and sulphur or 12½ lbs. of dry-mix sulphur lime to 50 gal. of water plus 1 pound of arsenate of lead.
III.—Second Summer Spray About 10 to 12 days after No. II.	Scab, Brown rot, Curculio.	Self-boiled lime and sulphur, 8-8-50, or 12½ lbs. of dry-mix sulphur lime to 50 gallons of water plus 1 pound of arsenate of lead.
IV.—Third Summer Spray About 10 to 12 days after No. III.	Scab, Brown rot, Curculio.	Same materials in the same proportions as for the second summer spray.
V.—Fourth Summer Spray About 10 or 12 days after No. IV.	Scab, brown rot, Curculio.	Same materials in the same proportions as for the third summer spray.

SPRAY SCHEDULE FOR CHERRIES

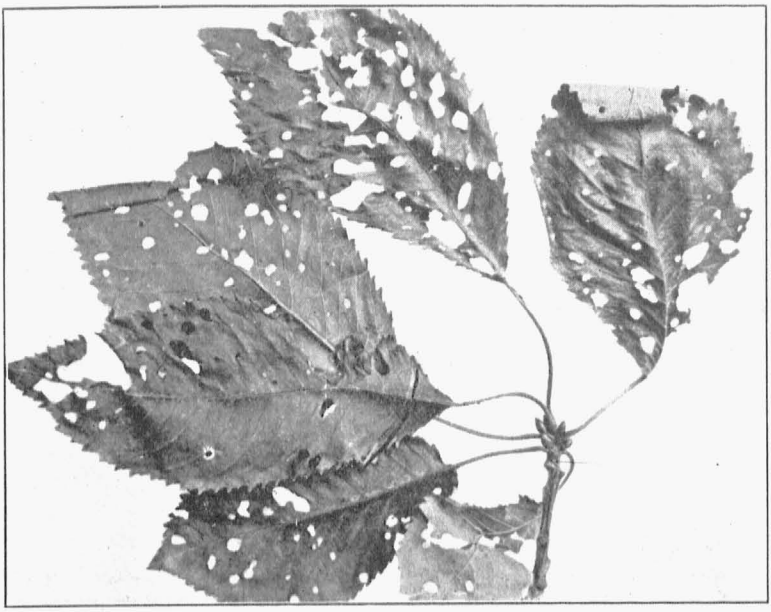
(The following schedule applies to sour cherries)

No. and Name of Spray, and When to Spray	What to Spray For	What to Use
I.—Dormant Spray Just before the buds swell in the spring.	San Jose scale, Cherry scale.	Lime-sulphur 1-7 when scale is present. If scale is absent, this spray is not required.
II.—First Summer Spray Just before the blossom buds open.	Curculio, Brown rot, Leaf spot.	Bordeaux 3-4-50 or Lime-sulphur 1½-50 and 1 pound of arsenate of lead.
III.—Second Summer Spray Immediately after the petals fall.	Curculio, Brown rot, Leaf spot.	Bordeaux 3-4-50 or Lime-sulphur 1½-50 and 1 pound of arsenate of lead.
IV.—Third Summer Spray 12 to 14 days after Number III.	Brown rot, Leaf spot, Curculio.	Bordeaux 3-4-50 or Lime-sulphur 1½-50 and 1 pound of arsenate of lead.
V.—Fourth Summer Spray Soon after picking the fruit.	Leaf spot, Leaf-chewing insects.	Bordeaux 3-4-50 or Lime-sulphur 1½-50. If leaf-chewing insects are present, add arsenate of lead at the rate of 1 pound to 50 gallons of spray.

SPRAY SCHEDULE FOR PLUMS AND PRUNES

No. and Name of Spray, and When to Spray	What to Spray For	What to Use
I.—Dormant Spray Any time after the leaves drop in the fall and until the buds swell in the spring.	San Jose scale, Black knot.	Lime-sulphur 1-7. This spray may be omitted if scale is absent.
II.—First Summer Spray Just before the blossom buds open.	Curculio, Brown rot, Leaf diseases, Leaf-chewing insects. Plant lice (aphids).	Lime-sulphur 1-50 and 1½ pounds of arsenate of lead. Add nicotine sulphate ¾ pint to 100 gallons of the spray where plant lice are serious.
III.—Second Summer Spray Immediately after the blossoms fall.	Curculio, Brown rot, Leaf diseases, Leaf-chewing insects, Plant Lice.	Lime-sulphur 1-50 and 1½ pounds of arsenate of lead. Add nicotine sulphate ¾ pint to 100 gallons of the spray where plant lice are serious.
IV.—Third Summer Spray* About 10 or 12 days after the second summer spray.	Curculio, Brown rot, Leaf diseases, Leaf-chewing insects.	Lime-sulphur 1-50 and 1½ pounds of arsenate of lead.

*During wet seasons susceptible varieties may require two or more additional sprays applied at intervals of 10 or 12 days.



Shot-hole injury on cherry leaves. This disease is also known as yellow-leaf and leaf spot. For control see the spray calendar for cherries.

Sour Cherries.—In orchards where the fungous diseases known as brown rot and leaf spot do not occur all the sprays as outlined above will not be needed. Since these diseases are so common in mature cherry orchards it will generally pay to apply all the sprays as outlined.

Sweet Cherries.—Bordeaux should never be used in spraying sweet cherries on account of the danger of the mixture doing severe injury to the fruit and foliage. Otherwise sweet cherries should receive the same treatment as sour ones, except the lime-sulphur solution should be used at the rate of 1 to 50 instead of 1½ to 50, to reduce the liability of injury from the spray mixture.

Additional summer sprays may be required to control brown rot if the season is wet. More sprays will also be required if curculio is serious. Where this is true the sprays containing lime-sulphur and arsenate of lead should be applied at intervals of about 10 days. It is important, however, that the spraying work be discontinued at least three weeks before picking time to prevent marring the appearance of the fruit.

Plant lice (aphids) frequently do damage to plums and prunes. When this pest is serious, add ¾ pint of nicotine sulphate to every 100 gallons of the spray mixture.

For the Japanese varieties of plums such as Burbank, Abundance, Chebot, etc., self-boiled lime and sulphur 8-8-50 should be substituted for the concentrated lime-sulphur solution. Atomic sulphur or the dry-mix sulphur lime may be used in spraying Japanese varieties of plums without danger of injury.

Grapes.—Where black rot is troublesome additional sprays made at intervals of about 10 days or two weeks may be required.

SPRAY SCHEDULE FOR GRAPES

No. and Name of Spray, and When to Spray	What to Spray For	What to Use
I.—Dormant Spray A few weeks before growth starts in the spring	Grape scale, San Jose scale, Anthracnose, Black rot.	Lime-sulphur 1-7 for both scale and anthracnose. If scale is absent for anthracnose and black rot use bordeaux 8-8-50.
Special Bud Spray As buds are swelling. Repeat in 5 to 7 days.	Grape flea beetle.	Arsenate of lead 3 pounds to 50 gallons of water.
II.—First Summer Spray When shoots are showing second or third leaf.	Black rot, Anthracnose, Flea beetle, Rose chafer.	Bordeaux 4-4-50 and arsenate of lead 3 pounds.
III.—Second Summer Spray Just before blossoms open.	Black rot, Anthracnose, Curculio, Flea beetle, Berry moth, Rose chafer.	Bordeaux 4-4-50 and arsenate of lead 2 pounds.
IV.—Third Summer Spray As soon as the bloom is off and the fruit is set.	Black rot, Anthracnose, Curculio, Berry moth, Downy mildew, Powdery mildew.	Same as for second summer spray.
V.—Fourth Summer Spray From 10 to 14 days after the Third summer spray.	Black rot, Anthracnose, Downy mildew, Powdery mildew, grape root worm.	Same as for third summer spray.
VI.—Fifth Summer Spray From 10 to 14 days after the fourth summer spray.	Black rot, Anthracnose, Chewing insects.	Same as for fourth summer spray.
VII.—Sixth Summer Spray From 10 to 14 days after the fifth summer spray.	Black rot, Other diseases and insects, if any.	Same as for fifth summer spray.

Lime-Sulphur is not used as a summer spray for the grape because it damages the fruit and burns the foliage.

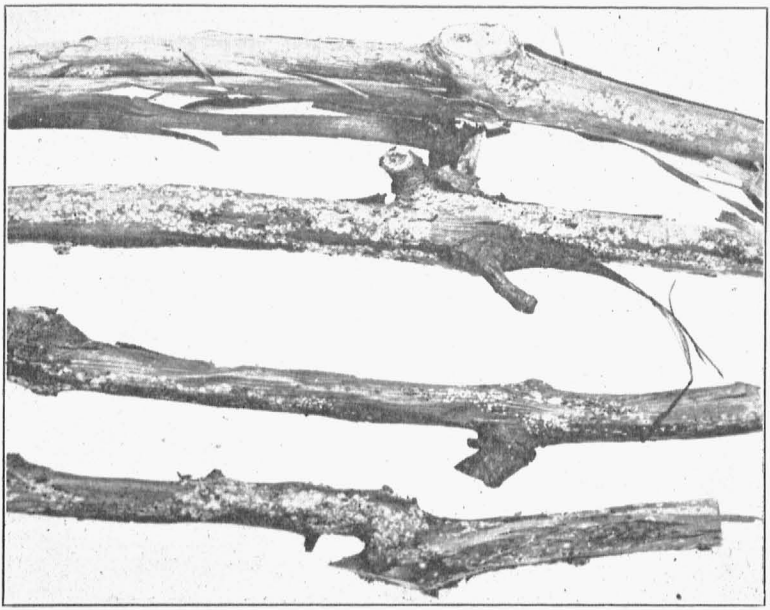
Thorough spraying and timely applications are required in successful grape culture. More beginners in commercial grape growing fail on account of improper spraying than from any other cause.

SPRAY SCHEDULE FOR CURRANTS AND GOOSEBERRIES

The currant is one of the favorite food plants of San Jose scale. The scale may also be found upon the gooseberry.

When scale is present, spray with lime-sulphur, 1 gallon to 7 gallons of water, just before the buds open in the spring.

The first summer spray is for the control of anthracnose, leaf spot, mildew and leaf-eating insects. It should be applied as the leaves are unfolding. Use



Grape canes showing a serious infestation of grape scale. To control, spray with lime sulphur 1-7 during the dormant season.

lime-sulphur 1¼ to 50, or bordeaux 3-4-50 and 1 pound of arsenate of lead. If plant lice are abundant, use nicotine sulphate at the rate of ¾ pint in 100 gallons of the spray mixture.

Two or three additional sprays may be required at intervals of about 2 weeks to control leaf spot, mildew and chewing insects. Lime-sulphur or bordeaux and arsenate of lead should be used, as for the first summer spray. The sprays should be discontinued about 3 or 4 weeks before harvest to prevent marring the appearance of the fruit and having it discriminated against upon the markets.

SPRAY SCHEDULE FOR RASPBERRIES, BLACKBERRIES AND DEWBERRIES

The practice of cutting out and burning the old fruiting canes immediately after harvest will tend to prevent injury from many diseases and insect pests. Such diseases as orange rust, mosaic, leaf curl and crown gall cannot be controlled by spraying. It is important, therefore, that the grower dig up with as many roots as possible and burn all plants infected by these diseases. To prevent such diseases from spreading, infected plants should be destroyed as soon as they are detected.

Soils on which diseased plants have grown should be cultivated in truck crops or field crops for several years before resetting. All nursery stock should be carefully inspected before planting. It is very important that healthy, vigorous, strong plants be used for transplanting. The best grade of nursery stock is apt to be the cheapest in the long run. Wherever possible, varieties resistant to the common diseases should be used.

Anthracnose, a fungous disease, is more serious on black raspberries than on blackberries and dewberries. The following spray schedule is usually effective in the control of the disease on these fruits: (1) A dormant spray consisting of lime-sulphur 1-7 applied shortly before growth starts; (2) lime-sulphur 1¼ to 50 applied when the young canes are from 6 to 8 inches high; (3) repeat this second spray just before blossoming. Some growers find that a fourth spray consisting of the same materials as for the second and third sprays applied immediately after harvest is profitable in controlling the disease. Bordeaux 3-4-50 may be substituted for the lime-sulphur in all the summer sprays mentioned.

When chewing insects are found feeding upon the foliage, arsenate of lead should be added to the spray at the rate of 1 pound to 50 gallons. It may be necessary at times to make special applications of arsenical sprays in which case add 3 or 4 pounds of stone lime or ⅓ more of the hydrated lime to each 50 gallons of spray. As with all sprays, thoroughness is essential to success.

SPRAY SCHEDULE FOR STRAWBERRIES

Well cared for strawberry fields and beds seldom require spraying. This is particularly true where the strawberry field or bed is renewed regularly and rotated with truck crops or field crops. Less injury is experienced where strong, healthy vigorous plants are used for setting.

Where fungous diseases and insects are troublesome, the following spraying schedule may be used:

SPRAYING SCHEDULE FOR STRAWBERRIES

I. Name of Spray and When to Spray	What to Spray For	What to Use
II. First Spray Soon after growth starts in spring.	Crown-borer, Leaf Roller, Slugs, Weevils, Flea-beetle.	Bordeaux mixture, 3-4-50 and arsenate of lead, 2 pounds
III. Second Spray About 12 to 14 days after the first spray.	Leaf-rollers, Slugs, and other foliage eating insects.	Bordeaux mixture, 3-4-50 and arsenate of lead, 2 pounds
IV. Third Spray Just as the plants begin to bloom.	Leaf-roller and other foliage eating insects.	Bordeaux mixture, 3-4-50 and arsenate of lead, 2 pounds.

The first spray should be made soon after growth starts in the spring, using 3-4-50 bordeaux and 2 pounds of arsenate of lead. The second spray should be made about 10 days or 2 weeks after the first. If the pests are serious a third application may be needed just before the plants begin to bloom. Bordeaux and arsenate of lead should be used as for the first spray. The strawberry may be sprayed without damage to the fruit until the berries are one-third grown.

The white grub is frequently a serious insect pest of strawberries. The grub feeds upon the roots and crowns of the plants. It may usually be prevented by planting sod land to truck or grain crops for a year or two before setting strawberries.

The crown borer, root louse and other insect pests may do injury to the strawberry plants. These and all the other insects and fungous diseases injurious to the strawberry may usually be controlled by the proper rotation of crops, the selection of young, vigorous, pest-free plants; and the use of old strawberry fields no longer than two years.

STANDARD SPRAYING MIXTURES—FORMULAS AND PREPARATION

Commercial Lime-Sulphur Solution.—The commercial lime-sulphur solution may be purchased from the manufacturers or dealers in practically all of the larger towns and cities. In many orchard communities the fruit growers club their orders and buy their supplies through the local dealers or direct from the manufacturers in car lots. Fruit growers associations may act as purchasing agents.

The different brands of commercial lime-sulphur vary according to the amount of lime and sulphur which they contain. By the use of an orchard hydrometer the density of any particular brand can be determined. Most of the commercial brands should test from 32 degrees to 34 degrees on the Baume scale.

A concentrated solution can be made from the following formula, testing 27 degrees to 29 degrees Baume, which is almost exactly like the commercial brand so far as composition and effectiveness is concerned:

Lime (burnt or stone)	40 lbs.
Sulphur (flowers or flour)	80 lbs.
Water	50 gal.

DILUTION TABLE FOR LIME-SULPHUR

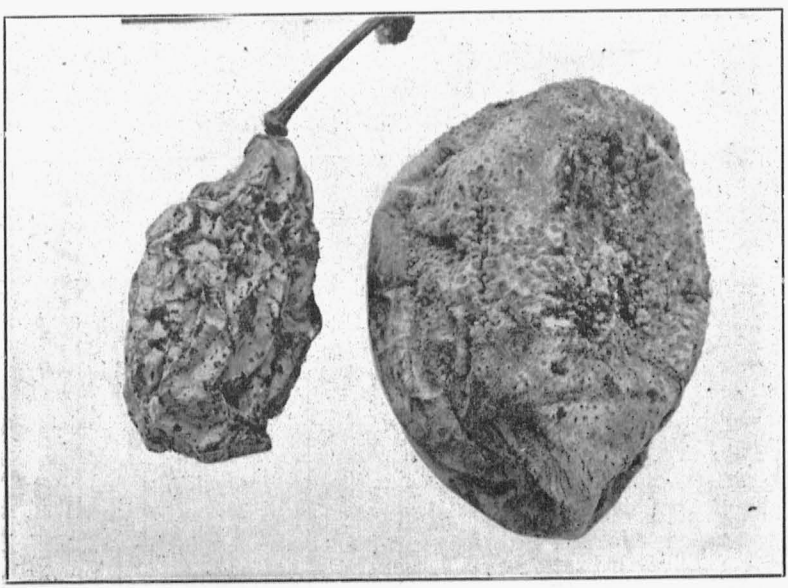
Baume reading (degrees)	To make 50 gallons summer sprays		To make 50 gallons dormant sprays	
	Lime-sulphur, (gallons)	Water, (gallons)	Lime-sulphur, (gallons)	Water, (gallons)
35	1¼	48¾	5¾	44¼
34	1½	48½	6	44
33	1½	48½	6¼	43¾
32	1½	48½	6½	43½
31	1½	48½	6½	43¼
30	1¾	48¼	7	43
29	1¾	48¼	7¼	42¾
28	1¾	48¼	7½	42½
27	2	48	8	42
26	2	48	8½	41½
25	2	48	8¾	41¼
24	2¼	47¾	9¼	40¾
23	2¼	47¾	9¾	40¼
22	2¼	47¾	10¼	39¾
21	2½	47½	11	39
20	2½	47½	12½	37½

The lime and sulphur may be mixed and boiled in iron kettles heated over outdoor fireplaces made for the purpose or the boiling may be done by steam. Add the lime to a large kettle or vat and start it slaking by adding a small quantity of water and when the action is vigorous sift in the sulphur and mix thoroughly with the lime. Sufficient water should be added from time to time to prevent the lime from drying out during the process of slaking. As soon as the lime is thoroughly slaked and the sulphur thoroughly mixed, enough water is added to bring the total volume to 50 gallons. Boiling is then continued for 45 to 50 minutes, water being added as needed to keep the volume at 50 gallons. After the boiling is completed the lime-sulphur can be diluted and used at once or it may be tested after cooling and stored in tight barrels. The test should be plainly marked on each barrel for future information in making dilutions.

The homemade concentrated lime-sulphur may be used with equally as good results as the commercial solution for making the dormant spray or the summer sprays provided the strength of the homemade product is tested carefully with an orchard hydrometer and the solution diluted according to the accompanying table.

MAKING AND BUYING LIME-SULPHUR SOLUTION

Where the fruit grower is not prepared to make lime-sulphur and needs only a comparatively small amount, he will usually get much better results in his orchard and find the work a great deal more satisfactory by buying the commercial product. Some of the largest orchardists also state that they can buy commercial lime-sulphur at prices so low that they cannot afford to make



"Mummied" plums. Caused by brown rot.

it at home. There is close competition in the sale of the product and the profits are small. The fruit grower will, therefore, usually find it to his advantage to buy the chemical rather than make it. It is also a fact that the commercial solution is more uniform in density and generally gives better results in the hands of the fruit growers than does the homemade product.

DRY LIME-SULPHUR

The use of dry lime-sulphur has increased greatly within the past few years. It is also true that the dry product has advantages worthy of consideration when compared with the lime-sulphur solution. Experimental tests and observations made at the Missouri Station have shown the following: To control insect pests and fungous diseases, it is always necessary to use the maximum and in some cases ¼ to ½ more than the amount usually recommended by the manufacturers in order to secure as good results as are ordinarily obtained by using the lime-sulphur solution at the recommended strength. When the dry product is so used the cost of the resulting spraying mixture is correspondingly increased. When sufficient amounts of the dry product have been used during the summer, the control of the scab fungus has been practically as good as when the lime-sulphur solution was used. The cost of the dry lime-sulphur has, however, been from 50 to 75 per cent greater than the lime-sulphur solution.

BORDEAUX MIXTURE

Where only a small quantity of bordeaux is desired, it may often be best to purchase the prepared product although a small quantity of bordeaux may be made without difficulty. In using prepared spraying chemicals, it is very important that the grower follow carefully the directions given on the containers.

If as much as two or three hundred gallons of bordeaux is needed, better results will generally be secured by making the spray mixture on the farm. The following formula and method of preparation has given satisfactory results in Missouri:

Blue vitriol (copper sulphate)	3 pounds
Stone lime	4 pounds
or	
Hydrated lime	6 pounds
Water	50 gallons

Only the highest grade of lime should be used. Since metal containers are corroded by copper solutions or bordeaux they should not be used in mixing or storing.

Making Stock Solutions.—The number of pounds of copper sulphate needed may be placed in a gunny sack or cloth bag and hung in a barrel or keg of water so that it is just below the surface of the water. This should be done a day or two before the spray is needed for use. When the copper sulphate is dissolved add sufficient water to make 1 gallon for each pound used. This is known and referred to hereafter as the copper sulphate stock solution.

If hydrated lime is used, the copper sulphate stock solution is the only one needed. The amount of hydrated lime required for each barrel or tank should

be mixed with a little water and stirred into a thin paste, after which it is ready to be poured through the strainer into the spray barrel or tank.

Where stone lime is used, slake the required amount in just enough water to make a thin paste. Stir and mix thoroughly after which add sufficient water to give 1 gallon for each pound of lime used. This is known and referred to hereafter as the lime stock solution.

The stock solution of copper sulphate will keep for several weeks without deterioration if evaporation is prevented. The lime stock solution deteriorates unless kept in air-tight containers. Where evaporation does occur, water should be added before using to bring the dilution up to 1 pound to each gallon.

Mixing.—According to the above formula, 3 gallons of the copper sulphate stock solution and 4 gallons of the lime stock solution, or 6 pounds of the hydrate lime made into a thin paste will be required for each 50 gallons of bordeaux to be made. Fill the spray tank about two-thirds full of water and start the agitator. Pour through the strainer 3 gallons of the copper sulphate stock solution for every 50 gallons of spray. Add 4 gallons of the lime stock solution or 6 pounds of hydrated lime made into a thin paste for every 50 gallons of spray. Then add the required amount of arsenate of lead and enough water to bring the volume up to the required amount, after which the spray should be used at once for best results. Since bordeaux deteriorates rapidly, the mixture should be used as soon after making as possible.

ARSENATE OF LEAD

Because of the necessity of controlling such insects as the codling moth, curculio, canker worm and other insect pests which bite and chew, arsenate of lead is usually required in every spray. It is generally used at the rate of 1 pound of the powdered or dry form to 50 gallons of either bordeaux or lime-sulphur spray.

The arsenate of lead may be purchased in either the dry or paste form. Nearly all growers now use the dry form as it is lighter and no trouble is experienced from evaporation as is true with the paste form. Since the paste form contains about 50 per cent water, twice as much should be added as when the dry form is used. The recommendations in this publication are all based upon the use of the dry arsenate of lead.

SELF-BOILED LIME AND SULPHUR

The following formula is used in making this mixture:

8 pounds of lump lime
8 pounds of ground sulphur
50 gallons of water

The best grade of stone lime should be used. Place the lime in a barrel or vat. Add a bucket of water to start slaking. When slaking is well begun, add another bucket or so of water, after which sift in the sulphur. *Stir* the *lime* and *sulphur vigorously* to prevent caking. Add water as needed to keep the mixture from drying or burning.

When the slaking process ceases, add water to make up to 50 gallons. The mixture should not be allowed to stand in the form of a paste. Strain it

into the spray tank or barrel, using a paddle to crush lumps of lime and sulphur and to work as much of the mixture through the strainer as possible. For best results, the spray should be used at once. It is important that self-boiled lime and sulphur be kept thoroughly stirred by the agitator otherwise it will settle badly to the bottom of the spray tank.

DRY-MIX SULPHUR LIME

The New Jersey Agricultural Experiment Station originated the dry-mix sulphur lime. This mixture was introduced to take the place of self-boiled lime and sulphur as a spray for the fruit and foliage of peaches. It is also used as a late summer spray for apples where blotch and scab are not serious. The formula by weight for making is as follows:

64 per cent superfine (dusting) sulphur
32 per cent hydrated lime
4 per cent dry calcium caseinate

To make 50 gallons of spray mixture use:

Sulphur	8 pounds
Hydrated lime	4 pounds
Calcium caseinate	8 ounces

The above amounts may be proportionately increased or decreased to meet the capacity of any particular spray tank.

Preparation.—The proper amounts of the ingredients should be mixed thoroughly. A screen having 12 to 14 meshes to the inch may be used to advantage in pulverizing the mixture. The dry mixture thus obtained will keep indefinitely if stored in a dry place. As a spray, it should be used at the rate of 12½ pounds to 50 gallons of water. Arsenate of lead should be added to this spray as with all others at the rate of 1 pound to 50 gallons.

SPRAY SPREADERS

Materials used with lime sulphur or bordeaux sprays to increase the adhesive and spreading powers of the spray are called spreaders. Practically all of the spreaders now being manufactured and sold by companies handling spraying materials have been carefully tried and tested in apple orchards at the Missouri Experiment Station. An effort has been made to carefully investigate each spreader as soon as it came on the market. Calcium caseinate spreaders have been used for several years.

From the spraying work done in apple and peach orchards the results and observations to date show that the spreaders used did not give enough better results to justify their use. It is possible, however, that the use of spreaders in spraying grapes, cherries, plums and other fruits having a smooth, sleek surface would prove profitable.

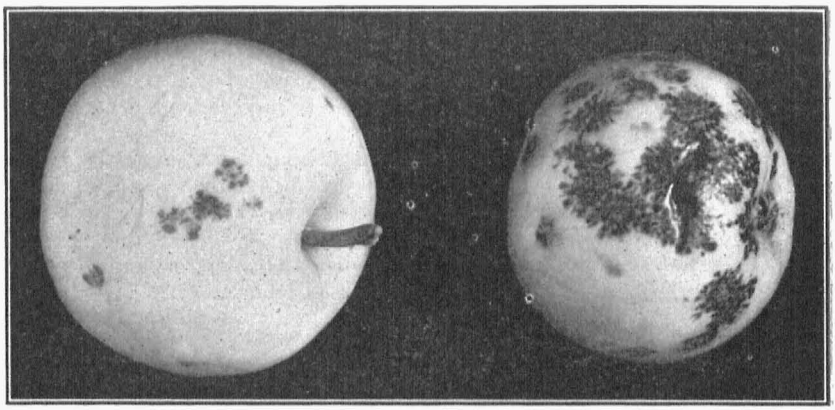
NICOTINE SULPHATE

This material is a tobacco product and may be purchased from companies dealing in spraying materials. It is generally used to control plant lice or aphids. Since the cost is very high, nicotine sulphate should not be used unless there is a real need. In spraying fruits to control plant lice, it is generally used at the rate of ¾ pint to 100 gallons of either lime-sulphur or bordeaux spray.

DUST VERSUS LIQUID SPRAYS

Extensive experiments and observations have been carried on by several state experiment stations to determine the relative merits of dust sprays as compared to liquid sprays. Some of the advantages of the dust spray may be enumerated as follows: (1) More trees may be sprayed in a given time. (2) On rough, hilly land, the dust sprayer and materials are more convenient to use. (3) Time is saved in loading the dusting machine and preparing the spray.

Some of the advantages for the liquid spray may be listed as follows: (1) In orchards where such diseases as apple scab and apple blotch are serious, practically all investigators and growers agree that the liquid spray is much more efficient than the dust spray. (2) The cost per tree for materials is much higher for dusting than for spraying, although the total cost is generally about the same. (3) In apple orchards where insect pests like the codling moth and the curculio are serious, better control is usually secured by the use of liquid sprays.



Fruit injured by apple blotch.

Very few growers in Missouri are now using dust sprays in their orchards. Several years ago when insect pests and fungous diseases were less injurious, dusting was more common and generally gave better results than it does in apple orchards at the present time.

Ordinary commercial sulphur is not suitable for dusting purposes. The finely ground and specially prepared sulphur and arsenicals are much more satisfactory. These products are manufactured and sold by companies dealing in spraying materials. Commercial concerns also handle machines and equipment suitable for applying dust sprays.

LUBRICATING OIL EMULSIONS

This spray is now being used extensively on fruit trees during the dormant season to control San Jose scale. Its use as a summer spray is not recommended on account of the danger of severe injury to both the fruit and foliage.

The following formula is recommended by the United States Department of Agriculture:

Paraffin lubricating-oil	1 gallon
Potash fish-oil soap	1 pound
Soft water	½ gallon

The soap, oil and water are placed in a vessel and brought to a vigorous boil by placing over a fire or by using live steam. While still hot, the solution is passed through a force pump at least twice, under not less than 60 pounds pressure. An emulsion cannot be obtained without the use of a pump. Ordinary stirring with a paddle is not sufficient. After the solution is thoroughly emulsified, it should keep indefinitely providing it is not allowed to freeze. Freezing which occurs at a temperature of about 18 degrees Fahrenheit causes the emulsion to break down, with the liberation of free oil which rises to the surface. An emulsion showing free oil should never be used as it may do injury to the trees.

If hard water is used, or if the tank is contaminated with traces of lime-sulphur or lime, a freshly made ¼-¼-50 bordeaux mixture will prevent the breaking down of the emulsion and consequent rising of free oil to the surface. If soft water and a clean tank are used this precaution may be unnecessary. It has been found that in practice water obtainable on the average farm, even if supposedly soft, generally breaks down the oil emulsion. To be on the safe side, the bordeaux stabilizer should be added to every tank of oil soap emulsion.

The Missouri Cold Emulsions.—The investigations of the Missouri Agricultural Experiment Station developed the fact that oil emulsions could be made without soap or heat. To do this, it was only necessary to use the materials which had previously been employed as stabilizers. These substances acted as emulsifiers without heat just as the soap had with heat.

The cold emulsions can be prepared more cheaply and easily than the oil soap emulsions. They also have another advantage in that they can be used with hard water, lime-sulphur, and in barrels or tanks contaminated with lime or lime water without breaking down. They are compatible with all combination sprays.

Field tests and investigations made by the Station have shown the cold emulsions to be just as effective in the control of San Jose scale as the oil soap emulsion. Observations and experiments indicate that there is no more likelihood of injury in the use of the cold emulsion than with oil-soap emulsions. Attention is called, however, to the discussion below entitled, Proper use of Lubricating Oil Emulsions.

Buying and Making Oil Emulsions.—Commercial concerns dealing in spraying materials manufacture and sell lubricating oil emulsions. The grower may buy ready to use, therefore, either the cold oil emulsion or the boiled oil-soap emulsion. Where one is not prepared to make the oil emulsion properly he will usually obtain better results by buying the product already prepared and ready for dilution. Moreover, it is also generally true that the manufactured product is more uniform and less dangerous to the fruit trees in the hands of the inexperienced grower than the homemade emulsions.

DIRECTIONS FOR MAKING COLD EMULSIONS

Formula I

Engine oil	2 gal.
Water	1 gal.
Calcium caseinate	4 oz.

Formula II

Engine oil	2 gal.
Water	1 gal.
Saponin	4 oz.

Formula III

Engine oil	2 gal.
Water	1 gal.
Copper sulphate (bluestone)	¼ lb.
or	
Iron sulphate (copperas)	¼ lb.
Burned lime	¼ lb.

Formula IV

Engine oil	2 gal.
Water	2 gal.
Copper sulphate	½ lb.
or	
Iron sulphate	½ lb.
Burned lime	½ lb.

Making Cold Stock Emulsions.—Formula I with calcium caseinate as the emulsifying agent was found to be one of the easiest to prepare and handle. The cost of 100 gallons of this spray was 38 cents as compared with 34 and 35 cents for Formulas III and IV. Formula I is considered superior, however, and worth the additional cost.

The oils used in making emulsions are of the cheap lubricating type, usually sold under the name of "engine oils", or of the type known as "floor oils" or "paraffin oils". Local oil dealers usually handle brands of oil suitable for sprays. Such oils should give a specific gravity test of 27° to 28° Baume, and have a viscosity of 90 Saybolt or higher. The better the oil for lubricating purposes, the poorer it is for a spraying emulsion. The value of an oil for lubrication is generally represented by its selling price. It is probable, therefore, that the cheaper oils meeting the specifications mentioned above, will be the best for spraying. They should cost from 15 to 23 cents per gallon in 50-gallon lots. Several companies sell oils suitable for spraying and persons desiring information about any particular brand should communicate with the Agricultural Experiment Station of the College of Agriculture.

To make 200 gallons according to Formula I, take 8 ounces of Kayso, (calcium caseinate), make into a paste by slowly adding water and stirring until 2 gallons of water have been added. Then add this to 4 gallons of oil, mix, and pump as in making the Government oil soap emulsion. To make an emulsion according to Formula II substitute 8 ounces of saponin powder, or the extract from ½ pound of soap bark, for the Kayso.

The stock emulsions made according to Formulas I, II and III as described above, contain 66 ⅔ % oil. To make a 2% oil spray use 3 gallons of stock emulsion to 97 gallons of water. If Formula IV is used, the stock emulsion will contain 50% oil, and 4 gallons will be required to 96 gallons of water in order to make a 2% oil spray.

These stock emulsions are ready for use with any kind of water or with lime-sulphur. They may also be put into tanks or barrels which have contained lime-sulphur, bordeaux or oil. A large enough quantity of the stock emulsion to last a day or two may be made by means of the power sprayer. The calcium caseinate emulsions will keep a long time. Oil sometimes separates out of the other emulsions after a few days, but can be re-emulsified by pumping again. All oil emulsions and proprietary or miscible oils stored in quantity should be thoroughly stirred before measuring out for use.

If it is desired to use 200 gallons of a 2% oil spray emulsified according to Formula III, put 4 gallons of oil in a half-barrel or other container, then add

½ gallon of the copper sulphate solution from a stock solution containing 1 pound per gallon and one gallon of water. Stir up the lime and add ½ gallon of the milk of lime from a stock solution containing 1 pound per gallon. Mix the oil and water, etc. by pumping the mixture back on itself, using a coarse spray. After a minute's pumping, reduce the opening in the nozzle until a fine spray is obtained and pump the emulsion into another container. Then pump it back again. The emulsion would probably be satisfactory with one pumping, but it is generally best to give it two. The finer the spray, the better is the emulsion obtained. Place the 6 gallons of emulsion in the spray tank and add 194 gallons of water making 200 gallons of spray.

To make the emulsion by means of a power sprayer, put the suction hose into a half-barrel containing the mixture, and pump it into the tank, Then pump it out of the tank into the container in which it is to be stored. It is essential if bordeaux is used as the emulsifying agent, that the pumping be done immediately after mixing the materials. Haste is not necessary when calcium caseinate is used. Only freshly made bordeaux or iron sulphate-and-lime mixture will act as a good emulsifying agent.

PROPER USE OF LUBRICATING OIL EMULSIONS

Oil emulsions have been used in Missouri for three years as dormant sprays for San Jose scale control. They are not recommended as foliage or fruit sprays. When directions for preparing, diluting and applying oil emulsions as a dormant spray are strictly followed, we believe that they are effective in controlling scale. Two per cent of oil is the strength recommended as a dormant spray. Remember also, that free oil, which may rise out of an improper emulsion, or from the diluted spray mixture, is liable to cause injury to fruit trees. If free oil does rise, the emulsion is not safe to use. Consult Missouri Experiment Station Circular 109 and Bulletin 205 on preparing oil emulsions. Do not spray free oil on trees. For best results a good emulsion must be maintained at all times. Lubricating oil emulsion is not fool-proof; but, if properly prepared and applied when weather conditions are favorable for dormant spraying, experience to date shows it to be safe. This also applies to the commercial oil emulsions and miscible oils on the market.

Some have had injury and poor scale control from the use of improperly prepared and applied oil sprays, so we urge strongly, careful preparation of the oil emulsion sprays. Injury has been reported from the use of oil sprays similar to lubricating oil emulsion, when applications were made immediately before periods of cold weather. Some also fear possible cumulative injury where dormant applications are repeated several years in succession. Experiments are now under way at the College of Agriculture which will determine whether such injury is likely.

POINTS TO BE REMEMBERED

The lubricating oil emulsions are not recommended as fungicides. There is no evidence that they have any fungicidal value. When mixed with bordeaux 3-4-50, however, the combination becomes a fungicide as well as an insecticide.

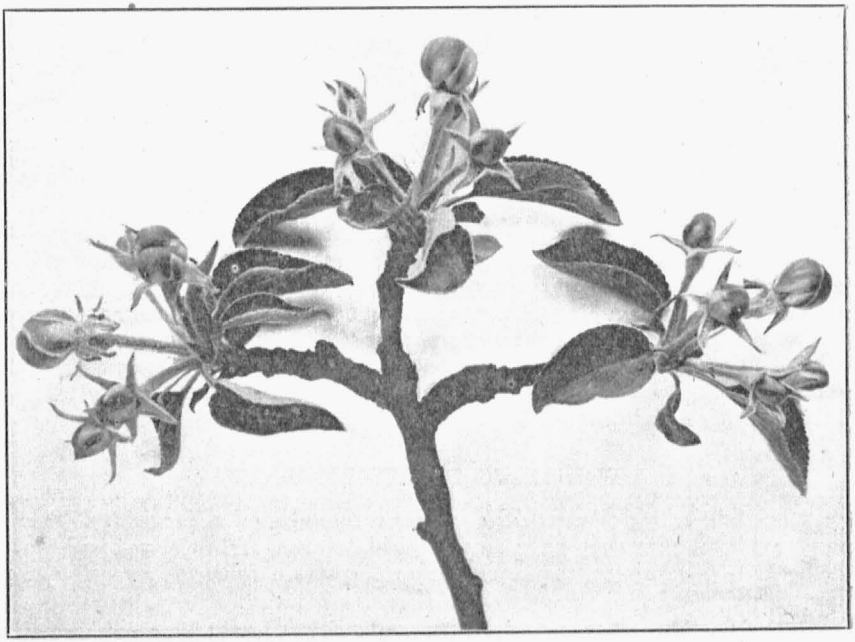
(1) For the effective control of scale either liquid lime-sulphur, the lubricating oil emulsions, or miscible oils may be used. If there is any slight advantage in the matter of scale control, it is on the side of the oils.

(2) From the point of view of scale control alone, the lubricating oil emulsion sprays are the cheaper.

(3) From the point of view of possible injury to the fruit trees, lime-sulphur has a decided advantage as it has never caused injury when applied on dormant trees. However, the oil emulsions are being used extensively for dormant sprays, and if the emulsions are properly prepared and diluted, evidence to date points to the fact that they can be safely used on dormant trees.

(4) Use ¼-¼-50 bordeaux with every tank of engine oil-soap emulsion. Stock emulsions in which free oil has separated out and come to the surface, due to freezing or any other cause should not be used. Do not use a dilute spray mixture in which free oil has separated out and come to the surface of the tank. Stir all stock emulsions before measuring out for use. If you make your own emulsions, follow directions carefully, especially instructions to use a pump giving good pressure. The pressure given by a hand pump can usually be increased by decreasing the size of the opening of the nozzle.

(5) Careful experiments and observations in Missouri have shown that San Jose scale can be effectively controlled with lime-sulphur, lubricating oil emulsions and miscible oils. A very thorough application is necessary and each spray must be used at the proper dilution. As many growers have failed to control scale with the oil sprays as with the lime-sulphur spray. It is not, therefore, so much a matter of which spray to use as it is of thorough spraying at the right dilution. One good dormant application each year should keep the scale well under control and prevent injury to the fruit and trees.

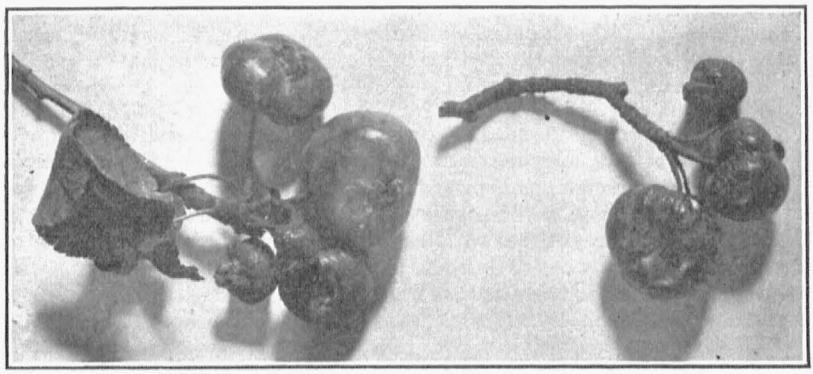


Cluster of apple buds in the "pink" stage, when the cluster bud or first summer spray should be made.

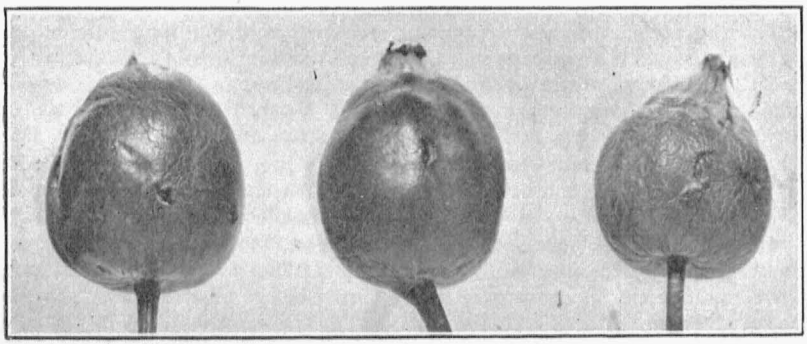
COMBINATION SPRAYS INCLUDING OIL

The Missouri Agricultural Experiment Station has been able to combine the dormant and first summer or pink spray for apple orchards. In so doing time, labor, and the cost of equipment for making one spray can be saved. The results obtained during the past two years have been satisfactory. From these results the indications are that the grower may wait to apply the dormant spray until the period for the pre-cluster bud or cluster bud application. A 2% cold lubricating oil emulsion may then be added to the lime-sulphur or bordeaux arsenate of lead at summer dilution and the combination spray used for the control of all the insect pests and fungous diseases injurious to the foliage and fruit buds at that time. The main pests to be combated at that period are San Jose scale, aphids, curculio, canker worm, apple scab and black rot leaf spot.

A bordeaux oil arsenate of lead spray, consisting of bordeaux made according to the 3-4-50 formula, a 2% cold lubricating oil emulsion, and one pound of dry arsenate of lead was used in one set of experiments. In another;



Apples dwarfed, gnarled and ruined by plant lice.



Work of plum curculio in scarring and deforming young apples. Many of the fruits drop as a result of such injury

lime-sulphur, oil, arsenate of lead, consisting of lime-sulphur 1½ to 50, a 2% cold lubricating oil emulsion and one pound of dry arsenate of lead was employed. The investigations have been made during two seasons, 1923 and 1924. The sprays were applied at different periods, ranging from the time of the appearance of the first green leaves until after the cluster buds separated but before the blossoms opened.

No material injury has so far been done to the young foliage or opening fruit buds. The tips and margins of the young apple leaves generally showed more browning or burning as a result of the application of lime-sulphur, oil, arsenate of lead than with the use of bordeaux, oil, arsenate of lead. Careful observations have shown that no fruit buds were destroyed and the injured leaves were soon replaced by new ones.

Sucking insects like San Jose scale and aphids have been effectively controlled at the pre-cluster bud and cluster bud periods. The spray has also controlled chewing insects like curculio and canker worms. Being a fungicide it has also been effective in the control of such fungous diseases as apple scab and black rot leaf spot. This spray has been very effective in the control of aphids, especially when applied immediately following the hatching of the aphid eggs. This period usually occurs shortly after the appearance of the first green leaves.

Where the grower decides to combine the dormant and first summer spray, it is important that he start the spraying work in time to finish before the blossom or flower buds open as the fruit and foliage are often seriously injured by the application of oil sprays after the cluster bud period. It is also important for best results that the oil emulsion, which is used for the control of such sucking insects as San Jose scale and aphids, be applied not later than the period between the appearance of the first green leaves and the opening of the first flower buds.

The addition of the oil to summer strength lime-sulphur or bordeaux may often be desirable because the grower may neglect or be unable to apply the dormant spray until after growth starts. Where this combination spray is used it is imperative that the spraying machinery and accessories be in first class condition and that sufficient materials be on hand to make the application. If delays occur the trees are apt to come into bloom before the spray can be applied to the entire orchard. The cluster bud or pink spray should generally be applied within a period of about seven days and the spraying work should cease while the trees are in bloom.

San Jose Scale and Peach Leaf Curl.—If San Jose scale and peach leaf curl must both be combated these troubles may be controlled by using a 2% cold lubricating oil emulsion with bordeaux made according to the 3-4-50 formula. Where San Jose scale is not present the bordeaux alone or lime-sulphur 1-15 or 1-20 is effective. One spraying is sufficient and it may be made in the fall after the leaves drop or in the spring before growth starts. In the control of peach leaf curl it is imperative that the work be done before the buds swell in the spring. For both San Jose scale and peach leaf curl thorough spraying cannot be emphasized too strongly. Unsprayed or partly sprayed buds may show the scale and curl.

SPRAYING EQUIPMENT AND ACCESSORIES

The spraying equipment should be such that thorough work may be done, otherwise, the results obtained by spraying will be disappointing. If suitable equipment is obtained less time and labor will be required in making the spray. Since some of the most important summer sprays must be supplied within a few days for best results, the opportunity for protecting the fruit against the ravages of insects and fungous diseases is greatly increased if the spraying equipment is what it should be. Delays caused by inferior or insufficient equipment may mean heavy financial losses.

A few of the essentials in spraying equipment may be summarized as follows:

Small Spraying Outfits.—The hand atomizers, bucket pumps, knapsack pumps, and compressed air pumps may be used effectively in spraying a few small trees, shrubs, and garden plants. They are not suited for spraying bearing apple trees and the results generally obtained by using such equipment in the orchard will not be satisfactory.

Barrel Pumps.—Apple orchards of from 4 to 5 acres may be sprayed efficiently with a good type of barrel pump sprayer. Every outfit of this kind should be equipped with a good agitator to keep the spray solution well mixed and a strainer at the bottom of the pump to prevent clogging the nozzles with particles of dirt.

Tank Pumps.—With an orchard of from 5 to 10 acres a double acting tank pump will be much more satisfactory than a barrel pump. Such a pump will maintain sufficient pressure for good work and since the tank may have a capacity of 100 to 150 gallons considerable time is saved in refilling. This is especially true where the orchard is some distance from the water supply.

Power Sprayers.—Bearing orchards of 10 to 25 or 30 acres can be most economically and efficiently sprayed with a gasoline power sprayer. Since a continuous high pressure is desired in order to obtain the best results in spraying, the gasoline power sprayer comes nearer meeting the requirements than any other type of power outfit.

SPRAYING ACCESSORIES

A spraying outfit is not complete unless it is equipped with all the useful accessories required for rapid and thorough spraying. Frequently a few dollars spent for such equipment will enable the orchardist to spray more effectively, with less difficulty and finish the work in from one-half to three-fourths the usual time.

Spray Hose.—It is economy to buy the best grade of high pressure hose. Hose about ⅜ to ½ inch inside diameter should be satisfactory for spraying work. The length of the hose will depend upon the kind of outfit used, distance between the rows, and size of the trees. In mature commercial orchards the average length should be about 35 to 50 feet. Barrel pumps and tank pumps should be supplied with not less than 25 to 35 feet of hose. In every case the hose should be long enough to permit the spray men to work around the trees without difficulty.

Shut-off.—This is a convenient device for cutting off the spray material whenever desired. It connects the spray hose with the spray rod. Its use saves spraying material and enables one to adjust or clean the nozzles quickly in case of clogging.

Spray Nozzles.—The angle disk type of nozzle is gen erally very satisfactory and efficient for most kinds of spraying work. The larger type is more suitable for the power outfits, while the smaller type is usually more satisfactory for the barrel pump or tank pump. Two nozzles may be attached to one rod by means of a Y if the spraying outfit has sufficient capacity and pressure. The Y's are made straight for angle nozzles and curved to a 45 degree angle for straight nozzles. All power sprayers and practically all barrel-pump and tank-pump outfits should develop enough pressure for two nozzles. In most cases the orchardist will save time and do better work by using the angle Y and two straight nozzles on each rod. It is important to set the nozzles on the spray rod at an angle of about 45 degrees. This allows the spray man to spray upward or downward with much less difficulty.

Miscellaneous Supplies.—Heavy hose couplings and clamps should be on hand and ready for use. A good pair of scales is required for weighing the spraying materials, since guess work may give poor results or it may do more injury than good. Every spraying outfit should be supplied with a good brass strainer for straining the spray mixture to prevent nozzle trouble. Extra parts of equipment most liable to wear or breakage should always be on hand.

Spray Guns.—The spray gun is now being used successfully by many Missouri apple growers. The spray gun consists of a large capacity nozzle attached to a short rod. The construction of the gun is such that the spraying solution passing through the rod may be varied from a wide angle, short distance spray, adapted for use on low trees or branches, to a narrow angle, long distance spray which will reach the tops of tall trees. One, may, therefore spray at close range, using a fine mist on lower branches; and on the treetops the spray may be made coarser and extended further by a slight adjustment of the spray controller.

A pressure of from 250 to 300 pounds is generally required for the successful use of the spray gun. It is, therefore, adapted for use only on power sprayers capable of furnishing a high, continuous pressure. In many cases, one spray gun is sufficient for one power outfit. Spray hose of about one-half inch diameter and not over 30 feet in length generally gives best results.

With sufficient pressure and when the spray gun is properly handled one man can do more work and do it easier than he can with the ordinary spray rod. The use of the spray gun has given as good results in the control of fungous diseases and insects injurious to apple orchards as the spray rod. Inefficient spray men are, however, more apt to do poor work or burn the fruit and foliage by over-spraying in using the spray gun than in using the spray rod. The principal argument favoring the use of the spray gun is that it is easier to handle and it saves time. In spraying high trees, some growers prefer to place a man in a spray tower or on the tank with a spray rod to spray the tops of the trees. Another man may use a spray gun from the ground to spray the lower half of the trees. Many commercial fruit growers who have become acquainted with the spray gun and its use, make the statement that it would be folly to use the spray rods longer for either high or low trees and that their spray men prefer to use the guns. They also maintain that the cost of labor in spraying is greatly reduced. It is admitted by all, however, that the spray gun requires a superior type of equipment. A spraying pressure of from 200 to 275 pounds with two guns is unsatisfactory, while a pressure of 275 to 300 pounds with one gun and one rod should be a success. The spray gun demonstrates the need of a high powered sprayer with a liberal reserve pressure.

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

PRACTICAL HINTS TO REMEMBER IN SPRAYING

1. Weigh or measure accurately all spraying materials and use them according to directions. If it is desired to experiment, do it in a small way and remember that at least three or four seasons' results should be secured before the practice is adopted for the whole orchard.

2. Apply the sprays at as nearly the proper time as possible and remember that the leaves and fruits are not protected unless they have been thoroughly covered with the spray. Unsatisfactory results are more often due to poor spraying than to other factors.

3. Use the standard spraying mixtures until you are convinced either by your own observation or by the observations and experiments of the College of Agriculture that the new materials are equally as good or better than the old.

4. Know when to spray, what to use, how to apply the spray to the best advantage, and what insects and diseases it is necessary to control.

5. Before the summer spraying season begins, secure enough spraying materials for at least two applications. This is necessary because there are only about seven to ten days time between the first and second summer sprays. Delays in ordering spray materials may mean the loss of a fruit crop.

6. Spraying materials if properly mixed, diluted and applied seldom do material injury to the leaves or fruit. Where injury is observed, however, study it carefully and be sure that the spray mixture is at fault before making radical changes in the spray mixture Frost injury, fire blight, and fungous diseases that may do harm to the fruit and foliage are often mistaken for spray-burn injury.

7. Use spraying equipment capable of doing the work required. Needed spraying accessories, such as better nozzles, spray rods and hose may mean the success or failure of the spraying work.

8. The practice of employing someone to spray the orchard often results in considerable expense and unsatisfactory fruit. It is usually advisable to spray your own orchard or lease it upon a share or cash basis.

9. Clean the spray tank or barrel, hose, rods and nozzles after each spraying by pumping clean water through them. Detach and oil the metal parts of the outfit which are apt to be difficult to adjust or remove as a result of the action of the spray.

10. To prevent injury to the face and hands from contact with the spraying solution, smear a heavy coat of vaseline on the face, wear a slouched hat and a pair of mule-skin gloves which should be kept thoroughly coated with axle grease.

11. In applying the third, fourth and later summer sprays, if the weather is hot and bright the lime sulphur solution may burn the fruit. Under such conditions bordeaux 3-4-50 and arsenate of lead is recommended. It is also true that bordeaux is more apt to burn during cloudy weather near the beginning of the spraying season than lime-sulphur.

12 The recommendations made in this publication are adapted as far as possible to the general conditions prevailing in the fruit-growing sections of Missouri. Every fruit grower should study carefully, however, the conditions in his own orchard, including the insect pests and fungous diseases, in order to be able to work out a spraying program best adapted to his own particular needs.