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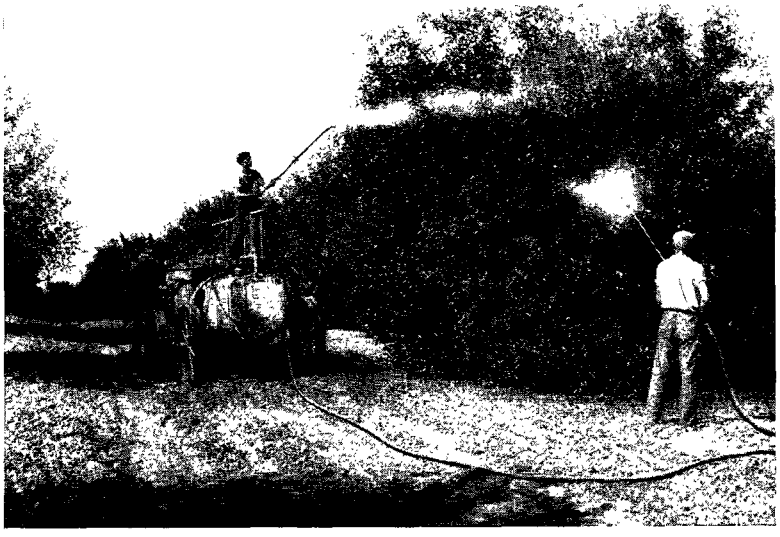
DEPARTMENT OF HORTICULTURE



A SPRAYING SCENE

SPRAYING FRUIT PLANTS[1]

W. F. PICKETT AND G. A. FILINGER

It is no longer necessary to convince fruit growers that spraying is essential if fruit trees are to be kept in a productive condition and sound fruit produced. All fruit growers, from the operators of the largest commercial orchards to the owners of home orchards, recognize the fact that spraying is unavoidable in the production of good fruit. Since a successful spray program is dependent upon such items as the life histories of many fungous diseases, the life histories of several injurious insects, the operation of a spray pump, weather conditions, variations in susceptibility of fruit varieties to many of

1. Contribution No. 114 from the Department of Horticulture.

the pests, the selection of the proper spray materials, the management of a spray crew, the convenience of the water supply, the natural ability of the orchard manager, etc., it is readily recognized that spraying is one of the most perplexing operations confronting the fruit grower. Furthermore, spraying is usually a preventive measure — not a curative one. Hence, sprays must be applied before injury is done — not after.

It is the purpose of this circular to aid the fruit grower to solve many of the spray problems which arise. It should be borne in mind, however, that any set of schedules and recommendations must be general in nature to be applicable to several regions and that the information contained herein must be modified to meet unusual or local conditions.

Although spraying is one of the most important orchard operations, it alone will not give economical or satisfactory control of many pests. Pruning and soil management methods, if properly handled, will increase crop production and also facilitate in the spraying. General orchard sanitation cannot be overvalued. By orchard sanitation is meant such operations as careful removal and burning of broken or diseased branches, plowing or disking of fallen leaves in the spring; removal and destruction of wormy apples before the larvæ leave the fruits; removal and destruction of mummified fruits; etc. Orchard sanitation is a valuable supplement to spraying in keeping many pests under control.

The grower must know which pests are likely to give him trouble and something of their nature or habits before he can do effective spraying. He must also be able to determine quickly the causes for defective fruits and tree injury. Each spray application should be put on for a definite purpose. Hit-and-miss spraying is uneconomical and does not aid in the production of sound fruit.

After the proper spray material has been selected and the correct time for its application determined, much of the success of a spray campaign depends upon the thoroughness with which the materials are applied. Authorities differ as to how much material is required to spray a tree economically. In general, however, to combat successfully such pests as apple scab, blotch, and codling moth in this region from 18 to 25 gallons of spray are required for a single application to a mature tree. For younger trees proportionately smaller amounts are required. Trees 1 to 4 years old may be sprayed thoroughly with from ½ to 2 gallons.

DISEASES OF FRUIT

The relative susceptibility to the common diseases of the more important Kansas apple varieties is shown in Table I. The data are based on observations made in the orchard of the Agricultural Experiment Station at Manhattan.

Apple varieties differ in their susceptibility to diseases from year to year. For example Jonathan, although listed as being resistant to both scab and blotch, may under certain conditions or during exceptional years suffer from these diseases.

TABLE I.—SUSCEPTIBILITY OF KANSAS APPLE VARIETIES TO DISEASES.

Manhattan, Kansas.

VARIETY.	Scab.	Blotch.	Frog-eye.	Cedar rust.	Fire blight.
Arkansas Black	s	vs	s	r	s
Ben Davis	vs	vs	?	r	s
Black Twig	vs	r	s	r	r
Delicious	vs	r	s	r	ss
Early Harvest	s	vs	r	ss	s
Gano	s	vs	s	r	s
Grimes	r	r	ss	ss	r
Jonathan	r	r	vs	vs	vs
Missouri	s	vs	?	r	s
Oldenburg	s	s	r	r	r
Rome	s	r	vs	vs	s
Stayman	s	r	s	r	r
Wealthy	r	ss	s	vs	vs
Winesap	vs	r	s	r	r
Yellow Transparent	ss	s	r	r	vs
York	r	ss	ss	r	s

s—susceptible. vs—very susceptible. r—resistant. ss—slightly susceptible.

Apple blotch is an important disease in this region. Although this disease attacks the leaves, twigs, water sprouts, small branches, and fruit, the greatest loss is caused by damage to the fruit. The diseased areas or lesions which this fungus produces on apples vary somewhat in appearance, depending upon the variety. The spots may be sunken, raised, or level with the surface of the fruit. The diseased areas are usually brown or black. In many cases they are irregular in outline and have a feathery margin. These two features are different from those of apple scab lesions, in which case the lesions are gray or dark green and fairly definite in outline. Compare figures 1 and 2. Numerous dark brown or black pimples are clustered near the centers of the older blotch lesions. These pimples are pycnidia or fruiting bodies of the fungus.

This disease overwinters in cankers on young wood. (Fig. 1.)

The planting of nursery stock free from blotch cankers is of extreme value, since this practice would materially reduce the chance of establishing the disease in the orchard. Dormant sprays aimed at killing cankers or preventing the dissemination of spores have not given satisfactory results.

Blotch can be controlled by proper spraying. Experiments at the Kansas Agricultural Experiment Station indicate that Bordeaux mixture is the best spray to use. From two to four applications per season are usually required on the blotch-susceptible varieties. The first of these is made 14 days after petal fall, the other applications following at two-week intervals.

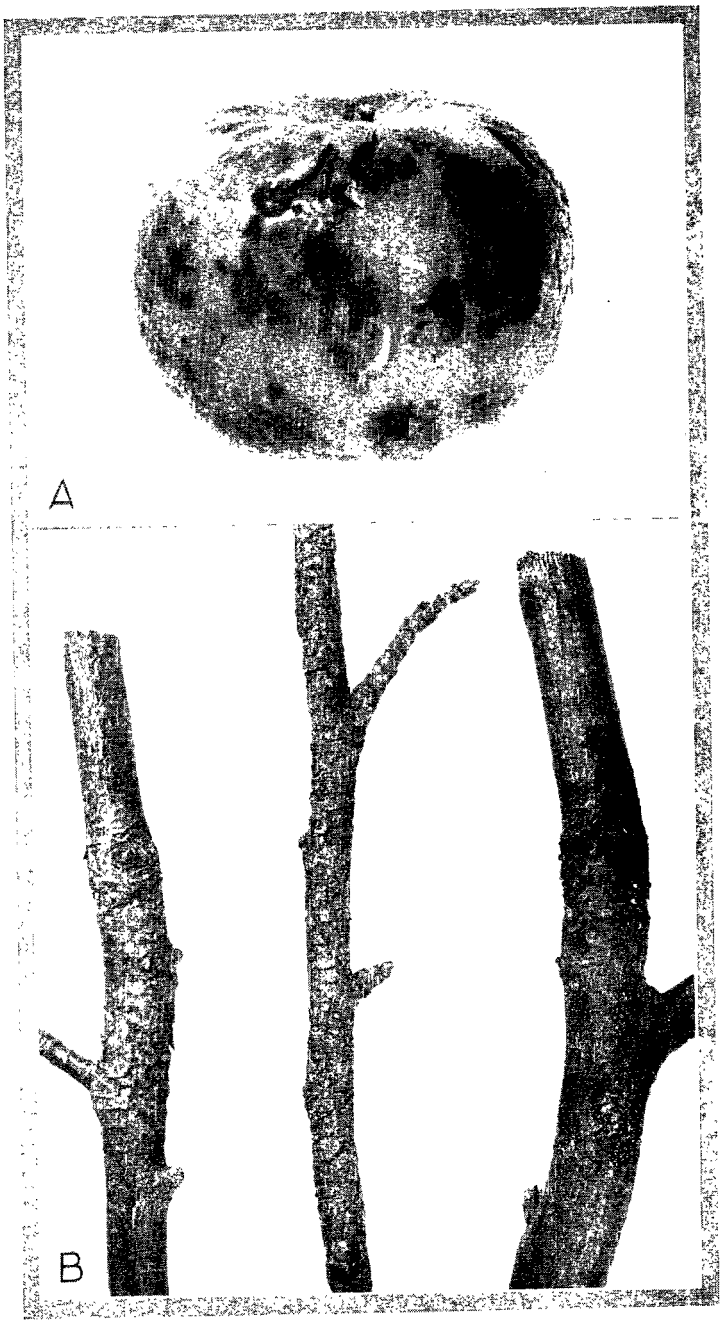


FIG. 1.—Apple blotch. (A) On fruit; (B) on young apple wood (overwinter cankers).

Apple scab is a serious disease on the fruit and foliage of Winesap, Stayman Winesap, Delicious, Ben Davis, Missouri Pippin, and other varieties. (Fig. 2.) Although the twigs are infected occasionally, practically no damage is caused by these infections. In some seasons this disease produces severe loss by infecting the pedicels or stems of the apple blossoms causing them to drop, with a

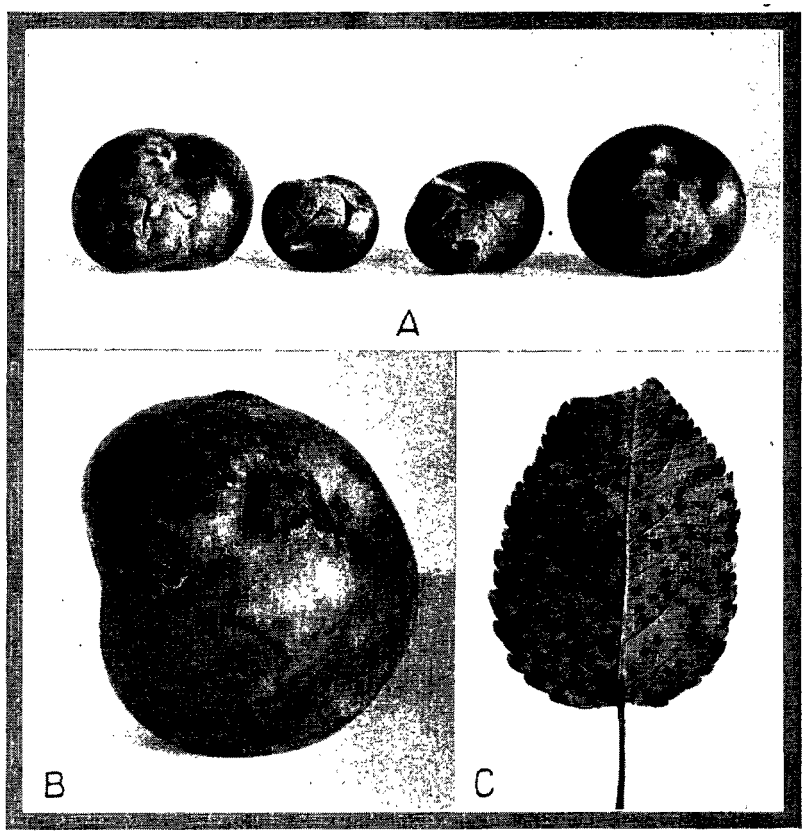


FIG. 2.—Apple scab. (A) On Winesap apples; (B) on a Ben Davis apple; (C) on leaf.

resultant smaller set of fruit. Since this disease is one which attacks foliage, it is one to be reckoned with in both young and bearing orchards. Occasionally a severe outbreak results in partial or nearly complete defoliation of young trees. This lowers the vitality of the trees and may delay their coming into bearing. The fungus causing apple scab is favored by cool, rainy weather and greater vigil should be given this pest during seasons when the spring is late.

Apple scab lesions on the foliage appear in the spring and early summer as roundish, dark olive-green areas. Later the center of each area dies and turns brown. (Fig. 2, C.)

Defoliation occurs when the infection is so severe that the lesions coalesce and a large part of the leaf is killed.

The damage which scab produces on the fruit is noticeable in several ways. (Fig. 2, A and B.) A possible reduction in the crop has been noted above. Also the apples may drop when they are from ½ inch to ¾ inch in diameter. In severe cases the fruit cracks open as shown in figure 2, A. Such fruits are worthless. Late infections which produce lesions from 1/8 inch to 1/4 inch in diameter

FIG. 3.—Black rot on apple leaf.

at the time the fruit is harvested materially reduce the length of time that the fruit may be kept in storage.

The control of this disease is best attempted by combining orchard sanitation and thorough, well-timed spraying. The apple-scab fungus lives over winter on the fallen leaves. The destruction of these leaves by early plowing will materially reduce the source of infection. Thorough spraying with lime-sulfur when the flowers are at the prepink, pink, and petal-fall stages will ordinarily control the disease. Spores are not produced on the overwintering leaves until rainy weather appears in the spring. In seasons when the early spring is dry the sprays scheduled to be applied when the blossoms are prepink and pink may be omitted, although there is an element of risk in this practice.

The Winesap trees in the orchard of the Kansas Agricultural Experiment Station were nearly completely defoliated by apple scab in 1920. During that season corn was grown as a companion crop making it impossible to spray. Since that time, however, the

disease practically has been eradicated from the orchard. Even unsprayed Winesap trees in 1927 and 1928 produced fruit with less than 1 per cent scab injury. This change was accomplished by a soil management program which called for the plowing under of cover crops in the early spring. This destroyed most of the overwintering leaves. A thorough spray program resulted in a clean crop of foliage.

Black rot or frog-eye is a serious disease of the foilage of some varieties of apples. The damage produced by this disease during the past few years has been on the increase. The black-rot organ-

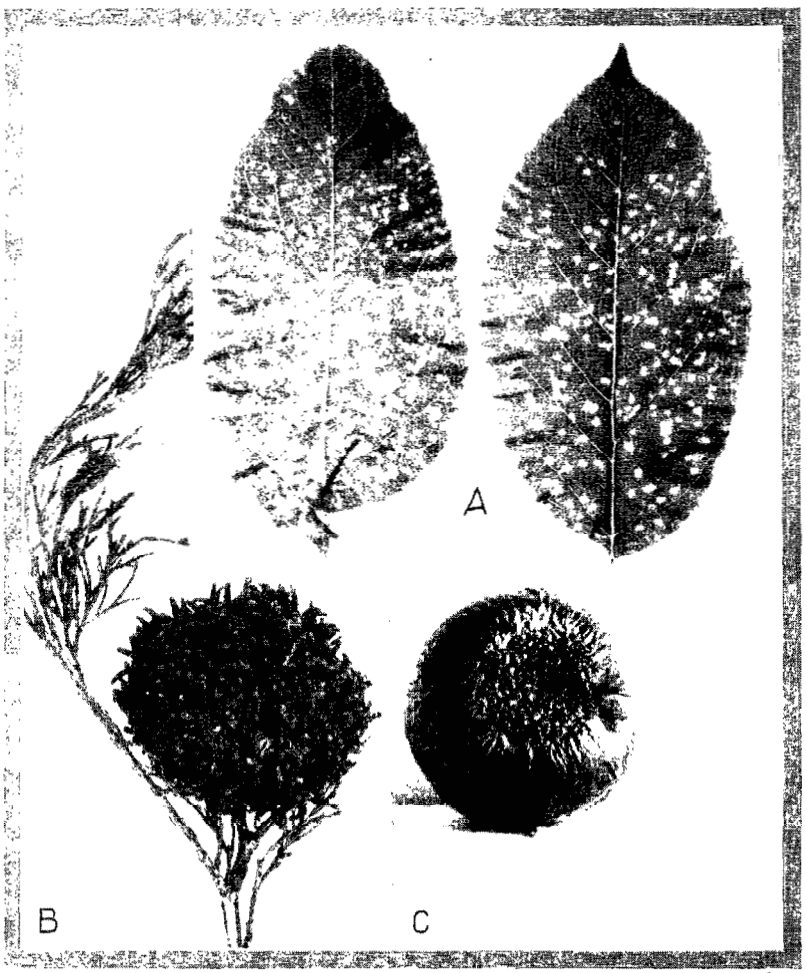


FIG. 4.—Cedar-apple rust. (A) Lesions on apple leaves; (B) gall on red cedar; (C) infection on apple.

ism produces small light-brown spots on the leaves. (Fig. 3.) Many times these lesions are marked with concentric rings, hence the name frog-eye. Preliminary experiments indicate that one or two applications of lime-sulfur concentrate diluted 1 to 35 or dry lime-sulfur 3½ pounds to 50 gallons of spray made before the blossoms open will aid in the control of this disease. Subsequent applications of fungicides are also of value.

Cedar-apple rustt must rotate its attacks from cedars to the apple and to the cedar again in order to complete its life cycle. The

FIG. 5.—Apple twig infected with fire blight.

disease is of primary importance on the foliage of Wealthy and Jonathan trees. (Fig. 4, A.) Occasionally lesions are produced on apples as shown in figure 4, C. Spraying is of little or no value in controlling this disease. If susceptible varieties are grown, all cedar trees within two miles of the orchard should be destroyed.

The galls produced on the red cedar are shown in figure 4, B.

Fire blight is a bacterial disease of apples and pears. The growing tips and blossoms are killed by the disease. Aphids and other insects do damage in disseminating fire-blight bacteria and spray-

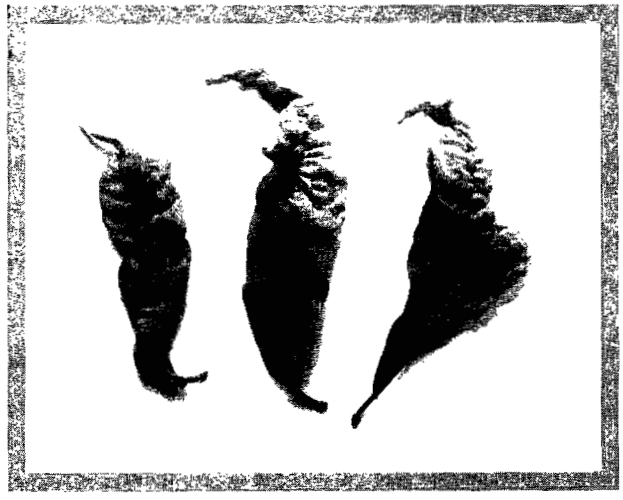


FIG. 6.—Peach leaves infected with peach leaf curl.

FIG. 7.—Peach leaves infected with bacterial leaf spot.

ing is of value in reducing this means of dissemination. (Fig. 5.) Special information concerning this disease can be secured on request.

Blister canker is a fungous disease which has done much damage to the Ben Davis, Gano, Missouri, and Winesap orchards in Kansas. The disease enters through some wound or break in the bark and grows down through the wood under the bark. Spraying is of no value in controlling this disease.

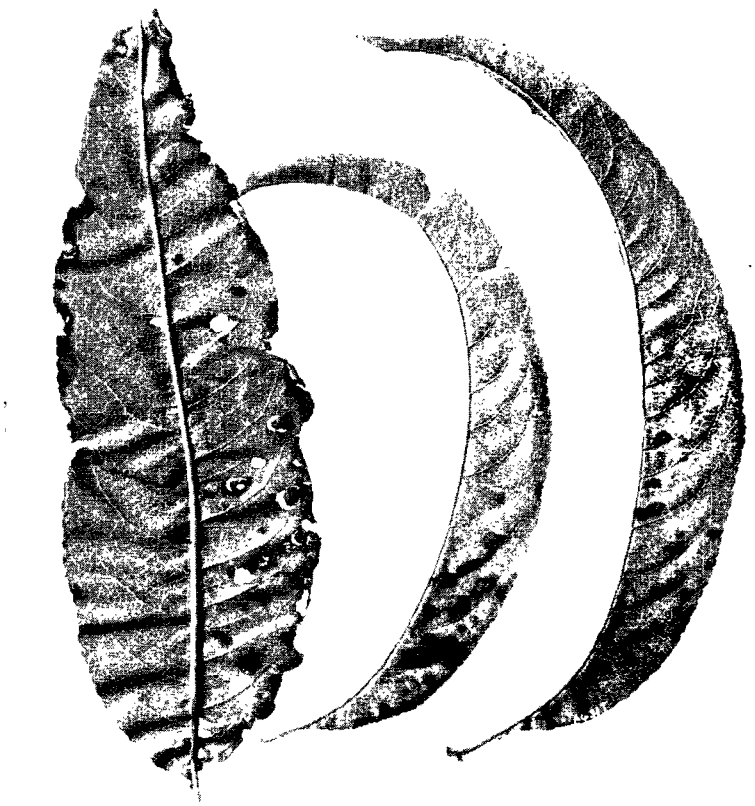


FIG. 8.—Peach leaves showing arsenical injury. Left, advanced stage; right, early stage.

Peach leaf curl is a serious disease of peach foliage in some seasons. Diseased leaves are thickened and distorted. (Fig. 6.) A thorough dormant spray of lime-sulphur wiil give complete control of this disease.

Bacterial leaf spot of peach is illustrated in figure 7. Although a spray schedule has not been perfected for the control of this disease, two or three applications of white Bordeaux, or zinc-lime,

see page 25, made at intervals of two weeks beginning when the shucks had fallen, kept the disease under check. Bacterial leaf spot causes the leaves to drop from the trees and if present in sufficient amount will bring about nearly complete defoliation.

Arsenical injury (fig. 8) is somewhat similar to the bacterial leaf spot but there are certain distinct differences. Usually the injured portions are larger and more regular in outline than the bacterial lesions. Arsenical injured areas are more likely to occur

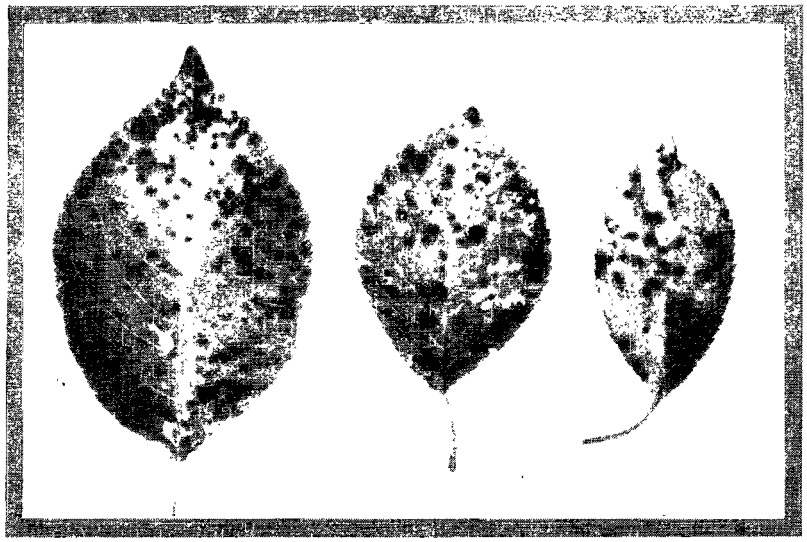


FIG. 9.—Cherry leaves infected with cherry leaf spot.

along the leaf margins. Arsenical injury may become manifest by producing yellow leaves which drop prematurely.

Lead arsenate, if used alone or in a combination spray deficient in lime, will produce the spray injury. To avoid this use lead arsenate sprays only when necessary and then always add as much high-grade hydrated lime as lead arsenate.

Brown rot is a fungous disease which attacks peaches, plums, and cherries. Brown rot produces the most damage during hot rainy weather, often just before harvest, although it causes wide-spread damage early in the season by attacking young fruits. Brown rot overwinters on mummies, or dried-up fruits, which lie on the ground or hang on the trees. The destruction of these mummies aids in controlling the disease. Thorough spraying with dry-mix lime-sulfur or some of the wettable sulfurs, in conjunction with orchard sanitation, usually gives satisfactory control. Liquid lime-sulfur or Bordeaux mixture may be used on some cherries and Japanese plums for the control of brown rot.

Cherry leaf spot is a disease of the foliage of cherry trees which has caused wide-spread damage in Kansas by defoliating the trees during the growing season. (Fig. 9.) Spraying with lime-sulfur concentrate diluted 1 to 35 or dry lime-sulfur 3½ pounds to 50 gallons of spray or Bordeaux, 3-6-50, will give good control of the disease. In experiments in the station orchards, lime-sulfur was found to be superior to Bordeaux in that the fruits from trees sprayed with lime-sulfur were larger than those from trees sprayed with

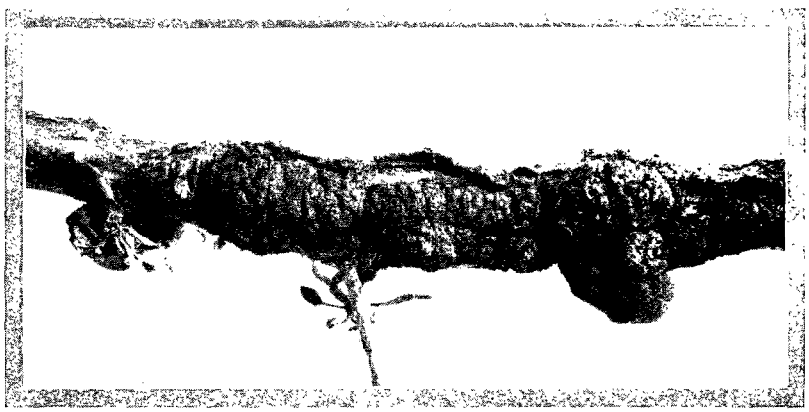


FIG. 10.—Canker on plum branch produced by black knot.

Bordeaux mixture. Many growers have secured good results by using Oxo-Bordeaux or some of the wettable sulfur sprays.

Black knot and plum pockets (figs. 10 and 11) are fungous diseases of the plum which, in some seasons, cause considerable damage to this crop.

Spraying is of little value in controlling these diseases. The removal and burning of the infected parts as soon as they are observed usually will keep these diseases under control.

Black rot is a common fungous disease of the grape. (Fig. 12.) The disease appears on the half-grown fruit as a light area. Later a brown ring is formed around the area and the entire lesion is dark brown. The flesh of the fruit under the lesions rots. Most of the fruits remain attached to the plant and are known as mummies. Destroying the mummies and following the spray schedule for grapes on page 32 will keep this disease under control.

FIG. 11.—Plums infected with plum pockets.

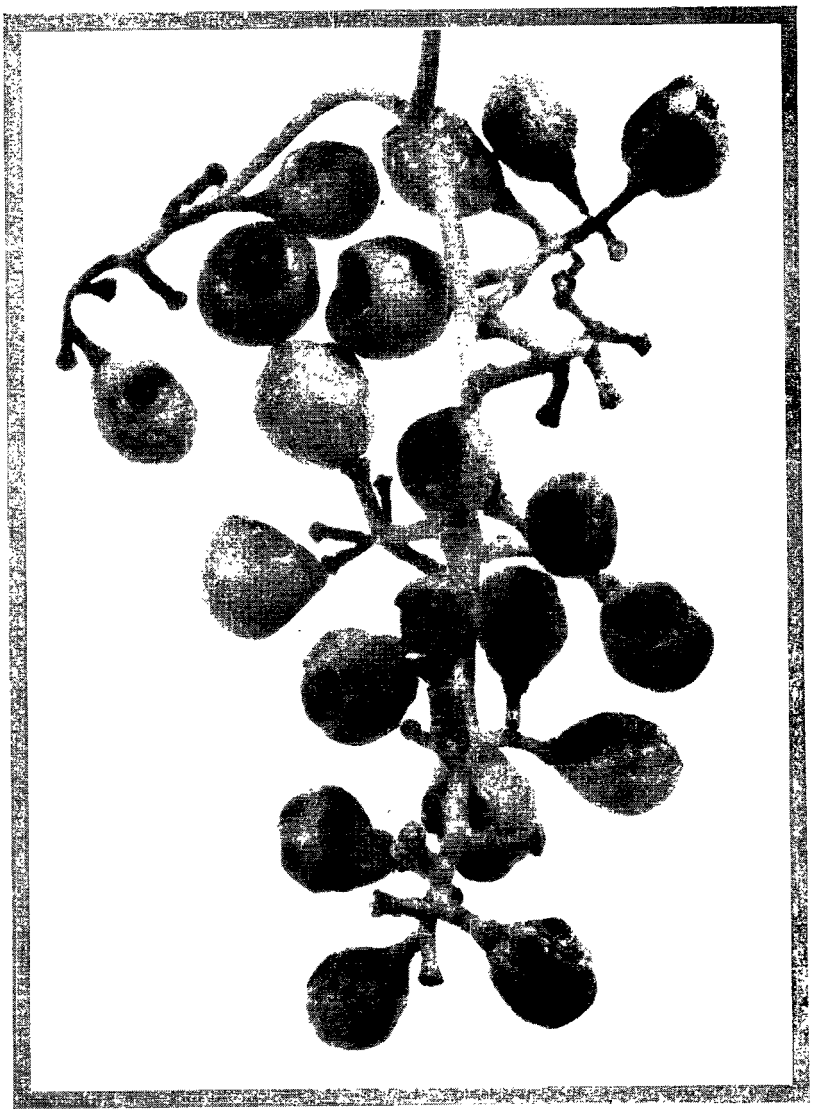


FIG. 12.—Grapes infected with black rot.

INJURIOUS FRUIT INSECTS

San José scale is one of the important fruit insects. It is small and inconspicuous but causes the loss of many fruit trees in Kansas every year. Trees that are seriously infested have a dull, ashy colored bark (fig. 13, A), weak foliage, and, on the heavily infested trees, many dead branches. San José scale infest's apples, pears, peaches, plums, and many shrubs. It can also be found on some forest trees. The Osage orange is subject to severe infestation and hedges of this plant often are a harbor for the insect from which it spreads annually to the adjacent orchards. Occasionally the scales are found on apple leaves and damage to the fruit is not uncommon. (Fig. 13, B and C.)

Thorough spraying with lime-sulfur or oil emulsion during the dormant season will control this pest. However, the orchardist should remove or spray any plants such as shrubs, Osage orange hedges, etc., that may be infested. In the southern part, of the state an annual dormant spray is necessary to control this pest, while in the northern sections some orchardists can keep it under control by spraying every two or three years.

Aphids or plant lice prove quite serious some seasons. These insects usually appear just as the buds are swelling. They cause the leaves to curl and drop; they also cause many of the fruits to fall prematurely or be deformed. These insects have sucking mouth parts and are controlled by using contact sprays, such as oil emulsions, lime-sulfur, and nicotine sulphate. The delayed dormant spray is valuable in the control of these pests. Some seasons it is necessary to add a contact spray such as nicotine sulphate to the cluster-bud and petal-fall sprays in order to control the aphids.

The plum curculio is the parent of the larvæ that are found in peaches, cherries, and plums. The adult is a small inconspicuous beetle which passes the winter in grass and rubbish and emerges early in the spring to feed on the buds and foliage. As soon as the fruit forms the beetles begin feeding on it. The feeding punctures are small round holes that cause the fruit to be dwarfed and ill-shaped. Eggs are laid in the fruit. The egg punctures are very conspicuous as the beetle cuts a crescent-shaped cut around each egg. Eggs laid in the pome fruits, such as apple and pear, seldom hatch but eggs laid in the stone fruits, such as peaches, plums, and cherries, hatch and cause wormy fruits.

Orchard sanitation which includes cultivation and destruction of all rubbish and weeds either in or adjacent to the orchard is of great assistance.

The apple curculio is a serious pest that has appeared recently in Kansas. At present its damage is greatest in the northeastern counties where it is proving to be more injurious than the plum curculio. It is similar to the plum curculio in appearance but is larger and a more voracious feeder. It does not infest the stone fruits, appearing only on apples, pears, and quinces. Its life history is similar

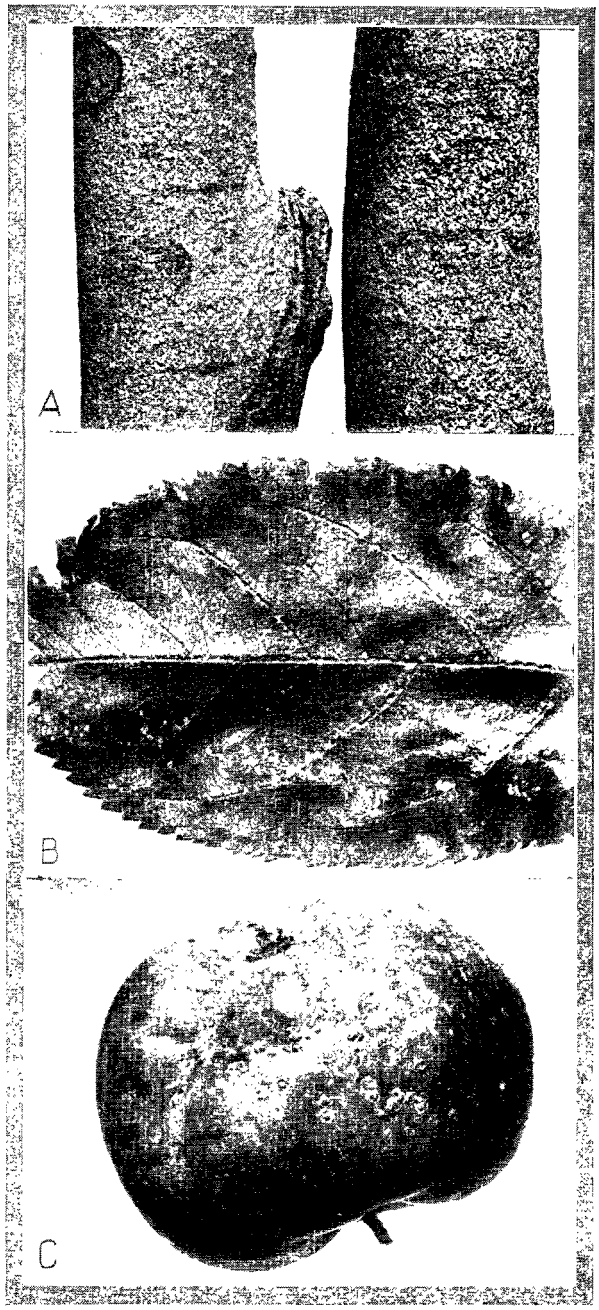


FIG. 13.—San José scale. (A) On apple branches; (B) on apple leaf; (C) on apple.

to that of the plum curculio except that it causes serious damage both early in the spring and again in midsummer. The feeding punctures are deep, narrow depressions that cause deformed fruit and promote decay. (Fig. 14.) The egg punctures are bottle-shaped. Soon after the larvae hatch many of the infested fruits fall and the larvæ complete their feeding and pupate in the fallen fruit. The adults of the new brood appear in late June and early July and attack the fruit by making numerous feeding punctures in a small area on the apple giving it a pepper-box appearance. Apples so damaged soon decay and fall. The curculio goes into hibernation in fallen leaves

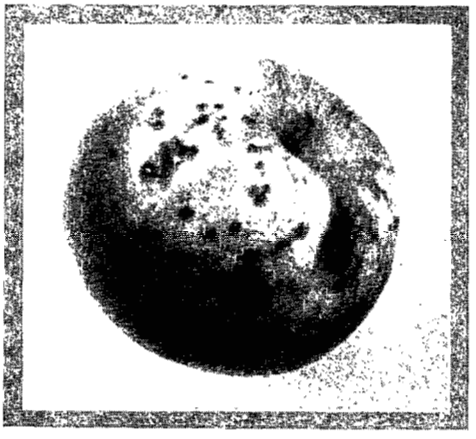


FIG. 14.—Fruit injured by apple curculio.

in late summer and appears again the next spring to begin feeding on the small fruits as soon as they form. Egg laying begins soon after petal fall.

Control measures in seriously infested orchards have not proved so successful as may be desired. Orchard sanitation is of value, especially the clearing up of leaves and rubbish in the early winter. Some orchardists pick up and destroy the "June drops" which contain the matured larvæ and the pupae. This method is only partly effective.

The codling moth is the most serious insect pest in Kansas orchards. It attacks only the pome fruits such as the apple, pear, and quince. The larvæ cause the familiar wormy apples. The adult is a small inconspicuous moth that is seldom noticed by the orchardist. There are from two to four generations or broods of this insect each season. The northern part of the state usually has two complete broods and a partial third, while the southern sections usually have three complete broods and occasionally a partial fourth. These broods are irregular and overlap, hence it is diffcult to time the sprays, especially during the latter part of the growing season.

The first-brood larvæ usually appear about four weeks after petal fall and may continue for three or four weeks. Cool weather may even prolong the brood so that they will appear over an eight-week period during exceptional years. The second brood usually follows the first brood in about six weeks if the weather is warm. The extent of the damage caused by the third brood depends upon the weather conditions during late August and September. Continual warm weather usually causes serious damage by this third brood.

Arsenical sprays are the best control measures, provided they

FIG. 15.—A convenient method of suspending a bait trap in an apple tree.

are applied thoroughly and timely. Careful orchardists observe the development of this insect daily in their orchards and time the sprays accordingly. The use of emergence cages, moth traps, and temperature records are of great value in getting a good control of the first brood. In fact, the season's control usually depends upon a good control of the first brood. The moth lays eggs only

during the late evenings when the temperature is above 65° F. Emergence cages and moth traps indicate the presence of moths in the orchard and a thermometer will indicate the favorable weather conditions for egg laying. The eggs hatch in 6 to 10 days. The fruit should be well protected with arsenicals during the entire hatching period.

A simple bait trap may be made by placing a mixture of 1 part of black strap molasses and 9 parts of water to a depth of about 2 inches in a pound coffee can. To this should be added a few drops of oil of rose geranium. The trap is suspended in the branches of

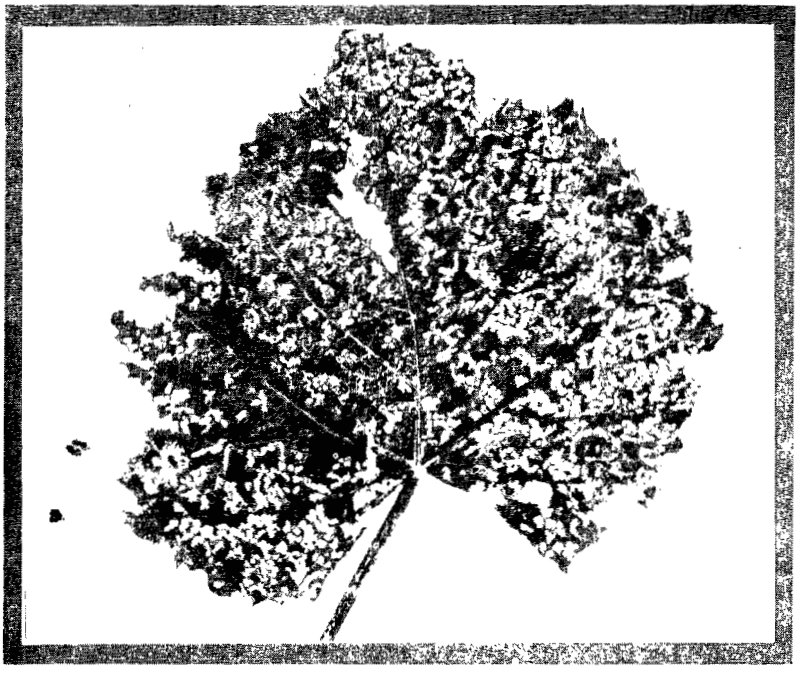


FIG. 16.—A grape leaf destroyed by the adult grape rootworm.

an apple tree in such a way that it may be lowered and examined daily. The liquid should be renewed every three or four days. A white or luminous can seems to attract the adult moths in greater numbers than dark containers. The purpose of the bait trap is mainly to indicate the time that spraying should be done and not to serve as a control measure in itself. (Fig. 15.)

Most commercial orchardists find it necessary to spray every ten days or two weeks during the entire growing season in order to control the codling moth. During recent years the dosage of arsenate of lead has been increased from 1 pound to 1½ or 2 pounds in the spray that is applied about four weeks after petal fall,

Orchard sanitation, which includes scraping and banding of the trees, screening of the packing sheds, etc., is helpful in controlling this serious pest. Chemically treated bands which serve as a larvicide are now commercially available.

Canker worms, skeletonizers, tent caterpillars, etc., frequently cause much damage on trees that do not receive the spray schedule as recommended for the control of codling moth and curculio. This condition is especially true in young orchards or during seasons of crop failures, Orchardists should watch closely for the appearance of these insects and if they are found in any great numbers the trees should receive a spray of arsenate of lead, 1½ to 50, immediately.

Grape rootworm is an important insect pest in vineyards. The adult insect causes damage by eating chain-like holes in the leaves. (Fig. 16.) The larvæ often injure the roots of vines. Control measures consist of thorough spraying with lead arsenate — 2 pounds to 50 gallons of water — as soon as the beetles make their appearance, which is usually in June.

SPRAY EQUIPMENT

Good spraying cannot be done without a good spray pump. There are many types of spray pumps. A small compressed-air sprayer holding from 2 to 3 gallons of spray is valuable for spraying small plants such as grapevines and truck-crop plants, but is not suited for tree spraying. The price for the compressed-air sprayer ranges from $5 to $10. The more expensive ones are made of brass and are economical to purchase because they do not corrode readily.

Barrel sprayers range in price from $15 to $60. Good barrel sprayers complete with hose, rods, nozzles, cut-off, skid, and barrel may be purchased for about $50. A working pressure of 100 to 150 pounds may be maintained. Good barrel sprayers may be used to advantage in spraying small plantings of fruit. Figure 17 shows a barrel sprayer with a pump jack and small gasoline engine attached. This outfit can be used conveniently where the spraying is not extensive enough to require a larger sprayer.

For orchards of 10 acres or more a power sprayer is necessary. The size of the machine to select will depend on the acreage, size of trees, and future plans of the owner. The rated capacities of power spray pumps vary from six to 24 gallons per minute with engines ranging from 1½ to 22 horse power. Larger pumps are manufactured for use in exceptionally large orchards or in stationary plants.

Small machines, which at optimum speed will deliver six to eight gallons per minute, will operate one spray gun and are suitable for orchards of ten to fifteen acres. For orchards of 20 to 30 acres a machine capable of operating two guns is necessary. The pump capacity should be 12 to 14 gallons per minute.

Larger power sprayers are suited for orchards of slightly over 30

acres. However, many growers find it more convenient and economical to use more than one outfit in orchards over 40 acres. In any event there should be sufficient equipment to be able to cover the entire orchard in three or four days.

SPRAY MATERIALS

Spray materials are divided into two classes—insecticides and fungicides. Insecticides are those sprays which are applied for the control of insects such as the San José scale and the codling moth.

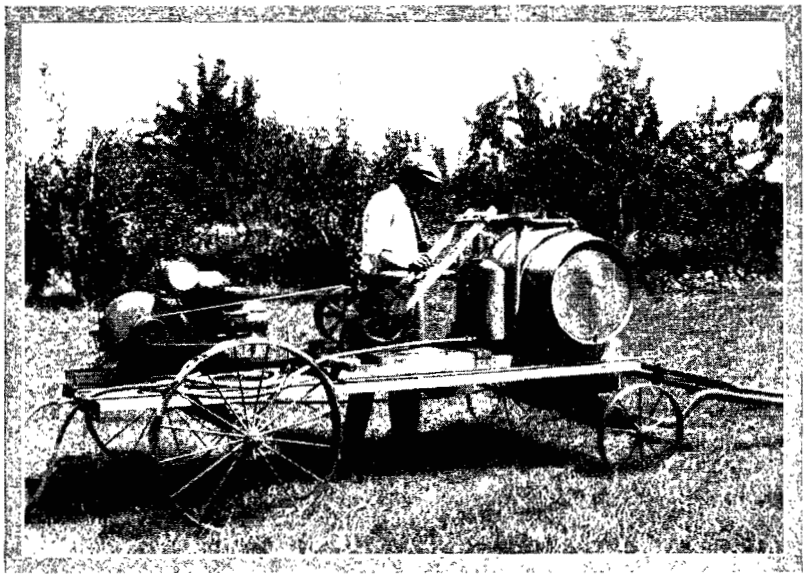


FIG. 17.—A barrel sprayer transformed into a small power sprayer by attaching a pump jack and gasoline engine.

Fungicides are those sprays used for controlling the fungous diseases such as apple scab and apple blotch.

There are two classes of insecticides—stomach poisons and contact sprays. Lead arsenate is the most important stomach poison and nicotine sulfate and the oil emulsions are the important contact sprays.

INSECTICIDES

Lead arsenate is the most important stomach poison used in spraying. It is applied for insects like the codling moth which bite out and swallow plant parts. The product is commonly sold as a dry white powder. The usual dilution is from 1 to 1½ pounds of the poison to 50 gallons of water or spray. For small amounts a teaspoonful may be mixed with a gallon of water. Lead arsenate does not dissolve to any appreciable extent. This makes it neces-

sary to keep the mixture stirred up to prevent the lead arsenate from settling out. Lead arsenate may be used in combination with nicotine sulfate, Bordeaux mixture, or lime-sulfur sprays. To prevent arsenical spray injury to plant parts, 1 to 2 pounds of a good grade of freshly hydrated lime should be added to 50 gallons of spray. Some recent investigations seem to indicate that a lead arsenate-oil combination may cause spray injury to plants, due to the liberation of free arsenic.

Nicotine sulfate is one of the most important sprays for insects of the aphid or plant-louse type that have sucking mouth parts. Nicotine sulfate may be purchased from drug stores or any of the spray supply houses. It is marketed as a heavy dark brown liquid. It may be applied to plants at strengths sufficient to kill plant lice without danger of injuring the foliage or fruit. The usual dilutions range from 1 to 800 parts of water, to 1 to 1,600 parts of water. Nicotine volatilizes more quickly if the solution has been rendered alkaline. Nicotine kills by paralyzing the insects after the nicotine vapors have entered the bodies through the breathing pores. To be effective, therefore, the solution should be alkaline. This is easily attained by the use of 2 or 3 pounds of soap or 1 pound of freshly hydrated lime to 50 gallons of spray when nicotine is used alone. Soap should not be added when the nicotine is used with lime-sulfur or Bordeaux mixture. Several so-called activators which increase the effectiveness of nicotine, such as "Penetrol," are now available on the market.

Oil emulsions have come into prominence within the last few years and are rapidly proving to be valuable as dormant sprays for the control of San José scale. Recent experiments at the Kansas Agricultural Experiment Station indicate that each of several commercial brands of oil sprays gave better control of San José scale than did lime-sulfur. Although the oil sprays were more expensive than lime-sulfur, they are probably better to use on account of their high insecticidal value. Oil sprays in general should be used when the temperature is above 40° F. and no sudden drop in temperature is predicted. A gentle breeze is beneficial. This hastens the drying of the oil and reduces the probability of the oil residues causing injury to the trees. In case dormant oil sprays are used they should be applied so that a considerable time elapses before lime-sulfur is used for scab control.

Oil sprays may be grouped into two classes: (1) Oil emulsions; and (2) miscible oils. The stock emulsions contain about 66 per cent oil while the miscible oils contain from 90 to 95 per cent oil. For dormant spraying both classes of oils are diluted so that the solution applied to the trees contains from 2 per cent to 4 per cent oil. To prepare 100 gallons of spray containing 2 per cent oil, add 3 gallons of the stock emulsion to 97 gallons of water. Use miscible oils according to instructions on the containers.

Oil emulsions may be prepared at home or purchased on the

market at prices ranging from 18 to 24 cents per gallon. Miscible oils sell at prices varying between 45 cents and $1 per gallon. In general the oil sprays which may be purchased on the market are more dependable than those prepared at home. Oil sprays should be purchased from reliable concerns only.

Some of the proprietary miscible oils are recommended for use as summer sprays to serve as an ovicide for codling moth control and as a spreader and sticker for various arsenical sprays. An ovicide is a material which kills eggs. There appears to be a bright outlook for the development of the so-called summer oils as supplemental sprays to the arsenical for codling moth control.

Lime-sulfur concentrate or commercial lime-sulfur is a heavy red liquid and is one of the most important of the spray compounds. This material may be prepared at home if a sufficient quantity be used to warrant the trouble. It is recommended that the average home orchardist or small commercial orchardist purchase this product, unless several growers can profitably cooperate in its manufacture. Those interested may secure special information concerning the home manufacture of lime-sulfur on request.

The fruit grower will usually find it advantageous to purchase lime-sulfur rather than to make it because the commercial product is more uniform in density or concentration and will probably give better results.

When liquid lime-sulfur is diluted at the rate of 1 part of lime-sulfur to 6 or 8 parts of water the spray is used as a dormant spray for the control of San José scale.

FUNGICIDES

Lime-sulfur concentrate diluted at the rate of 1 part to 35 or 40 parts of water is one of the standard fungicides and is used for the control of apple scab, cherry leaf spot, and other diseases. If the lime-sulfur solution is kept sealed from the air in some tightly stoppered container in a place where this liquid will not freeze, it may be kept from one season until the next.

Dry lime-sulfur is a substitute for the liquid form and, due to the great convenience in handling this product, many orchardists are using it. The instructions given on the container as sent out by the manufacturers should be strictly followed. This compound is not satisfactory for dormant spraying.

Wettable sulfur sprays have come into prominence in recent years. These materials consist of finely divided sulfur, in some cases of a colloidal nature, together with some other material which acts as a wetting agent. Sulfur alone will not stay in suspension in water and hence cannot be used in a liquid spray, but when a wetting agent is added the sulfur may be uniformly distributed in water. Wettable sulfurs have a place in the control of diseases of the stone fruits and may be of value in the sprays beginning with the petal-fall application on apples. These sprays mix satisfactorily with lead arsenate and nicotine sulfate. Sulfur sprays should not be used

shortly before or soon after an oil spray has been applied to plants. There are several commercial brands of wettable sulfurs available and in all cases the manufacturers' recommendations should be followed.

Dry-mix lime and sulfur is recommended as a fungicide for peaches and tender plums. The general formula, as developed by the New Jersey Agricultural Experiment Station, for making 50 gallons of spray is as follows:

Flowers of sulfur	8 pounds
Fresh hydrated lime	4 pounds
Calcium caseinate or Kayso	½ pound

These amounts may be proportionately increased or decreased, depending upon the quantity desired.

The ingredients are mixed together dry and sifted to remove lumps. A thin paste with water is made and slowly added to the spray tank which should be nearly full of water. The mixture is thoroughly stirred or agitated, the water brought up on the correct level, and used immediately. Lead arsenate may be added if chewing insects are present or nicotine sulfate may be added if plant lice are troublesome.

Bordeaux mixture is one of the best of the fungicides. This spray is of great value in the control of apple blotch. The spray may be made at home as follows: The general formula of 3-6-50 should be used. This means 3 pounds of copper sulfate (blue vitriol) and 6 pounds of fresh hydrated lime to each 50 gallons of spray. The copper sulfate should be dissolved in about 3 or 4 gallons of water. The spray tank should be filled to about the 40-gallon mark, the 3 or 4 gallons of copper sulfate solution added, and the dilute solution stirred. Into this should be poured immediately a thin paste made of 6 pounds of fresh high-grade hydrated lime in 5 or 6 gallons of water. The resulting mixture should be stirred or agitated vigorously and used the same day it is made.

Smaller quantities may be prepared by reducing the formula to the desired amount.

Metal containers should not come into contact with the concentrated solution of copper sulfate. Only fresh, high-grade hydrated lime should be used.

Nicotine sulfate and lead arsenate may be used in combination with Bordeaux if the pests to be combated make such a combination desirable.

Bordeaux mixture is sold on the market in the paste or powder forms. These are not so satisfactory as the freshly prepared home-made Bordeaux.

Instant Bordeaux mixture has the advantage of not requiring the preparation of a stock solution of copper sulfate. This spray may be prepared by filling the spray tank about three-fourths full of water and washing in the correct amount of finely pulverized cop-

per sulfate (snow) with the agitator running. The hydrated lime is then added as in the regular Bordeaux mixture.

White Bordeaux or zinc-lime mixture has the general formula of 4-4-50. It is prepared by dissolving the zinc sulfate in a half-tank of water with the agitator running. This compound dissolves readily in water. To this is added the lime as in Bordeaux mixture. The principal use of this spray is for the control of bacterial leaf spot of the peach.

Spreaders and stickers are various materials such as calcium caseinate, soap, and some of the oil sprays to use with lead arsenate and other sprays to increase the spreading and adhering qualities of the latter. Experimental results do not show conclusively that the spreaders and stickers increase the insecticidal or fungicidal values of the sprays.

SPRAY SCHEDULES

SPRAY SCHEDULE FOR APPLES

No. 1: Delayed Dormant Spray—For San Jose and Other Scale Insects and Plant Lice

Commercial liquid lime-sulfur is used at the rate of 1 gallon to 7 or 8 of water. At this strength 6 gallons of lime-sulfur and 44 gallons of water would be required for each 50 gallons of spray.

This spray is usually applied when the buds begin to show green tips. (Fig. 18.) In larger orchards it is often necessary to start

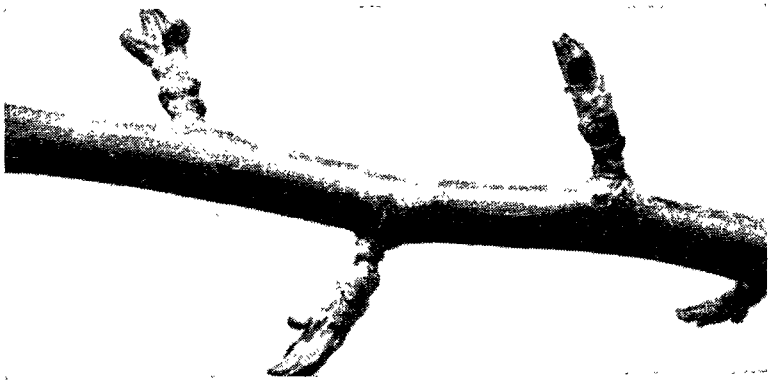


FIG. 18.—Apple buds at the stage of development at which the delayed dormant spray should be applied.

its application a trifle earlier in order to insure its completion before the cluster-bud stage is reached.

This spray is primarily designed for the control of San José scale but often assists in checking aphis damage also. If aphis damage is threatened, ½ pint of nicotine sulfate may be added to each 50 gallons of spray material.

No. 2: Pink or Cluster-bud Spray—For Apple Scab, Frog-eye, Plum Curculio, Canker Worm, and Tent Caterpillar

This spray consists of:

Liquid lime-sulfur	1½ gallons
(Or dry lime-sulfur	4 pounds)
Arsenate of lead	1 or 1½ pounds
Water	50 gallons

FIG. 19.—Upper left: Apple fruit spur showing the right time to start the application of the pink or cluster-bud spray. Lower left: The same fruit spur later showing the stage at which the pink or cluster-bud spray should be finished. Right: Fruit spurs showing the best time to start the application of the calyx or petal-fall spray. The petals have just fallen.

This spray is applied when the buds have separated in the cluster and show pink, but before the blossoms open. (Fig. 19, upper and lower left.)

When arsenate of lead is to be used with lime-sulphur sprays, the water and lime-sulphur should be placed in the tank first and the lead which has been stirred up in a small quantity of water should be added to the spray tank just before the spray is applied, and with the agitator in motion.

If aphis damage is threatened, ½ pint of nicotine sulfate may also be used for each 50 gallons of spray material.

No. 3: Calyx-cup or Petal-fall Spray—For Apple Scab, Frog-eye, Codling Moth, Canker Worm, and Plum Curculio

This spray consists of:

Commercial liquid lime-sulfur,.....	1½ gallons
(Or dry lime-sulfur..... 4 pounds)	
Arsenate of lead,.....	1½ pounds
Water	50 gallons

The grower may start this calyx-cup spray when from one-half to two-thirds of the petals have fallen from the blossoms and it

FIG. 20.—Left: Apple fruit spur showing calyx cups nearly closed. The calyx-cup spray should be applied at once. Right: Closed calyx cups. At this stage of growth it is too late to apply the calyx-cup spray.

should be finished before the calyx cups close. (Fig. 19, right, and fig. 20, left.)

Even though this spray is applied 3 to 4 weeks before the appearance of codling moth larvae, it is particularly important in combating this pest, as a considerable number of these insects, especially those of the first brood, gain entrance to the apple through the calyx. Poison lodged in the calyx cup by this spray may remain effective throughout the season.

No. 4: Second Codling Moth and First Blotch Spray—For Apple Blotch, Apple Scab, Codling Moth, and Canker Worm

Bordeaux mixture, 3-6-50, with 1½ pounds of arsenate of lead for each 50 gallons of spray, is the application recommended for general use. It should be applied approximately 14 days after petal fall.

Bordeaux mixture rather than lime-sulfur is recommended for this spray because it has proved to be the more effective fungicide

for the control of apple blotch, and also because it is less apt to burn or russet fruit and foliage, on hot sunshiny days.

Bordeaux may cause injury during damp, foggy, or rainy periods, but if the weather is at all suitable most growers will prefer to risk Bordeaux russeting rather than to have the fruit of blotch-susceptible varieties ruined by this disease.

Lime-sulfur at the same strength recommended for the petal-fall application has been successfully substituted for the Bordeaux mixture by some growers for use on varieties which are not attacked by blotch, but which may be injured by late scab infection. This choice of materials will depend largely on the previous experience of the orchardist. It may be well to reduce the strength of lime-sulfur somewhat during unseasonably warm weather.

Wettable sulfur sprays may be used on varieties which are subject to spray injury if lime-sulfur or Bordeaux is used.

An arsenate of lead spray alone, at the rate of 1½ pounds to 50 gallons of water, may be sufficient at this time on varieties not ordinarily attacked by scab, blotch, or frog-eye, such as Grimes or York.

No. 5: Third Codling Moth and Second Blotch Spray—For Codling Moth and Apple Blotch

This spray is the most important spray for codling moth control. It is timed so as to have the fruit fully protected with arsenicals at the maximum hatch of the first brood. This usually occurs about four weeks after petal fall but should be determined more accurately by the use of emergence cages, moth traps, temperature records, and orchard observations. Except on varieties that blotch very badly and in orchards where blotch has not been controlled satisfactorily during the previous seasons, this spray should consist of arsenate of lead 1½ or 2 pounds to 50 gallons of water and 1½ pounds of hydrated lime. If Bordeaux mixture is used the lime may be omitted. For varieties that blotch badly, and especially if blotch has not been controlled in the past, 3-6-50 Bordeaux or wettable sulfur should be used.

No. 6: Third Blotch and Fourth Codling Moth Spray—For Apple Blotch and Codling Moth

Good control of apple blotch requires three or four sprays usually applied at two-week intervals, following petal fall. The first blotch sprag that is applied 14 days after petal fall is the most important spray for this disease. A spray applied approximately 6 weeks after petal fall is second in importance. Such a spray would follow spray No. 5 by 10 days or 2 weeks. Under such conditions, this spray is valuable in controlling the late members of the first brood of codling moth, and under such conditions all varieties should receive an arsenate of lead spray 1½ to 50, and 1½ pounds of hydrated lime at this time. It is not necessary to include the Bordeaux

mixture for varieties not susceptible to apple blotch. Wettable sulfurs do not produce so much russeting as Bordeaux and may be used if a fungicide is desired.

No. 7: Second Brood Codling Moth Spray—For Codling Moth and Apple Blotch

The second brood of codling moth usually appears about 9 to 10 weeks after petal fall or about 6 weeks after the first brood. The second brood usually continues over a long period. This spray should be timed by the use of emergence cages and moth traps so as to be on the fruit when the larvæ begin hatching in large numbers. It should consist of arsenate of lead, 1½ to 50, for all varieties. Varieties that blotch badly and that are likely to be damaged with late blotch infection should receive Bordeaux mixture, 1½-3-50, in addition to the arsenate of lead.

No. 8: Third Brood Codling Moth Spray—For Codling Moth and Sooty Blotch

This spray will consist of arsenate of lead, 1 or 1½ pounds to 50 gallons of water. Or, if sooty blotch or other fungous diseases are in evidence, it may be well to use a fungicide, such as a wettable sulfur, in this application; this will be influenced largely by the weather. Sooty blotch is more prevalent during wet weather.

The spray for the third brood of codling moth is applied when the need is shown by the codling moth cage, usually during August.

SPRAYING PEARS

While the preceding schedule has been prepared for apples, it should also, with some modification, be effective for pears. Ordinary lime-sulfur sprays are liable to russet the skin of some varieties of pears and may cause severe burning in hot weather. Under such circumstances use Bordeaux, 3-6-50, or wettable sulfur if a fungicide is necessary. As a rule fewer sprays are required for pears than for apples. The best plan is to determine the insects and diseases to be combated and to spray accordingly.

SPRAY SCHEDULE FOR AMERICAN PLUMS

Home orchardists may find it convenient to substitute dry lime-sulfur for the liquid form specified in this schedule, and commercial Bordeaux for the home made. If either of these substitutions is made the directions supplied by the manufacturer should be followed.

About 4 pounds of dry lime-sulfur to 50 gallons of water is considered summer strength.

Six to eight pounds of manufactured dry Bordeaux to 50 gallons of water are usually considered equal to the 3-6-50 home-made formula. Oxo-Bordeaux, 4 pounds, and hydrated lime, 4 pounds, may be used as the fungicide.

No. 1: Dormant Spray—For San Jose Scale

Lime-sulfur, as recommended for apples, should be used if scale is serious. It should be applied when trees are dormant, preferably in early spring.

No. 2: First Summer Spray—For Plum Curculio and Brown Rot

Any one of the following combinations may be used:

1. Commercial liquid lime-sulfur	1¼ gallons
Lead arsenate	2 pounds
Water	50 gallons
2. Bordeaux	3-6-50
Lead arsenate	2 pounds
3. Dry lime-sulfur	4 pounds
Lead arsenate	2 pounds
Water	50 gallons
4. Oxo-Bordeaux	4 pounds
Lead arsenate	2 pounds
Hydrated lime	4 pounds
Water	50 gallons

This application should be made just before the blossom buds open.

No. 3: Second Summer Spray—For Plum Curculio and Brown Rot

The use of lime-sulfur or Bordeaux, 3-6-50, given as for spray No. 2, wettable sulfur, or Oxo-Bordeaux is recommended.

This spray should be applied immediately after the petals have fallen.

No. 4: Third Summer Spray—For Plum Curculio and Brown Rot

Lead arsenate with one of the sulfur sprays or Bordeaux sprays recommended under Nos. 2 and 3 may be used at this time.

This spray should be applied two weeks after petals fall.

No. 5: Fourth Summer Spray—For Brown Rot

This spray should be applied two weeks after No. 4 if brown rot has been troublesome in previous years. Either the sulfur sprays or the Bordeauxs recommended under No. 2 may be used. A Bordeaux is probably to be preferred in dry, hot weather.

Dry-mix lime-sulfur, as recommended for peaches, may be used in this application.

It is usually not necessary to use arsenate of lead in any of the plum sprays at this time as the curculio should be under control.

No. 6: Fifth Summer Spray—For Brown Rot

Later applications than No. 5 may be used in some instances if necessary, but the final spray should be applied two or three weeks before the fruit ripens.

SPRAY SCHEDULES FOR PEACHES, APRICOTS, AND JAPANESE PLUMS

No. 1: Dormant Spray—For San Jose Scale and Leaf Curl

Commercial liquid lime-sulfur as for apples, dormant strength, 1 to 7 or 8, should be applied while the trees are dormant, preferably in early spring shortly before growth starts.

The use of oil emulsion in this spray is not advisable. Oils will control the scale insects but will not control peach leaf curl. The control of this disease is very important.

No. 2: First Summer Spray—For Plum Curculio, Scab, and Brown Rot

One and one-half pounds of arsenate of lead should be used for each 50 gallons of spray. Dry-mix lime-sulfur or wettable sulfur should be used. If wettable sulfur is used 1½ pounds of hydrated lime is necessary to prevent arsenical injury. Oxo-Bordeaux may be used in the place of the sulfur sprays.

This spray should be applied after blooming when most of the shucks or petals or both have fallen.

No. 3: Second Summer Spray—For Plum Curculio, Scab, Brown Rot, and Leaf Spot

The same spray mixture as in No. 2 is recommended. It should be applied two weeks after spray No. 2.

Due to rapid development of fruit and foliage it is advisable to follow in one week, if curculio persists, with an arsenate-of-lead hydrated-lime spray.

No. 4: Later Sprays—For Scab and Brown Rot

A fungicide as recommended in No. 2 should be used to which arsenate of lead should be added if insects threaten. This spray should be applied as necessary to control brown rot, usually four weeks before ripening begins.

In any instance when arsenate of lead is used without a fungicide, hydrated lime, 1½ pounds to 50 gallons of spray, is necessary to prevent spray injury.

SPRAY SCHEDULE FOR SOUR CHERRIES

Home orchardists may find it convenient to substitute dry lime-sulfur for the liquid form specified in this schedule, and manufactured Bordeaux for the home-made. If either of these substitutions is made the directions supplied by the manufacturer should be followed.

No. 1: First Summer Spray—For Plum Curculio and Brown Rot

Any one of the following combinations may be used:

1. Commercial liquid lime-sulfur,	1½ gallons
Lead arsenate	1½ pounds
Water	50 gallons
2. Dry lime-sulfur	4 pounds
Lead arsenate	1½ pounds
Water	50 gallons
3. Wettable sulfur as recommended by manufacturer	
Lead arsenate	1½ pounds
Water	50 gallons
4. Bordeaux	3-6-50
Lead arsenate	1½ pounds
5. Commercial Bordeaux as recommended by manufacturer	
Lead arsenate	1½ pounds
Water	50 gallons

This spray should be applied just before blossom buds open.

No. 2: Second Summer Spray—For Plum Curculio, Brown Rot, and Leaf spot

Lead arsenate with one of the sulfur sprays as given for No. 1 is preferred, although Bordeaux may be used.

This spray should be applied when the petals have fallen.

No. 3: Third Summer Spray—For Plum Curculio, Brown Rot, and Leaf spot

Lead arsenate with either of the sulfur sprays or the Bordeaux recommended under No. 1 may be used at this time. The sulfur sprays are probably the better.

This spray should be applied two weeks after petal fall.

No. 4: After Fruit is Picked—For Leaf Spot

Bordeaux, 3-6-50, should be applied after fruit is harvested in case trees are seriously infected by leaf spot.

SPRAYING GRAPES

A spray schedule for grapes must be flexible. During some seasons it will be necessary to apply several sprays to insure a clean crop and healthy foliage while during other seasons, though rarely, no spray applications are needed.

Black rot (fig. 12) and powdery mildew are the important fungous diseases of the grape. Bordeaux mixture, 3-6-50, is used for controlling these diseases.

The grape leaf folder, the grape rootworm, and the grape berry moth are important grape insects which are controlled by the use of arsenate of lead.

The above pests can usually be controlled by applying a combina-

tion spray of Bordeaux, 3-6-50, and 2 pounds of lead arsenate to 50 gallons of spray, at the following times:

1. As the leaf buds are opening.
2. Just before the flower buds open.
3. Just after the blossoms fall.
4. Ten days after spray No. 3.
5. Two weeks after spray No. 4.

Oxo-Bordeaux may be substituted for any of the Bordeaux 3-6-50 sprays mentioned above.

Midsummer sprays of Bordeaux may be needed if late infections of mildew occur.

Anthracnose is an important grape disease in many grape-growing regions east of the Rocky mountains. Dormant strength lime-sulfur, 1 to 8, is important in controlling anthracnose. The summer Bordeaux sprays are also of value against this disease.

The grape leaf hopper is controlled by applying nicotine sulfate, ½ pint to 50 gallons of water, when the insect is in the nymph stage. The nymphs live on the under side of the grape leaves and are unable to fly although they run in all directions when disturbed. In spraying for the control of this insect it is important to use high pressure with a coarse driving spray and to have the nozzles so arranged that the spray is directed upward under the leaves. In this region the nymphs appear the last of June or early in July.

SPRAYING STRAWBERRIES

Spraying for Disease Control

The foliage of the strawberry is subject to the attacks of only one important fungous disease, the strawberry leaf spot. The leaf-spot lesions are purplish spots the centers of which are nearly white. The disease is found on the leaves of most varieties of strawberries. Aroma and Dunlap strawberries are damaged only lightly by the disease, while Warfield and Gandy are among the most susceptible varieties. During relatively dry seasons, the disease is more active than in moist seasons.

During moist seasons it does not pay to apply a spray to control the leaf spot. However, if conditions justify spraying, Bordeaux mixture applied just before the blossoms open and at intervals after the crop is harvested, may check the attack of the disease.

Spraying for Insect Control

Perhaps the most important insect which attacks the foliage of the strawberry and which may be controlled by spraying is the strawberry leaf-folder.

This insect appears as a small slender green caterpillar feeding on the inside of strawberry leaves which it has folded together and sewed with silk threads to form protection for itself.

An application of lead arsenate sprayed on the leaves before many of the leaves are folded will keep this insect in check. There

are three broods of the insect each season but the later broods which appear after the crop of berries has been harvested do the most damage in Kansas.

The use of a short rotation is one of the best ways to keep fungous diseases and insect pests of the strawberry under control.

SPRAYING BRAMBLES

Two important diseases of brambles, crown gall and orange rust, cannot be controlled by spraying. Plants infected with these diseases should not be accepted from the nursery. There is considerable variation among varieties in orange rust susceptibility.

Anthracnose is an important raspberry disease which is difficult to control. Lime-sulphur applied as follows may prove beneficial.

1. In early spring before growth starts, apply concentrated lime-sulfur diluted at the rate of 2½ gallons in 50 gallons of spray.
2. When new shoots are 6 to 8 inches high, use concentrated liquid lime-sulphur diluted at the rate of 1¼ gallons in 50 gallons of spray.
3. Just before the blooming period, use concentrated liquid lime-sulfur diluted at the rate of 1¼ gallons in 50 gallons of spray.

In addition to the application of sprays, old fruiting canes should be removed as soon as the crop is picked.

More detailed information regarding San José scale, fruit-tree borers, grape insects, cherry leaf spot, the home manufacture of lime-sulfur concentrate, etc., may be obtained upon request from the Agricultural Experiment Station, K. S. C., Manhattan, Kan.