SPRAYING APPLE ORCHARDS FOR INSECTS AND FUNGI

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OBJECT OF CIRCULAR

The object of this Circular is to set forth, as clearly as the writer is able, some of the salient points in the spraying of apple orchards for insects and fungous diseases. Emphases are laid especially on the particular insecticides and fungicides which are to be used, on the methods of their preparation, and on the manner and time of applying the mixtures to the trees. The information conveyed herein is derived from many sources, including a wide range of literature on the subject of spraying, the personal experience and past experimental work of the men in the Departments of Horticulture and Entomology at the University of Illinois, the experience of many practical orchardists whom the writer has visited, and the writer's own experience in preparing spraying mixtures in the field and in the laboratory.

This Circular is not intended to record the results of new or original investigations, but is merely a guide, based on what now appears to be the best practice in applying insecticides and fungicides to apple orchards, designed to assist Illinois orchardists in their spraying operations. It is the writer's belief and hope that the recommendations presented in the following pages will have to be supplanted by better ones within a very few years. Better methods and probably better mixtures will be discovered. In the meantime, however, apple growers must be content to use to the best advantage, the information which is at hand.
STANDARD SPRAY MIXTURES

From among the many chemicals which have been used for making spray mixtures a certain few have come to be recognized as standards. Their efficiency under various circumstances and for various purposes is pretty well established, and while there still remains much to be learned about them, these mixtures can be recommended with the assurance that, when judiciously used, they will accomplish what is expected of them.

Spraying mixtures may be divided into three principal classes: insecticides, fungicides, and combined insecticides and fungicides. Insecticides are used for the control or destruction of insect pests. Fungicides are for the control or prevention of fungous diseases. Combined insecticides and fungicides are for both insects and fungi.

INSECTICIDES

Insecticides are classified according to their action, as poisons and contact remedies. Poisons are used against chewing insects, which obtain all or a part of their food from the surface of plants. To be effective these materials must be applied to the food of insects in sufficient quantities to destroy them when eaten. Contact remedies smother the insects by stopping their breathing pores, or corrode their bodies in the same way that an acid or a caustic burns a piece of cloth or the flesh of a person's hand. Contact remedies are used against insects which obtain their food, by means of sucking mouth parts, from the juices beneath the surface of the plants. This group of insects includes the various scales and plant lice.

POISONS

The best known and most commonly used of the standard poison sprays are the arsenicals, the active poisoning property of which is arsenuous acid.

Paris Green

Paris green is the best known and most commonly used of the arsenical poisons. When of first class quality it is one of the most satisfactory to apply and is very effective in destroying chewing insects. In its pure form it contains 58.65 percent of
arsenious acid, 31.29 percent of copper oxid, and 10.06 percent of acetic acid. Commercial Paris green should contain 56 percent of arsenious acid, at least 52 percent of which should be in combination with the copper oxid and the acetic acid. Free or water soluble arsenious acid is dangerous to foliage, and not over 4 percent should be allowed in Paris green used for spraying. Paris green is sometimes adulterated with foreign substances such as finely ground gypsum and sand. These add to its weight and lessen its effectiveness.

The purity of a sample of Paris green cannot be known with certainty without the making of a chemical analysis. There are, however, a few simple tests by which its quality may be fairly well determined by the orchardist.

Paris green should be a very fine dry powder entirely free from grit, smooth and velvety when rubbed between the fingers. Matting or caking together of the particles generally indicates carelessness in manufacture, and makes the even distribution of the poison more difficult.

The color should be a beautiful clear green. Adulterations sometimes give it a faded or dull appearance. Faulty colors can be detected by placing a pinch of the sample on a piece of clean, dry glass. The glass is held at a slight angle and tapped gently in order to cause the poison to run down, leaving a smear or streak on the surface. This streak should remain bright emerald green in color—not whitish or dull.

A good quality of Paris green dissolves completely in ammonia water. This test is conclusive for adulterations like sand and gypsum, as these will remain in the bottom of the vessel after the Paris green itself has gone into solution. It does not, however, indicate the presence of free arsenious acid, since the crystals of arsenious acid are also soluble in ammonia water.

Where the buyer has the use of a compound microscope, a minute examination of the sample will determine with great certainty the quality of the Paris green. A small sample is placed on a slip of glass which is tilted slightly and tapped on one edge to cause the poison to run down, leaving a thin streak of green on the glass, in the same manner as indicated in the directions for the color test. The sample is then examined under an objective of medium power, one-fifth or one-quarter inch. As thus observed pure Paris green may present the appearance of well-defined spheres, generally more or less separated from each
other, with whitish or transparent crystals of arsenious acid (white arsenic) projecting from a few of the spheres.*

George E. Colby in Bulletin No. 151 of the California Agricultural Experiment station thus describes the appearance of impure samples of Paris green as seen under the compound microscope: "In impure samples of Paris green there will be observed, in addition to the above described particles of either spherical or irregular shape, a considerable quantity of material of crystalline shape, usually of white color, the pure green being quite distinct from the adulterants, as seen under the microscope, and as easily recognized as wheat can be distinguished from impurities that might be mixed with it."

As a spraying material Paris green has two principal disadvantages. It settles very quickly in water, necessitating continuous agitation of the spray mixture during the process of application. It sometimes contains considerable quantities of free arsenic and is then liable to injure the foliage.

Paris green is applied to apple trees in proportions varying from 4 to 8 ounces to 50 gallons of water. The standard Paris green mixture, however, is as follows:

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

Slake the lime carefully in a small quantity of water by pouring on just sufficient to start the slaking. Add water from time to time to prevent burning the lime. When properly slaked it will be found in the form of a smooth thick paste. Dilute this paste with enough water to make a milk of lime that will pour readily. Strain this milk of lime into the spray tank or mixing tub through a brass or copper strainer (20 meshes to the inch) to remove all lumps of gritty foreign substance. Then add sufficient clear water to make up fifty gallons of spray mixture. Mix the Paris green in a pint of water taken from the spray tank, by shaking in a jug or large bottle. Pour it through the strainer into the diluted lime water in the spray tank or mixing tub. Keep the mixture very thoroughly agitated throughout the process of spraying.

Paris green is used against codling-moth, canker-worm, curculio, leaf skeletonizer, tent-caterpillars, fall web worm, grass-

*If made by the most newly invented methods, the particles of Paris green will appear more irregular in shape and slightly more variable in size, than where made by the older method.—See California Bulletin No. 151, George E. Colby, for description of new method of making Paris green.
hoppers, green fruit-worms, and other leaf- and fruit-eating insects.

Home Made Arsenate of Lead

During the past few years arsenate of lead has been growing steadily in favor with orchardists as an arsenical insecticide. In experiments on the control of the second brood of codling-moth, at the University of Illinois, arsenate of lead proved slightly superior to Paris green as a remedy for this pest. Good results were also obtained from the use of arsenate of lead in spraying apples for curculio. The Washington State Experiment station, after a protracted study of remedies for the codling-moth, states that "arsenate of lead has been found to be better than any other substance for spraying this insect." Arsenate of lead is being used almost to the exclusion of Paris green in some of the Rocky mountain and the Pacific coast states, and a number of the commercial apple growers in Illinois are now using this insecticide with satisfactory results.

Arsenate of lead possesses several distinct advantages over Paris green. It is more adhesive and can be applied in much stronger doses to the trees without injuring the foliage or russetting the fruit. It is, however, slightly higher in cost, for, while the components of the poison are cheaper, weight for weight, than Paris green, larger quantities of the insecticide must be used. The amount found most effective in the experiments at the University of Illinois on the control of the codling-moth, was two pounds and three ounces of home-made arsenate of lead mixture to fifty gallons of water.

Arsenate of lead is prepared by mixing acetate of lead (sugar of lead) with arsenate of soda. To insure good results these materials should be of first-class commercial quality. The arsenate of soda should not contain more than 2 or 3 percent of chlorin, and "the quality to be used is that known to the manufacturers and the trade as 68 percent arsenate of soda," containing 47.8 percent of arsenious acid and only 0.57 percent of chlorin. A well crystallized sample of acetate of lead, containing from 58.8 percent to 60 percent of available lead oxide, is the other constituent. Nitrate of lead may be used in place of acetate of lead,

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*Spraying for the Codling-Moth. John W. Lloyd, University of Illinois Agricultural Experiment Station Bulletin No. 114.
†Spraying Apples for the Plum Curculio. S. A. Forbes, University of Illinois Agricultural Experiment Station Bulletin No. 108.
‡Spraying for the Codling-Moth. John W. Lloyd, University of Illinois Agricultural Experiment Station Bulletin No. 114.
but owing to its higher cost, the use of the latter compound is advisable.*

Arsenate of lead is prepared for spraying in the following manner: Use

10 ounces arsenate of soda,
25 ounces acetate of lead,
50 gallons of water.

Dissolve 10 ounces arsenate of soda in 1 gallon of water and 25 ounces acetate of lead in 2 gallons of water. Pour the two solutions, one after the other, into a mixing tank, or directly into the spray tank, containing 47 gallons of water. Stir thoroughly to insure a perfect combination of the two chemicals. The white precipitate which forms when the two solutions combine in the water is a mixture of arsenate of lead and other compounds formed when the two chemicals unite.

Both arsenate of soda and acetate of lead will dissolve much more rapidly in hot water. When preparing considerable quantities of lead arsenate, however, it will be found convenient to make up the solutions sometime ahead, dissolving the chemicals by suspending them in coarse sacks near the tops of barrels of water. Thus, if 31 pounds 4 ounces of arsenate of soda be dissolved in 50 gallons of water, each gallon of the solution, when well stirred so as to distribute the material evenly, would contain 10 ounces of arsenate of soda. And if 78 pounds 2 ounce of acetate of lead be dissolved in 50 gallons of water, every gallon of the liquid would represent 25 ounces of acetate of lead. Hence one gallon of the former and one of the latter solution would contain sufficient arsenate of soda and acetate of lead, respectively, to make 50 gallons of spray mixture. Proportionate quantities of the solutions can be used in making up the mixture in 100-and 200-gallons quantities.

Commercial Arsenate of Lead

Among the prepared insecticides so extensively advertised by various manufacturers, the lead compounds of arsenic are the most reliable. The arsenates of lead prepared by a number of well known firms are effective insecticides. Chemical analyses indicate that samples of these arsenates contain from 17 to 24 percent of insoluble arsenious acid, the amount varying mostly with the quantity of water mixed with the various samples. The

*Arsenical Insecticides. George E. Colby, California College of Agriculture Experiment Station Bulletin No. 151.
quantities of free arsenious acid found were mere traces, quite insufficient to cause injury to foliage.

Commercial arsenate of lead is usually more expensive than the home-made compound. Nevertheless if the orchardist has difficulty in obtaining first class chemicals with which to manufacture his own, or if he has only small areas to spray, it will pay to use the commercial brands rather than risk injuring his crop or going to the trouble of making up his own mixture.

Commercial arsenate of lead is mixed with water in proportions varying from 1 pound to 3 pounds to 50 gallons. The directions of the manufacturers generally require the use of the larger quantity.

3 pounds commercial arsenate of lead,
50 gallons of water.

The arsenate of lead is mixed into a smooth paste with a small quantity of water. It is then poured into the amount of water required to make up 50 gallons, either in the spray tank or a mixing tub, and kept well agitated during the operation of spraying.

Arsenate of lead is used against the same insects as is Paris green.

CONTACT INSECTICIDES

Lime Sulphur Wash

Lime and sulphur washes are made up in a number of different ways and are known by various names taken from the localities where they were first used. Thus we have the Oregon wash, the California wash, and the ordinary lime-sulphur wash, proper. The Oregon wash contains copper sulphate and the California wash contains common salt, in addition to lime and sulphur. Experiments in Illinois, New York, and other states indicate, however, that these washes are not more effective than those made of lime and sulphur alone.

The formula for making lime sulphur wash is as follows:

15 pounds fresh lime,
15 pounds sulphur,
50 gallons water.

The preparation of lime-sulphur wash requires some means for boiling the mixture. When large blocks of trees, forty acres or over, are to be sprayed, a steam cooking plant should be installed. When smaller areas are to be treated the mixture may
be cooked in large iron kettles heated over a brick fire place, built at some spot convenient to the orchard and to a water supply.

Lime-sulphur wash may be prepared in fifty gallon quantities in the following manner: In a forty-gallon iron kettle heat 12 gallons of water nearly to boiling. In a separate vessel mix 15 pounds of sulphur, either flour of sulphur or flowers of sulphur, with enough water to make a thin paste. Pour the paste into the heated water and when the mixture is just below boiling put in 15 pounds first-class lump lime. Add cold water from time to time as the mixture threatens to boil over. After the lime has completely slaked, boil the wash for one hour, stirring almost constantly to prevent caking on the sides of the kettle. Then strain into the spray tank and add sufficient water, either hot or cold, to make up a total quantity of 50 gallons of the mixture. Double this quantity of lime-sulphur wash may be prepared with a forty-gallon kettle by using double the quantity of lime, sulphur, and water given above. Lime-sulphur wash should be handled in wooden vessels, as far as possible, and the spray pumps and hose should be cleaned at the end of each day's work, by pumping clear warm water through them.

When considerable areas of orchard have to be sprayed with lime-sulphur wash, special conveniences for the preparation of the mixture are essential. Elevated platforms, a gravity water supply system, and pipes for the conduction of steam, and the cooking of the wash in barrels or tanks should be arranged for.

*Time of Application.*—Lime-sulphur wash is applied to trees only when they are dormant. Experiments indicate that the wash is most effective when applied just before growth begins in the spring. It may, however, be applied with beneficial results in the fall after the trees have lost their foliage, and some benefit is derived from spraying even in mid-winter. Where lack of time in the spring, or soft ground in the orchard, prevent spring spraying, it will be necessary to apply the wash in fall or winter.

*Thorroughness of Application.*—Owing to the rapid rate of increase of some scale insects, and especially the San Jose scale, it is necessary to start the season by destroying, if possible, every individual infesting the trees. The twigs should be coated on all sides and to their very tips. If the wind is blowing strongly, so that a perfect coating cannot be secured from all sides, a second application should be made, taking advantage of a calm day or of a wind from the opposite direction, to cover the unsprayed side of the tree.
Insects Combated. — Lime-sulphur wash is used to destroy San Jose scale, Forbes scale, oyster shell bark louse, and scurfy scale. It is probably also effective against the eggs of many different insects, destroying them by its corrosive action.

Kerosene Emulsion

Kerosene emulsion is one of the most efficient of the contact insecticides used against soft-bodied insects.

The formula for its preparation is simple. To make a stock mixture use

\[
\begin{align*}
\frac{1}{2} \text{ pound whale oil soap or hard soap, or 1 quart of soft soap,} \\
2 \text{ gallons kerosene,} \\
1 \text{ gallon soft water.}
\end{align*}
\]

Dissolve the soap in the water heated to boiling. Remove the water from the fire, and add the kerosene to the hot mixture, churning or stirring it violently at the same time. The mixing can be done most effectively by pumping the emulsion back upon itself through a hand force pump of the bucket type. Continue the mixing until a creamy emulsion, which shows no free oil on the surface, is obtained. The emulsion made in this way will keep indefinitely. The amount of kerosene emulsion made by the above formula should be diluted with 27 gallons of water making a total of 30 gallons of spray mixture; that is, 1 gallon of the stock kerosene emulsion to 9 gallons of water.

Time of Application.—Kerosene emulsion of the strength recommended above is for application of the trees at any time while in foliage. This spray is a remedy rather than a preventive, and is to be used after the appearance of the insects for which it is to be applied.

Insects Combated.—In apple orchards, kerosene emulsion is particularly designed as a remedy for green apple aphis on the foliage and for woolly aphis on the trunks and branches. For the former insect it is applied in the form of a spray. Against the woolly aphis it is applied with a brush to the crevices and forks where the insect hides.

Fungicides

Bordeaux Mixture

Among the various fungicides there is none so widely used nor so generally effective as Bordeaux mixture. Up to be present time no other spray material has been found which can be recommended so highly for the control of the various fungous dis-
eases of the apple. Bordeaux mixture, therefore, is the only fungicide which will be described here.

Bordeaux mixture is made up of copper sulphate (blue stone or blue vitriol), freshly slaked lime, and water. The mixture itself is composed of complex and insoluble compounds of lime and copper which remain in suspension in water during the process of spraying. It is made up in various strengths depending upon the purposes for which it is to be used. The following formula is the one most commonly recommended:

4 pounds copper sulphate,
4 pounds fresh lime,
50 gallons water.

While the proportions given above are for the standard preparation, it is advisable, under certain circumstances, to use a weaker mixture. Where orchardists have sprayed thoroughly and regularly year after year, and have adopted good cultural methods generally in their plantations, the sources of infection from fungous diseases will be greatly reduced, and the use of the formula given below will be found sufficient to hold fungi in check.

3 pounds copper sulphate,
3 pounds fresh lime,
50 gallons water.

To prepare 50 gallons of Bordeaux mixture, dissolve the copper sulphate in 25 gallons of water. Mix the lime, carefully slaked (see directions for slaking the lime, page 6), with another 25 gallons of water. Then pour the two simultaneously through a brass or copper strainer, that will remove all lumps of lime, into a mixing tub, or directly into the spray tank. Stir vigorously as the two solutions fall into the tub or tank.

When large quantities of Bordeaux mixture are to be prepared, it is customary to make up stock solutions of copper sulphate and lime. One hundred pounds copper sulphate are dissolved in 50 gallons of water. The sulphate is suspended in a coarse sack near the top of the barrel in order to hasten solution. To dissolve this quantity, the copper sulphate should be suspended in the water over night. One hundred pounds of lime are slaked, in the manner referred to on page 6, and diluted with sufficient water to make a total quantity of 50 gallons. When the two are stirred so that the copper sulphate and the lime are evenly distributed throughout, each gallon of the two mixtures will represent two pounds of sulphate or two pounds lime. To make 100 gallons of Bordeaux from these stock mixtures, take from the copper sul-
phate barrel 4 gallons of the concentrated or stock solution, and in another barrel or tub dilute it with 46 gallons of water. From the lime mixture barrel take 4 gallons of the milk of lime, well stirred, and dilute in a fourth barrel or tub with 46 gallons of water. Then pour the two dilute preparations simultaneously through a strainer into a mixing tub, stirring vigorously as they fall into the tub. When thoroughly mixed the Bordeaux is ready for the spray tank. It is difficult to secure a good combination of the lime and copper sulphate in the spray tank itself, where quantities larger than 50 gallons are used. For this reason it is advised that the mixing be done in a special tub before being poured into the spray tank.

In the preparation of Bordeaux mixture on a large scale, as where orchards of twenty acres or larger are to be sprayed, a system of elevated tanks should be used. In such a system the water is drawn by gravitation from a supply tank to the various dilution tanks, and again from these to the mixing tank, and finally piped to the spray tanks. The saving in labor and time will much more than compensate for the small outlay necessary to construct a spray mixing outfit of the kind referred to. Elevated mixing outfits are shown in figures 3, 4, 5, and 6, pages 21, 22 and 23.

To make a good Bordeaux mixture it is essential to use good material. All weights and measurements must be accurate. The lime mixture and the copper sulphate solution must be dilute when poured together. Good fresh lime must be used, and the slaking must be performed as directed on page 6. Bordeaux mixture should be handled only in wooden vessels and the pump with which it is applied should have brass parts or be brass-lined throughout. The mixture should not be left standing longer than three or four hours before being applied.

Time of Application.—Bordeaux mixture may be applied to apple trees with safety at practically all times of the year. Indiscriminate spraying is, however, very objectionable. Bordeaux mixture is preventive in its nature. It should be used, as far as possible, just before an attack by a fungous disease is expected. It should be applied at the very beginning of the season to checkmate those fungi, like apple scab, whose attacks occur with considerable certainty soon after growth commences in the spring. If the fungus which is to be combated attacks the crop later in the season, as bitter rot regularly does in some localities, the time of its occurrence should be known, and the preventive given a few days before the attack ordinarily occurs. In case a fungous attack comes unexpectedly, Bordeaux should be applied as soon
as the first indications of its presence are known, in order to curb
the disease before its ravages become marked.

Fungi Combated.—Bordeaux mixture is used in spraying apple
trees to control apple scab, bitter rot, fruit blotch, leaf spot, brown
rot, sooty fungus, and other fungi.

**COMBINED INSECTICIDES AND FUNGICIDES**

Because the principal expense involved in the operation of
spraying is connected with the actual application of the mixtures,
and for the reason that both fungi and insects must be combated,
it is almost a universal practice to mix insecticides and fungicides
and apply them together. This practice is to be recommended
strongly, though certain exceptions must be made to this general
rule (see page 31). Bordeaux mixture is invariably the fungicide
used in making these combination sprays, and for Illinois con-
ditions, either Paris green or Arsenate of lead is strongly advised
as a poison insecticide.

**Bordeaux-Paris Green Mixture**

4 ounces Paris green,
50 gallons Bordeaux mixture.

The Paris green is mixed with a pint of water taken from the
barrel or tub containing the dilute lime water, before the lime and
copper sulphate are mixed. A convenient way to mix the Paris
green and water is to shake them together in a jug or large
bottle. Pour the Paris green paste into the dilute lime water,
and proceed to make the Bordeaux mixture in the usual way. By
preparing the double mixture in this way a better distribution of
the Paris green is obtained, and the poison will not settle out of
the mixture in the manner common with Paris green and water.
If the Paris green paste be added to the prepared mixture, it will
not, on account of the flocculent character of the Bordeaux, be
evenly distributed throughout the Bordeaux. Hence it is essen-
tial that the Paris green be mixed with the dilute lime water be-
fore the lime and copper sulphate solutions are poured together.

**Time of Application.**—Bordeaux-Paris green mixture is used
for the three early sprayings against the codling moth and the
apple scab fungus. These sprayings are applied, first, after the
cluster buds have broken but before the blossom buds open; second,
immediately after the most of the blossoms have fallen; and third,
ten days after the second spraying. Later in the season it is more
common to apply the fungicide and insecticide separately, unless
there are both insects and fungi to be combated, when the com-
bined mixture should again be used. Many orchardists make it a
regular practice to add Paris green to Bordeaux mixture as a pre-
caution against insect attacks, whenever they spray.

*Insects and Fungi Combated.*—Bordeaux-Paris green mixture
is designed as a specific preventive of attacks of apple scab fun-
gus and codling moth. It is also effective against all the fungi
and insects mentioned under the headings, “Paris green” and
“Bordeaux mixture.”

**Bordeaux-Arsenate of Lead Mixture**

- 35 ounces home-made arsenate of lead mixture
- (10 ounces arsenate of soda and 25 ounces acetate of lead),
- 50 gallons Bordeaux mixture;

or

- 1 to 3 pounds commercial arsenate of lead,
- 50 gallons Bordeaux mixture.

In preparing Bordeaux-arsenate of lead, using the home-
made formula, the arsenate of lead must be made in the water
which is to be used in diluting the milk of lime. Pour the solu-
tions of arsenate of soda and acetate of lead, one after the other
into the water, stirring vigorously to secure a complete combina-
tion of the two. The lime paste is then added to the water con-
taining the arsenate of lead mixture, and the dilute milk of lime
thus prepared, is mixed with the dilute copper sulphate solu-
tion in the manner recommended for the preparation of ordinary
Bordeaux mixture.

Commercial arsenate of lead, like the home-made arsenate, is
mixed with the water used to dilute the milk of lime. If the ar-
senate is in the form of a powder or a thick paste, it must be work-
ed up with a little water, into a thin smooth mixture before being
diluted with the full quantity of water. The lime is then added
to the dilute arsenate of lead and mixed with the dilute copper
sulphate solution in the usual manner.

When commercial arsenate of lead is mixed directly with the
Bordeaux mixture, it is difficult to secure an even distribution of
the poison, and when the home-made product is prepared in the
Bordeaux mixture a complete chemical union between the arsen-
ate of soda and the acetate of lead cannot be obtained. For these
reasons it is advised that the directions given for the preparation
of Bordeaux-arsenate of lead be followed implicitly.

**Dust Sprays**

In 1903 experiments to test the efficiency of dust sprays were
undertaken by the Department of Horticulture of this station.
These experiments extended over a period of three years, during which time 147 trees were sprayed with the liquid sprays, 167 with dust, and 110 were maintained as check or control trees and left untreated. These trees produced a total of 372,726 apples, each of which was examined for insect and fungous attacks.

The following is a summary of the conclusions reached as a result of these experiments.

"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 placed together because the behavior of foliage was the same in both. Leaves began falling in July and, in early September, these trees were practically denuded. This 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 were 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 of very little value even as evaporator stock.

"Dust-spray is 52 percent cheaper than liquid spray and it is easier to transport about the orchard. It has no other advantage.

"The results of the experiments are sufficiently decisive to warrant the conclusion that dust-spray is absolutely ineffective as a preventive of injury from prevailing orchard fungi, and that it is considerably less efficient as an insect remedy than is the liquid method of applying arsenites."

**VARIOUS ESSENTIALS AND CONVENIENCES FOR PREPARING SPRAY MIXTURES**

*Water Supply.*—Since water is the medium by which insecticides and fungicides are ordinarily applied, it is very essential that an abundant supply be convenient to the orchard where the spraying applications are to be made. Where the number of trees to be sprayed is small, as in home orchards of from one to five acres, a cistern or surface well supply will be sufficient, and its nearness to the orchard will be a matter of secondary importance. For orchards of larger size it is necessary to provide some special and convenient source of water supply. This may be found in a near-by stream, in artesian wells, or in large ponds. Sometimes water may be piped from distant sources to the orchard. An

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*SPraying Apples—Relative Merits of Liquid and Dust Applications, C. S. Crandall. University of Illinois Agricultural Experiment Station Bulletin No. 106.*
hydraulic ram may be utilized to pump water from large springs or from streams. A windmill, a gasoline engine, or a hand pump may be used to raise water to the top of a river bank or from a deep well. But the source of water supply most available to the greatest number of Illinois orchards is the shallow field pond. Throughout most of the apple growing regions of Illinois the lower sub-soil is a close, more or less impervious hard-pan. By means of a plow and scraper a hole is scooped out in a low place in or near the orchard. The pond may be sunk four or five feet below the level of the surrounding soil. The deeper it is, the better, as the loss from evaporation becomes less in proportion to the depth of the pond. A pond 50 feet long, 30 feet wide, and 4½ to 5 feet deep should hold a sufficient supply for 50 acres of orchard throughout a season's spraying. Such a pond may be made more retentive of water if the bottom and sides are well puddled. In fact, in districts where the soil is not especially retentive in character, it may be necessary to mix clay with the soil in the bottom and along the sides in order to form a lining that will hold water.

Barrels, Tubs, and Mixing Vats.—The receptacles for holding the mixtures and solutions may be of many forms and sizes. If the plantation to be sprayed be smaller than ten acres, and a hand spray pump mounted on a barrel be used for making the application to the trees, fifty-gallon vinegar or kerosene barrels may be used. Not fewer than five receptacles of considerable size are required if Bordeaux mixture is to be a part of the spray, two for the concentrated lime and copper sulphate solutions, two for the dilute solutions, and one into which to pour the diluted lime and copper sulphate in mixing. Barrels or tubs are the most convenient receptacles for the concentrated copper sulphate, the dilute lime, the dilute copper sulphate, and the mixing vat. A tight wooden box of a size sufficient to contain the required quantity of slaked lime paste may be used instead of a barrel. The barrel or tank to which the pump is attached is sometimes used as a mixing vessel. A better mixture can be obtained in a separate barrel where it can be more thoroughly and conveniently stirred.

Where orchards larger than ten acres are to be sprayed, large tubs or vats holding from 100 to 200 gallons or more should be provided. Oil casks of 250 to 500 gallons capacity may be obtained at reasonable prices, and these, sawn in two in the middle, make excellent tubs for the purpose. Two 50-gallon barrels for the concentrated mixtures of lime and copper sulphate (or a 50-gallon box for the lime), two 125-gallon tubs made from a 250-
gallon cask, for the dilute mixtures, and a 250-gallon cask, for the mixing vat, make a good outfit for an orchard where only one spraying machine is used. If the orchard is so large as to require two or more spray outfits, large dilution tubs may be necessary, and probably more than five receptacles will be needed to handle the various mixtures rapidly. In illustrations Nos. 3, 4, 5, and 6, various types of tubs and mixing receptacles are shown.

Scales and Measures.—Emphasis must be laid on the importance of accurate measurements and weights in preparing all the spray mixtures described in this circular. The orchardist must remember that he is handling chemicals which combine in certain definite proportions, and that he is making up a prescription just as difficult of preparation as many prescriptions that he would trust only an apothecary to fill.

Where only small quantities of lime and copper sulphate are to be used, the orchardist may have his chemicals weighed out in definite quantities by the dealer from whom he purchases them, each unit quantity being wrapped in a separate package. But if the orchardist is using the spraying materials in barrel lots, he will require a scale to weigh out accurate quantities. A small platform scale with a scoop attachment is probably the most convenient form.

To measure the quantities of liquid the capacity of each tub and bucket should be marked. By means of a gallon measure, mark on the inside of the buckets used in handling the mixtures, the gallon, 2-gallon, 3-gallon, and 4-gallon heights. Similarly on the inside of the mixing tubs mark the 25-50- and 100-gallon heights. With the various receptacles thus marked the operator will have no difficulty in making up his mixtures in absolutely correct proportions without inconvenience or loss of time.

Buckets.—Two to four strong wooden buckets are generally required. Even where elevated platforms are used, and the water and mixtures are run by means of pipes and valves from tub to tub, two or three buckets will be found convenient for various purposes. Metal buckets cannot be used in handling the spray mixtures since the chemicals corrode them, and very quickly eat through the metal.

Strainers.—No spray pump will perform satisfactory work unless the spray mixtures are free from dirt, lint, or other material likely to clog the pump or the nozzles. The orifice in the nozzle is very small and easily clogged. For this reason every precaution must be taken to keep the mixture, as it finally goes into the spray tank, perfectly free from foreign matter. If the
Bordeaux mixture be strained through a brass or copper strainer having 20 meshes to the inch, as it is drawn from the mixing tub to the spray tank, all particles of grit, unslaked lime, and other foreign matter, will be removed. But one straining only will be found to be a very tedious task as the grit and dirt gradually fill up the meshes of the strainer and prevent a free flow of the mixture. It is, therefore, strongly advised that the dilute milk of lime and copper sulphate solution be strained together through a sieve as they are being poured into the mixing vat, and that the Bordeaux mixture be strained again as it is being run into the spray tank. The strainers should be as large as can be handled conveniently. The process at best is a tedious one, and the use of small strainers makes it discouragingly slow. For a barrel mixing outfit, the strainers shown in figures 1 and 2 are very satisfactory. The funnel-shaped one is used on the spray barrel, and the boat-shaped one is used for the milk of lime and copper sulphate. In larger mixing outfits, for use over the mixing vat, a strainer may be made by fastening a piece of brass mesh to the bottom of a wooden trough, and the boat-shaped strainer shown in figure 2 may be used for the final straining into the spray tank.

**Fig. 1. Funnel Strainer.**  
**Fig. 2. Boat-Shaped Strainer of Large Capacity.**  

*Jug for Mixing Paris Green.*—An earthen jug holding half a gallon to a gallon, or a large bottle, make the best vessels for mixing Paris green. A small tin funnel is a convenience in pouring the poison into the jug.

*Cooking Apparatus.*—There are numerous contrivances for the cooking of lime-sulphur wash, and the apparatus in each case must be left largely to the ingenuity of the individual orchardist. To work at all rapidly provision must be made for a plentiful supply of hot water and the boiling of large quantities of the mix-
Two forty-gallon iron kettles heated over a brick or stone fire place, out of doors, will keep a barrel spraying outfit supplied with mixture. For power spray outfits with 200 gallon tanks, more kettles must be used, or else steam heaters must be provided and the cooking done in barrels or tubs. For this purpose a five to ten-horse power steam boiler or a steam feed cooker can be used.

_Elevated Platforms._—Elevated platforms are devised to save the labor and time of handling the spray mixtures from tub to tub by hand power. They are built in either two or three levels, depending upon whether a water supply tank is used or whether the water is pumped directly to the dilution tubs. The lowest level is just sufficiently high to draw the mixture by gravitation from the mixing tub to the spray tank mounted on a wagon and driven along side of the platform. The second level is enough higher than the first to draw the solutions from the dilution tubs to the mixing tank. The third level must be slightly above the tops of the dilution tubs, and it may be higher if the orchardist wishes to obtain greater water pressure. The water is pumped to the supply tank or directly to the dilution tubs by gasoline engines, windmills, or hand pumps. The various tanks are provided with spouts and valves through which to draw off the mixtures, and with pipes, hose, or troughs, to conduct them from one tub to another.

The convenience and saving resulting from the use of elevated platforms can scarcely be over estimated. It will pay to use some form of elevated platform mixing outfit for any area larger than ten acres. Illustrations 3, 4, 5, 6, represent various types of elevated platform outfits in actual use in Illinois orchards.

**Applying Spray Mixtures to the Trees**

_Apparatus._—It is not the purpose of the writer to go into the details of the apparatus required for the application of spray mixtures. It is designed only to discuss very briefly the various parts of a successful spraying outfit. A strong force pump, a tank to convey the liquid from tree to tree, a wagon or a cart to transport the tank, very strong five to seven-ply rubber hose (30 foot lengths for use from the ground and 10 foot lengths for use from a spray tower), extension spray poles ten to twelve feet in length, nozzles that are readily cleaned and that will throw a fine mist-like spray, a tower built or mounted on the wagon to permit spraying the tops of the trees, are the principal pieces of apparatus required.
Fig. 3. Complete spray mixing outfit for the preparation of Bordeaux mixture. Note particularly the water supply tank elevated above the level of the mixing platforms.
Fig. 4. Spray mixing outfit of inexpensive construction. Note shed for the housing of lime and other spraying materials; also arm at end of platform for lifting barrels of lime, etc. This outfit is provided with two extra dilution tubs.

Fig. 5. Spray mixing outfit of good design. Note the following features: Barrels for concentrated lime and copper sulphate solutions, tubs for dilute mixtures, and vat for mixing; also pump at rear to draw water from spray pond. This outfit lacks elevated supply tank and storage shed.
FIG. 6. Spray mixing outfit of inexpensive construction suitable for an orchard of five to twenty acres. The water is drawn by pump and hose from a small stream just back of the mixing outfit.

For smaller orchards of less than ten acres, a first class hand pump mounted on a fifty-gallon barrel, or upon a tank of larger capacity, will answer fairly well. Its chief fault is the difficulty of keeping up a good and constant pressure. In orchards of from ten to thirty acres a hand pump of the duplex or double acting type mounted on a 200-gallon tank makes a moderately good outfit. A more constant pressure can be maintained with a pump of this sort than with a single acting barrel pump, but the work is harder, and to keep up a really high pressure two men are required. If orchards larger than thirty acres in size are to be sprayed, a power sprayer is needed. When the trees are young, that is from three to nine years old, a geared power sprayer deriving its power from the axles or wheels of the wagon answers very well. A power sprayer of this type is shown in figure 8, page 25. For larger trees we strongly recommend the use of a first class gasoline engine of two and one-half to three horse power, attached to a double or triple-acting pump. A complete spray outfit of this kind is illustrated in figure 9, page 26.
The spray tank must be made to suit the size of the orchard. A 50-gallon barrel placed either on its side or on its end, a 100-gallon cask, placed on its side, or a half-round tank of 200 to 250 gallons capacity, are probably the most serviceable forms of spray tanks. Half-round tanks are shown in figures 8 and 9, pages 25 and 26. Whatever form of tank is used, an outlet should be provided near the bottom, in order that the scale which gradually accumulates on the interior of the tank from the compound used in spraying, together with foreign matter of various sorts, may be cleaned out easily. This scaly material is certain to clog the nozzles and cause endless annoyance unless it is removed at frequent intervals.

Thorough agitation of the spray liquid in the tank during the process of application is very essential. Spray tanks must, therefore, be provided with agitating devices. Agitators are attached either to the pump or engine, or are worked by hand, or by power derived from the wheels of the wagon.

Any strong wagon or cart may be used to transport the spray tank over firm ground. Working with large tanks on soft ground
it is necessary to use wagons with wide-rimmed wheels. For this purpose the tires should not be less than six inches in width, and eight to ten inches is preferable. It is difficult to obtain wheels of this width, and it may be necessary to have extra rims attached to ordinary wheels to secure the width desired. The rims of the wheels on the spray outfit shown in figure 14, page 28, were widened in this manner. The wheels may be entirely boxed in, as in figure 9, page 26, to prevent the accumulation of mud inside the rims.

Cheap hose should never be used for spraying. It is likely to give out just at the time it is most needed. For high pressure machines a first class half-inch seven-ply rubber hose will give the best satisfaction. A five ply hose may be used for hand pumps, but the stronger hose is recommended as being more satisfactory in the long run.

The spray poles should be of bamboo lined either with brass or aluminum tubes. For general work the double, or two point

Fig. 8. Geared power sprayer. Power derived from hind axle of spray wagon. An excellent type for use in young orchards of large acreage. Note necessity for large compression tanks and powerful gearing in sprayers of this type.
FIG. 9. A gasoline power spray outfit with tower attached. Note curtain for protection of the engine and the pump (raised to show machinery), and broad-rimmed wheels boxed in to prevent the accumulation of mud inside the tires.
nozzle, will be found satisfactory. Clusters of three or four nozzles at the end of a ten or twelve foot pole are heavy and tiring on the operators. Spray poles should be kept moving constantly, and if they are made too heavy, the workmen are almost certain to rest them more or less on the branches, thus spraying some parts of the tree too heavily and other parts too lightly.

Nozzles are of various types. Nozzles of the Vermorel type have long been considered the best in producing a spray of great fineness. For applications of Bordeaux mixture, where it is desirable to coat the leaves and fruits evenly and completely without drenching them, the Vermorel or other nozzles of the same type should be used. For very tall trees, which cannot be sprayed readily even from a spray tower, it is advisable to use a nozzle of the Bordeaux type that throws a more solid stream and carries farther than the Vermorel. Bordeaux nozzles are also recommended for the application of arsenical sprays, applied by themselves, for the destruction of the codling moth. With such nozzles it is possible to throw the spray with great force into the calyx cups of the young apples, thus insuring a plentiful supply of poison to flavor the first meals of the newly-hatched codling moth larvae. All nozzles should have a disgorging device to permit rapid cleaning in case they become clogged.

Spray towers are devices which enable the operator to throw the spray to the tops of the trees or to direct it downward from above into their heads and branches. A tower consists of a framework of wood or steel bolted firmly to the frame of the wagon.

FIG. 14. Pumping Bordeaux mixture from conveyor to spray tank in the orchard.
and often secured to the tank as well, a platform supported by this frame work and raised some four or five feet above the spray tank, and a railing about the platform to keep the operator from falling off. Spraying towers are a necessary part of the equipment in all commercial orchards where the trees are more than eight or nine years old. Towers are illustrated in figures 9, page 26, and 13, page 28.

Heavy cotton sheets to cover the horses and harness should be provided. These covers should come down as far as the horses' knees and hocks. Where a gasoline power sprayer is used, the engine and pump are generally located under the spray tower platform. Hence, if the sides of the tower below the platform be enclosed with heavy muslin or canvas, the machinery will be well protected.

Thoroughness.—The first and chief element of the successful application of spraying mixtures is thoroughness. The spores, which fungicides are intended to destroy, are very small. Placed end to end 500 spores of the apple scab fungus would measure but one inch. Placed side by side it would require 5,000 to measure one inch. 2,500,000 spores of this fungus could be placed on one square inch of surface. In view of the extremely small size of fungus spores, it can be seen that very small unprotected spots on the apples or on the leaves would give access to the disease. Therefore, it is absolutely necessary that every bit of the surface of the apple tree, which is liable to fungus attack, should be covered and kept covered with the spray mixture. And if thoroughness of application is necessary as a protection from fungus diseases, it is scarcely less necessary as a remedy for insects. Dr. Burrill of the University of Illinois has estimated the surface area of the leaves on a good sized apple tree at 25,000 square feet. Fifty gallons of spray mixture would cover from fifteen to eighteen such trees, or 375,000 to 450,000 square feet. Spread out on the ground this would represent an area of eight and one-half to ten acres. The four ounces of Paris green used in 50 gallons of water, only a single handful of poison, must be spread very thin to cover such an area completely, or else much of the surface must be left unprotected. In Bulletin No. 114 on "Spraying for the Codling-Moth" Professor Lloyd of the University of Illinois says, "If it were possible to place a quantity of poison within the calyx cavity of each and every apple upon the tree, very few codling-moth larvae attempting to enter by way of the calyx would survive." That spraying, therefore, is most ef-
fective, which most completely coats all parts of the plant exposed to insect and fungus attack with poison or fungicide.

Character of Spray.—For the man without the time or the inclination to study carefully the principles of the operation of spraying, the best spray to use at all times is a very fine mist, that will float through the trees like a fog, applied under a pressure of 125 to 150 pounds to the square inch. The orchardist who notes carefully the character of the various insects and fungous enemies, which attack the apple crop, and studies the effect of different methods of applying spray mixtures, may vary this arbitrary recommendation to good advantage. Dormant tree sprays may be applied under very high pressures, as much as 200 pounds to the inch being an advantage. Applications of Bordeaux-Paris green mixture should be made at pressures of not over 125 pounds per square inch. When thrown with greater force, the small particles of gritty matter which Bordeaux mixture contains cannot fail to injure to some extent the skin of the apples and the foliage on the tree. The writer believes that, if Bordeaux mixture be applied alone, 100 pounds pressure is sufficient to secure a fine misty spray that will fall softly on the leaves and fruits, giving an even coating of Bordeaux, that the spray will not run together into drops as quickly as it would if the particles were driven together by a higher pressure. Arsenate of lead applied alone for the first brood of the codling moth, should be put on under high pressure, the higher the better up to 200 pounds. At this high pressure the poison will be driven through the rudiments of the stamens deep into the calyx cups of the young apples. Paris green applied with a small quantity of lime and very carefully strained through a fine sieve, might also be applied at a high pressure, perhaps 150 to 175 pounds per square inch, though the gritty particles of lime would endanger the skin of the apples and the foliage to some extent. Following the spraying for the first brood of codling moth, it may not be necessary or advisable to make any applications at pressures higher than 125 pounds. In deciding on the character of his spray, the grower must also take into consideration the denseness of the foliage, the height of the trees, and the distances to which the spray must be thrown.

Amount of Spray.—It is customary to advise spraying until the surfaces of the leaves are coated with spray in the form of very fine drops, discontinuing the operation just before the drops begin to run together and dripping from the foliage commences. In practice it is difficult to attain this ideal completely, but the
more nearly it can be approached the better. Yet for the care­
ful and observant orchardist, variations from this treatment may
be an advantage. In spraying dormant trees for San Jose scale,
it is almost impossible to coat every twig and fork in the tree
with lime-sulphur solution, unless the operation is continued un­
til there is more or less dripping from the trees. The recent
practice of applying Bordeaux mixture for apple scab, and the
poison spray for codling moth, in two separate sprayings, instead
of combining the two in the manner now generally recommended,
has already been referred to under another heading. This prac­
tice enables the operator to spray the trees with the insecticide
till every little apple is coated, and every calyx cup has been pro­
vided with a plentiful supply of the poison. At the same time
the russetting of the fruit and injuring of the foliage, which com­
monly result from very heavy applications of Bordeaux mixture,
are avoided by applying the mixture by itself in more mod­
erate quantities. It will be seen, therefore, that the discrimi­
nating orchardist may exercise judgment in deciding upon the
amount of spray he will apply. At the same time the orchardist
who does not fully understand both the theory and the prac­
tice of spraying, should follow the rule given at the beginning of
this paragraph.

When to Spray.—The most effective spraying is preventive
spraying. If the foliage and fruit be thoroughly coated with
poison or fungicide before the first chewing insect or the first
fungus spore light upon them, the insect will be destroyed at its
first meal and the first fungous infection will be prevented. When
insects or fungous diseases have become plentiful, both are more
difficult to control. They multiply more and ever more rapidly.
More of them will find unprotected spots on the foliage and fruit
and secure not only one meal but several, if they be insects, or
obtain a foot-hold from which to grow and spread, if they be fungi.
The orchardist may, therefore, accept the following as the first
principle in regard to time of spraying: Spray to coat the foliage,
twigs or fruit with poison or fungicide just before an attack by chew­
ing insects or fungous diseases is expected.

The rule just given in the paragraph above is by no means
indefinite. We know, taking one year with another, with consid­
erable certainty, when several of the worst diseases and insect
pests of the apple orchard make their attacks. Of these pests
apple scab fungus and codling moth are almost annual in their
recurrance and the time of their appearance is pretty generally
known. By spraying each season, just before the time that ex-
perience and observation have shown us that these pests make their first appearance, the orchardist may be reasonably certain of protecting his crop from their ravages.

Apple scab and codling moth are widely distributed throughout apple-growing regions everywhere, but there are other pests, more local in character, that have to be combated only in certain sections. Apple orchards in the southern part of Illinois are subject to attacks by bitter rot fungus, and all orchards, where the disease has ever been prevalent, should be sprayed annually late in June and throughout July, as a preventive measure. In some sections of the state of Illinois, especially in southern and western Illinois, plum curculios cause great damage to the apple crop, and some protection against them is necessary. Observant orchardists will know from experience about what time various insects and diseases appear in their orchards from year to year. Bearing in mind the idea of protection or prevention, they will be better able to determine for themselves the exact time to apply spray mixtures, than is possible by following a regular schedule or calendar of spraying operations.

Insects or fungi, however, often appear unexpectedly, or their first attacks are made so unobtrusively, that the orchards are infested before the orchardist has discovered their presence. In such cases the second principle in regard to the time of spraying should be followed, viz., prompt applications of poisons or insecticides. The orchardist need not wait till his spraying calendar tells him to spray. He should get his mixtures on NOW. He will not, of course, apply sprays for dormant trees when the foliage is on, nor poison sprays to destroy leaf-eating insects at the time when the fruit is ready to harvest. The exercise of ordinary judgment will, however, prevent his falling into such gross errors as these. Such pests as San Jose scale, army-worm, occasionally very severe attacks of tent-caterpillars, canker-worm, grasshoppers, late scab, sooty fungus, fruit blotch, brown rot, and leaf-spot, may require this prompt spraying as soon as their appearance is discovered.

There are some insects, moreover, against which we have no effective preventive spray, insects which pierce the skin of the plant and suck their food from the tissues where poison cannot be placed. The green apple-aphis, which attacks the foliage, the woolly-aphis which infests the forks of the branches and the crevices about wounds, oyster-shell scale or bark-louse, scurvy-scale and San Jose scale, must for the most part, be combated after they appear. Prompt measures should then be taken to destroy them.
But while it is advisable for the orchardist to determine for himself, after a full study of his individual circumstances, just how often and at what times to spray, we are aware of the fact that many apple growers are not in a position to give the time necessary for a full study of the matter, and will require a more specific guide than the principles just stated. For all Illinois conditions we advise three early applications of Bordeaux mixture and Paris green or Bordeaux mixture and Arsenate of lead, applied either separately or in combination, for apple-scab, and for the first brood of codling moth. But other applications of spray mixtures will depend more or less upon locality and circumstances, and the schedule for spraying apple orchards presented on page 37 has been worked out in an endeavor to meet the more important requirements of Illinois apple growers.

In preparing the spray calendar, reference is made to three parts of the state, Southern Illinois, Central Illinois, and Northern Illinois. Southern Illinois comprises the following counties, and all south of them: Calhoun, Green, Macoupin, Montgomery, Fayette, Effingham, Cumberland, and Clark. Northern Illinois comprises the following counties and all north of them: Rock Island, Henry, Bureau, La Salle, Grundy, and Kankakee. Central Illinois includes the intermediate section.

Spraying When There is a Light Crop.—When there is a light crop it is more important to spray than when there is a full crop. With a very heavy or full crop the losses will be less severely felt. Indeed the thinning caused by apple scab, codling moth and curculio—the chief causes of the “June drop”—may be more or less of an advantage to the health of the tree, and the size, though not the quality, of the remaining fruit. On the other hand a sparse crop, being apt to follow a heavy crop, occurs during a season when insect and fungus pests, as a result of the favorable breeding conditions of the previous year, are likely to be exceptionally numerous. Thus, there is likely to be a larger percentage of loss in years of light crops than in years of heavy crops. In any event, since the crop is already light, the orchardist cannot afford to lose any quantity of his fruit. Moreover the fruit is generally worth more per barrel in off-years than in seasons of full crops.

Spraying When There is no Crop.—The crop of fruit is essentially dependent upon the health and development of the tree. Anything which lowers the vitality of the tree lowers its potential productivity. Blossom buds are formed the season before the crop is produced. Early loss of foliage through insect and
fungous attack will tend to prevent the formation of flower buds, or else leave them weak and non-resistent to unfavorable weather conditions, reducing the prospect for next season's crop. Failure to spray in off-seasons will permit the multiplication of leaf-eating insects and most of the injurious fungi; thus carrying over a plentiful infection of both to the succeeding year.

Orchards having no crop should be sprayed when the young leaves are just beginning to unfold, or just before the blossoms open in case the crop reaches blossoming stage. If the failure is not yet evident, spray again as soon as the blossoms fall. In no case omit this spraying unless the failure is absolute. Sometimes very unpromising crops have been saved by an application at this time. Spray again the last week in June with Bordeaux-Paris green mixture as a protection to the foliage against shot-hole fungus and other foliage diseases which appear late in the season. Other applications may be made in case severe attacks of insects or fungi occur, though as a general rule these three applications will be sufficient.

**BENEFITS OF SPRAYING**

Spraying has been found so universally profitable that it seems scarcely worth while to discuss its benefits. The ever increasing army of insect and fungous pests requires ever increasing vigilance and persistence in the application of preventive and remedial measures. The enormous increase in the area being planted with apple trees throughout every important apple growing region in the United States, is resulting in an increasing production of this crop. The public taste is becoming more and more discriminating. As a result of these factors in the orcharding business, the possibility of disposing of a poor grade of fruit is decreasing, at the same time that the actual amount of insect-and fungous-injured fruit is increasing. These self-same conditions, however, create the opportunity to make large profits by producing a high grade of fruit. A first class grade of apples cannot be grown in a region such as Illinois, where insect and fungous pests are very prevalent, unless special precautions are taken to guard against them. Illinois produces certain varieties of apples of unsurpassed flavor and market value, when free from imperfections caused by insects and diseases. It will pay to grow perfect specimens of these varieties. Spraying is the most effective preventive of the damage liable to occur through attacks of these pests.
<table>
<thead>
<tr>
<th>No. of Treatment</th>
<th>District</th>
<th>Insects or Fungi</th>
<th>Treatment</th>
<th>Time of Application</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (extra)</td>
<td>For entire state</td>
<td>San Jose scale and other scales (Oyster-shell Bark-louse, Putnam scale, Forbes scale, Scurfy scale)</td>
<td>Lime-Sulphur Wash</td>
<td>Early in spring while trees are dormant  (Feb 20 to April 1)</td>
<td>Apply the first spring after scale is discovered. This spray may be substituted for No.1 (a Bordeaux spray) if desired</td>
</tr>
<tr>
<td>1</td>
<td>For entire state</td>
<td>Apple scab fungus</td>
<td>Bordeaux-Paris green mixt.</td>
<td>Just before bloom opens (April 1 to May 10)</td>
<td>Date varying with season and latitude</td>
</tr>
<tr>
<td>2</td>
<td>For entire state</td>
<td>Codling moth, Canker-worm, Tent-caterpillars, Apple scab fungus</td>
<td>Bordeaux-Paris green mixt. or Bordeaux-Arsenate of lead (may be applied separately if desired)</td>
<td>Just after the blossoms fall (April 20 to May 20)</td>
<td>Date varying with season and latitude</td>
</tr>
<tr>
<td>3</td>
<td>For entire state</td>
<td>Codling moth and leaf-eating insects generally</td>
<td>Bordeaux-Paris green mixt. or Bordeaux-Arsenate of lead (may be applied separately if desired)</td>
<td>7 to 10 days after No. 2 (April 30 to May 30)</td>
<td>Date varying with season and latitude</td>
</tr>
<tr>
<td>4</td>
<td>Southern Illinois</td>
<td>Curculio</td>
<td>Arsenate of lead</td>
<td>Last week in May or first week in June (July 22 to June 26)</td>
<td>Spray very thoroughly. Curculio is also a severe pest in some counties on Mississippi river in Central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td>5</td>
<td>Southern Illinois</td>
<td>Curculio</td>
<td>Bordeaux-Paris green mixt. or Bordeaux-Arsenate of lead</td>
<td>Third week in June (June 16 to 23)</td>
<td>Curculio a severe pest in some counties on Mississippi river in Central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td></td>
<td>Central Illinois</td>
<td>Bitter Rot</td>
<td>Arsenate of lead</td>
<td>Last week in June (June 23 to 30)</td>
<td>Curculio a severe pest in some counties on Mississippi river in Central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td>6</td>
<td>Southern Illinois</td>
<td>Second brood Codling moth, Curculio, and various leaf-eating insects, Bitter Rot, late Apple Scab, Fruit Blotch, Leaf Spot</td>
<td>Bordeaux-Paris green mixt. or Bordeaux-Arsenate of lead</td>
<td>About the end of June or first of July (June 26 to July 3)</td>
<td>Curculio a severe pest in some counties on Mississippi river in Central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td></td>
<td>Central Illinois</td>
<td>Same insects</td>
<td>Same as above</td>
<td>Second week in July (July 7 to 14)</td>
<td>Curculio a severe pest in some counties on Mississippi river in Central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td></td>
<td>Northern Illinois</td>
<td>Late Apple Scab, Leaf Spot</td>
<td>Same as above</td>
<td>Third week in July (July 14 to 21)</td>
<td>Curculio a severe pest in some counties on Mississippi river in Central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td>7</td>
<td>Southern Illinois</td>
<td>Second brood Codling moth, Curculio, Leaf-skeletonizer, Fall web-worm, grasshoppers, Bitter Rot, late Apple Scab, Fruit Blotch, Leaf Spot</td>
<td>Bordeaux-Paris green mixt. or Bordeaux-Arsenate of lead</td>
<td>7 to 10 days after No. 6 (July 6 to July 13)</td>
<td>Bordeaux may be omitted if reason is not favorable for development of late apple scab. See note for central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td></td>
<td>Central Illinois</td>
<td>Same insects</td>
<td>Same as above</td>
<td>7 to 10 days after No. 6 (July 14 to July 24)</td>
<td>Bordeaux may be omitted if reason is not favorable for development of late apple scab. See note for central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td></td>
<td>Northern Illinois</td>
<td>Second brood Codling moth, and various leaf-eating insects Late Apple Scab, Leaf Spot</td>
<td>Same as above</td>
<td>7 to 10 days after No. 6 (July 21 to July 31)</td>
<td>Bordeaux may be omitted if reason is not favorable for development of late apple scab. See note for central Illinois Bordeaux may be omitted in orchards not previously attacked by bitter rot</td>
</tr>
<tr>
<td>8</td>
<td>Southern Illinois</td>
<td>Second brood Codling moth, Curculio, Grasshoppers, Bitter Rot</td>
<td>Bordeaux-Paris green mixt. or Bordeaux-Arsenate of lead</td>
<td>10 days to 2 weeks after No. 7 (July 16 to July 27)</td>
<td>To be applied in seasons favorable for bitter rot</td>
</tr>
<tr>
<td>9</td>
<td>Southern Illinois</td>
<td>Bitter Rot</td>
<td>Bordeaux mixture</td>
<td>Last week in July or first in August (July 24 to Aug. 7)</td>
<td>To be applied in seasons favorable for bitter rot</td>
</tr>
<tr>
<td>B (extra)</td>
<td>For entire state</td>
<td>Green Apple Aphis</td>
<td>Kerosene emulsion</td>
<td>As soon as Aphis appears in considerable numbers (June 7 to July 10)</td>
<td>To be applied in seasons favorable for bitter rot</td>
</tr>
</tbody>
</table>
Fig. 15. A sprayed middle in an experimental orchard leased by the Department of Horticulture, near Flora, Clay, Co. Ill.—October 21, 1908. Note considerable amount of foliage retained. Contrast with figure 16.

Fig. 16. An unsprayed middle in same orchard as shown in figure 15. Photo, taken October 21, 1908. Note depletion of foliage. This middle adjoined the sprayed middle shown above.
Spraying is Insurance.
It pays to spray intelligently.