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KANSAS STATE COLLEGE OF AGRICULTURE
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MANHATTAN, KANSAS

DEPARTMENT OF HORTICULTURE

COMBATING FRUIT PESTS IN KANSAS[2]

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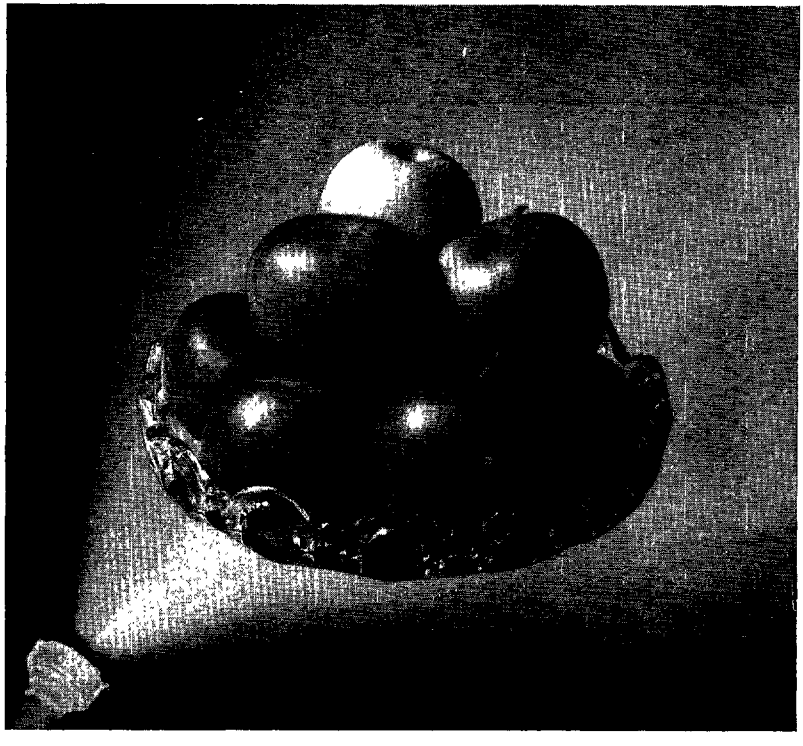

Orchard Spraying Is Necessary to Produce Sound Fruit

1. Circular 169 was written by W. F. Pickett and G. A. Filinger. Most of the illustrations were prepared by W. F. Pickett.
2. Contribution No. 166 from the Department of Horticulture.

INTRODUCTION

Pest control, soil management and pruning are three operations of first rank in modern orcharding in Kansas. Although all three operations are important and none can be placed in a dominant position, the pest-control problem has become very acute in recent years. There are several reasons for this situation. First, the number of pests and their severity have increased with the length of periods during which fruit has been grown in the same sections. New insects and diseases have been introduced and native ones have changed host plants. Second, prolonged drought periods have favored some of the pests and aggravated their damage. Third, the consuming public is constantly demanding higher grades of fruit.

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

Spraying is the most effective way of controlling many of the diseases and insects which attack fruit and fruit plants in Kansas. The orchardist can spray his plants more intelligently if he has a knowledge of the pests which affect his crops, the equipment used in spraying, the spray materials, and the technique of spraying.

DISEASES OF FRUIT

The relative susceptibility to the common diseases of the more important Kansas apple varieties is shown in table 1. 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 1.—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 Cooper	s	vs	r	r	s
Early Harvest	s	vs	r	ss	s
Gano	s	vs	s	r	s
Golden Delicious	r	r	s	ss	ss
Grimes	r	r	ss	ss	r
Jonathan	r	r	vs	vs	vs
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

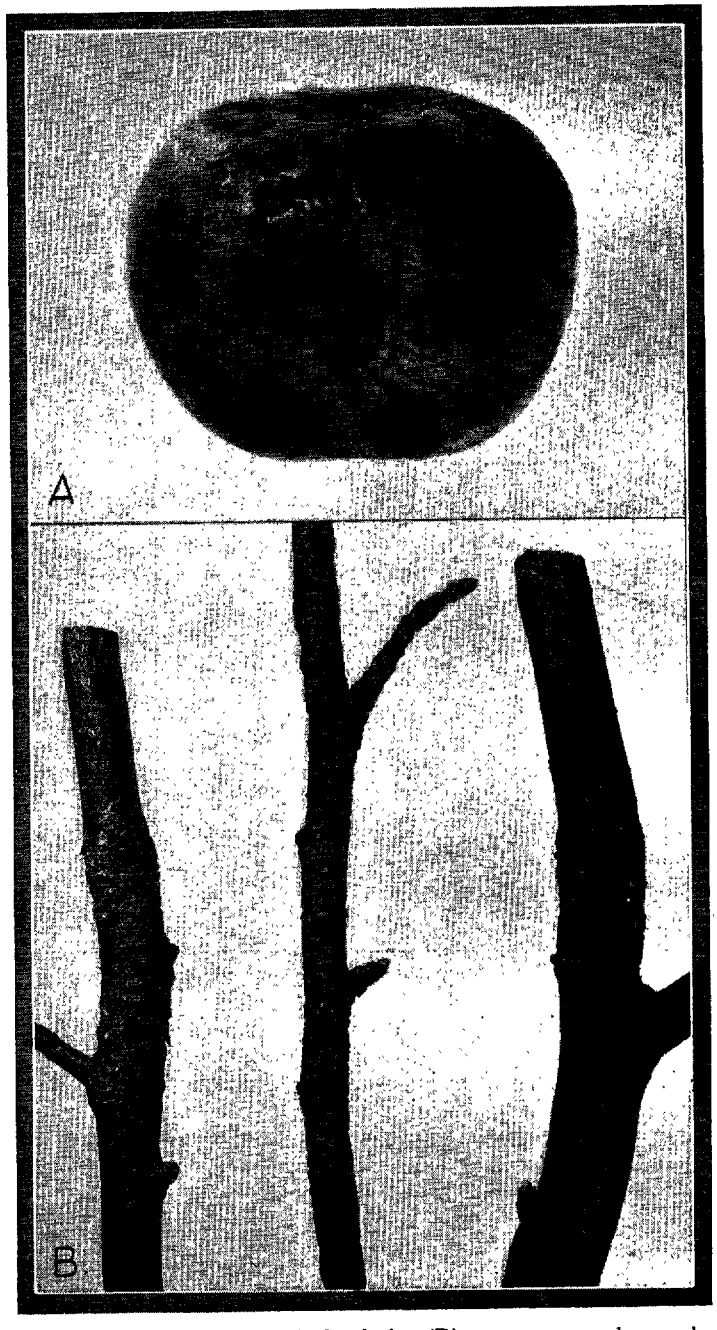

FIG. 1.—Apple blotch. (A) On fruit; (B) on young apple wood (overwinter cankers).

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.

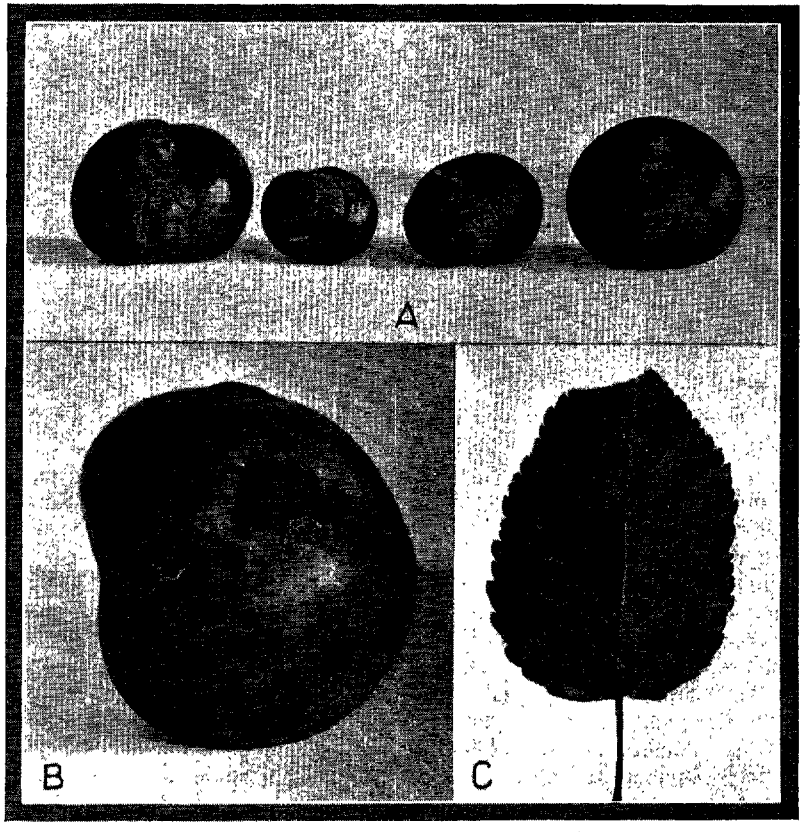

FIG. 2.—Apple scab. (A) On Winesap apples; (B) on a Ben Davis apple; (C) on leaf.

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 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

FIG. 3.—Black rot on apple leaf.

causing apple scab is favored by cool, rainy weather and greater attention should be given this pest during seasons when the spring is late.

Apple scab lesions appear in the spring and early summer on the foliage 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 ¼ inch in diameter 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 reduce the source of infection materially. Thorough spraying with lime-sulfur when the flowers are at the pink and petal-fall stages will ordinarily control the disease. Spores are not produced on the overwintering leaves until

FIG. 4.—Peach leaves infected with peach leaf curl.

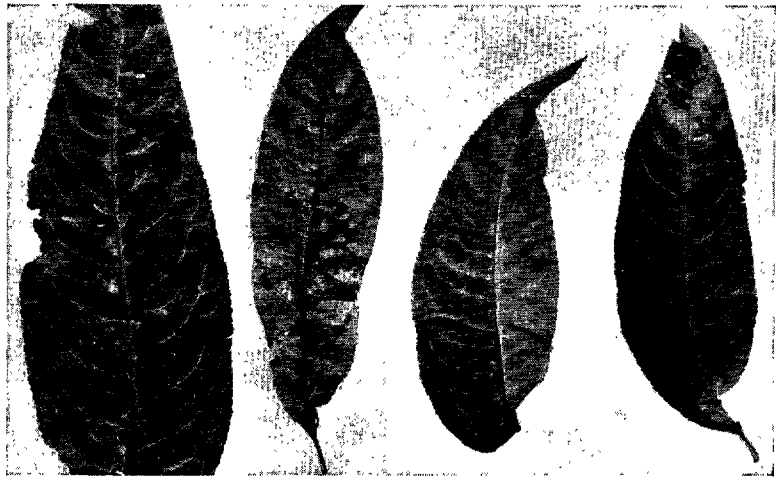

FIG. 5.—Peach leaves infected with bacterial leaf spot.

rainy weather occurs in the spring. In seasons when the early spring is dry the spray scheduled to be applied when the blossoms are pink may be omitted, although there is an element of risk in this practice.

Results from experiments in northeastern Kansas during the past eight years indicate that liquid lime-sulfur gave the best control of apple scab, dry lime-sulfur was next, and flotation sulfur third.

FIG. 6.—Peach leaves showing arsenical injury. Left, advanced stage; right, early stage.

The degree of damage to the leaves was in the same order. The materials that gave the best control of the disease caused the most injury to leaves.

Black rot or frog-eye is a serious disease of the foliage of some varieties of apples. The black-rot organism produces small light-brown spots on the leaves. (Fig. 3.) These lesions are frequently marked with concentric rings, hence the name frog-eye. Experiments indicate that one or two applications of lime-sulfur concen-

trate 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 copper sprays such as Bordeaux are of value if the disease persists into the summer.

Peach-leaf curl is a serious disease of peach foliage in some seasons. Diseased leaves are thickened and distorted. (Fig. 4.) A thorough dormant spray of lime-sulfur will give complete control of this disease. Since the disease organism overwinters on bud scales, this spray may be applied in the fall after the leaves are shed. If San José scale is not present, six and one-fourth gallons of liquid lime-sulfur per 100 gallons is sufficient. A 4-4-50 Bor-

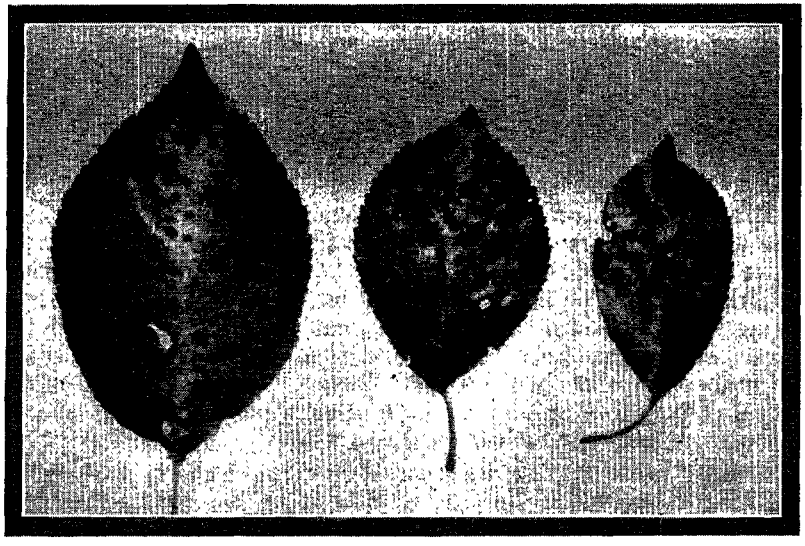

FIG. 7.—Cherry leaves infected with cherry leaf spot.

deaux mixture to which is added a quart of commerical oil emulsion will give good control of peach-leaf curl if applied either in the fall after the leaves have dropped or in the spring before growth starts.

Bacterial leaf spot of peach is illustrated in figure 5. Although a spray schedule has not been perfected for the control of this disease, two or three applications of white Bordeaux, 4 pounds of zinc sulphate, 4 pounds of hydrated lime to 50 gallons of water, made at intervals of two weeks beginning when the shucks have 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. 6.) 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 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. Zinc sulphate-lime, 4-4-50, protects peach trees against arsenical injury.

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 widespread 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 cherries and plums for the control of brown rot.

Black rot is a common fungous disease of the grape. (Fig. 8.) The disease appears on the half-grown fruit as a light colored 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. Must of the fruits remain attached to the plant and are known as mummies. Destroying the mummies and following the spray schedule for grapes (page 31) will keep this disease under control. The removal of all canes around the base of each plant will help control this disease as it often starts on these "sucker" shoots.

Cherry leaf spot is a disease of the foliage of cherry trees which has caused widespread damage in Kansas by defoliating the trees during the growing season. (Fig. 7.) 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 Bordeaux mixture. Many growers have obtained good results by using some of the new insoluble copper compounds such as Coposil, Basicop, Cupro K, etc., or some of the wettable sulfur sprays.

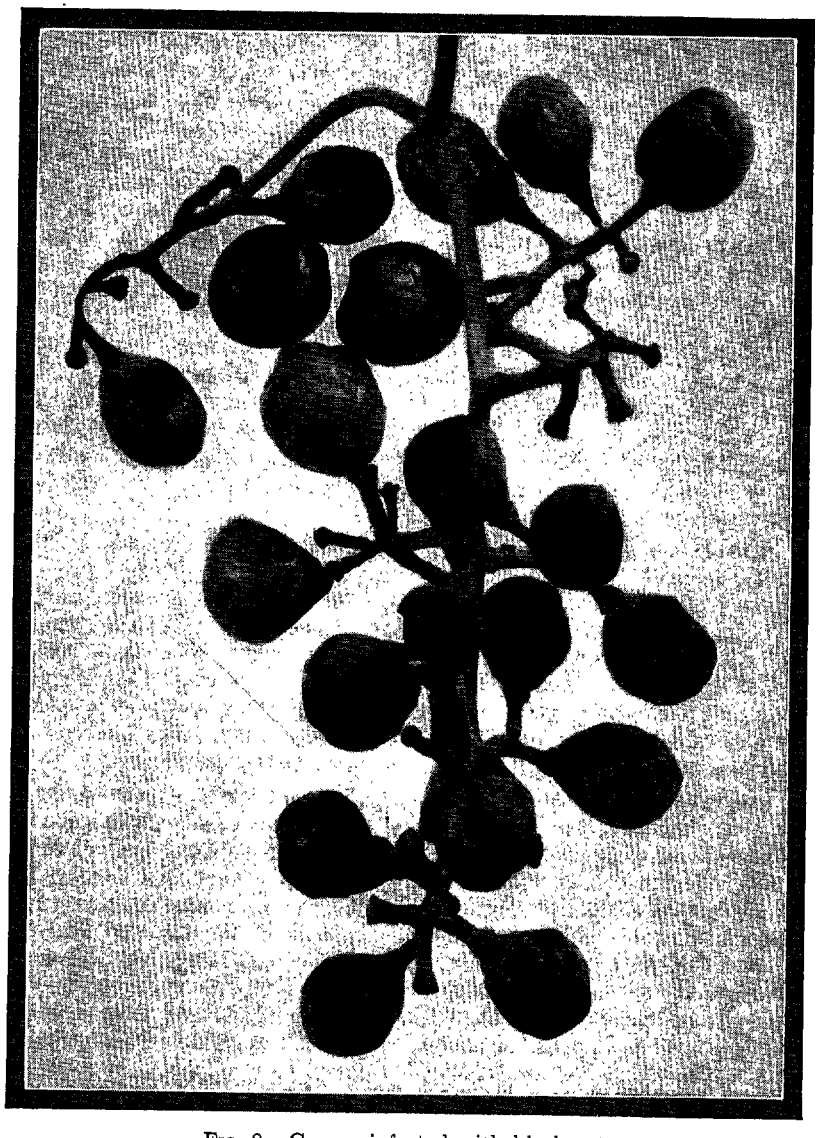

FIG. 8.—Grapes infected with black rot.

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. 9, A), weak foliage, and, on the heavily infested trees, many dead branches. San José scale infests 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. 9, B and C.)

Thorough spraying with a 3-percent 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 cluster-bud 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 larvae 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. Lead arsenate in the cluster-bud and petal-fall sprays will kill many of the adults.

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 larvae cause the familiar wormy apples. The adult is a small inconspicuous moth that is seldom noticed by the

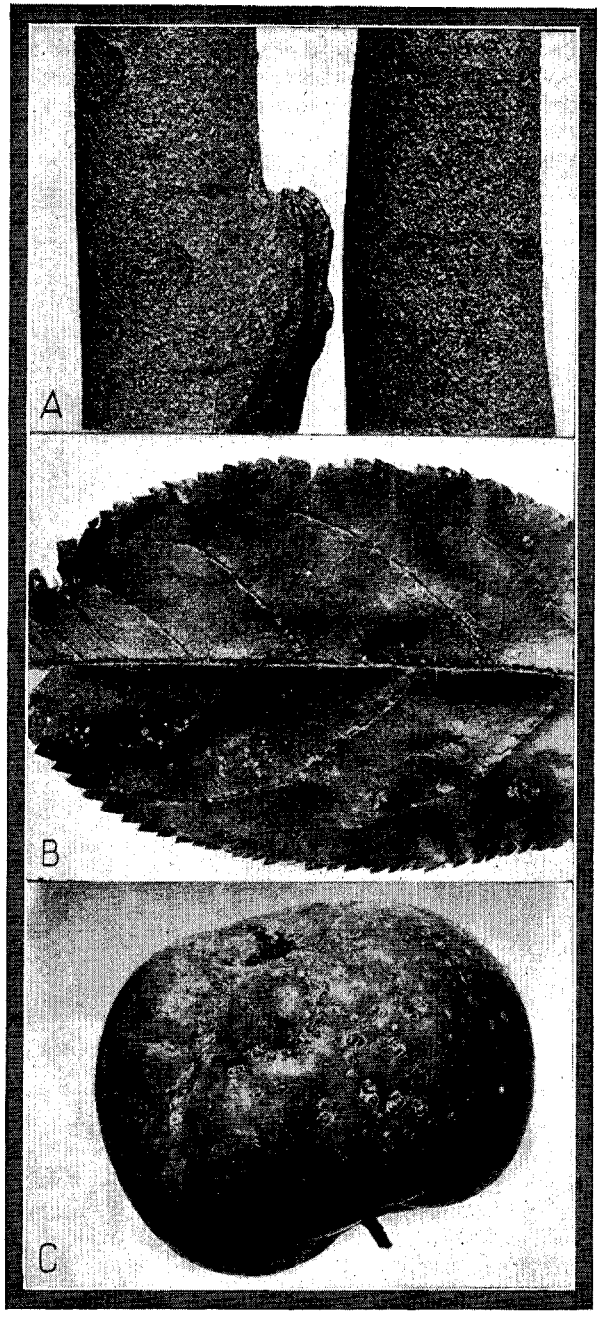

FIG. 9.—San José scale. (A) On apple branches; (B) on apple leaf; (C) on apple.

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 diffi-

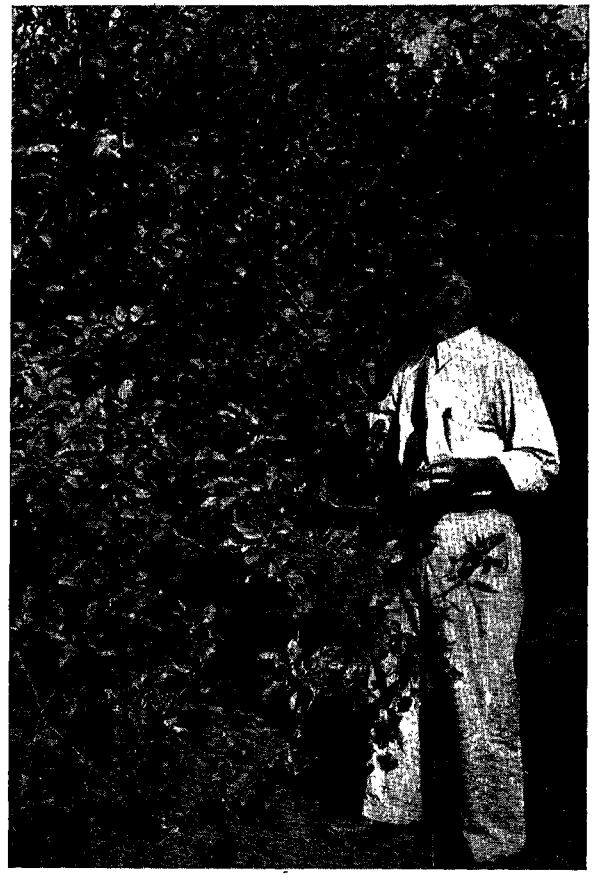

FIG. 10.—A convenient method of suspending a bait trap in an apple tree.

cult to time the sprays, especially during the latter part of the growing season.

The first-brood larvae 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 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 3 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 outer branches near the top of 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. 10.)

In order to get good control many commercial orchardists find it necessary to spray every 7 to 10 days during the time that trap records show a heavy codling moth flight. The dosage in early season sprays should be two pounds of arsenate per 50 gallons in order to build up a deposit equivalent to about 15 milligrams of arsenic per square centimeter to control the codling moth. The dosage is reduced in late sprays to one and one-half pounds per 50 gallons to avoid too heavy a residue at harvest time.

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, and should be resorted to as a supplementary measure when commercial control cannot be obtained with the recommended spray schedule.

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 plum 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 chainlike holes in the leaves. (Fig. 11.) The larvae 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.

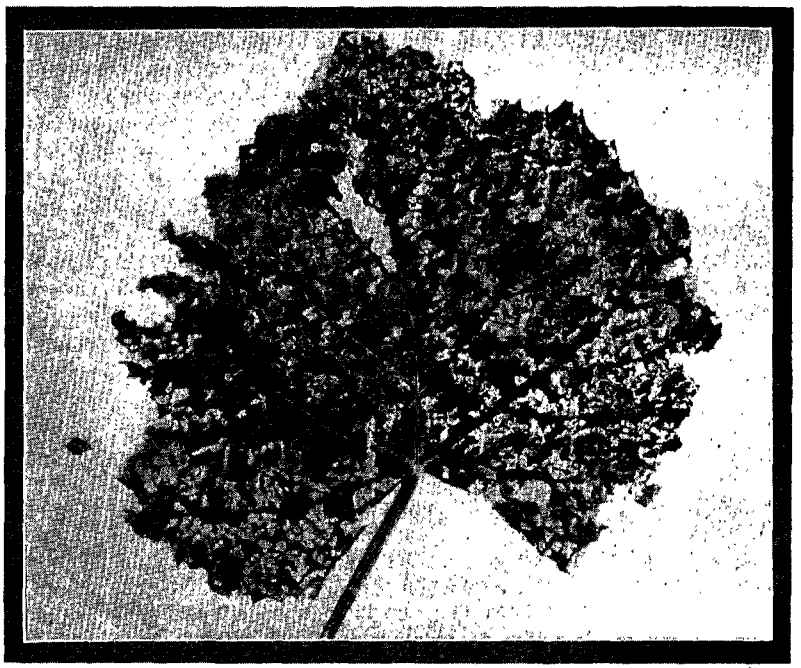

FIG. 11.—A grape leaf destroyed by the adult grape rootworm.

Red spider, a small mite, is a general feeder. Included in its hosts are apple, cherry, peach, brambles, truck crops, and many ornamental plants. It is more abundant and more destructive during periods of drought. The red spider overwinters either as an adult in crevices or tree trunks and in leaves and trash under trees or in the egg stage. Infested leaves become mottled in appearance and if severely attacked will drop. Red spider can be controlled with a 3-percent dormant oil spray or later with a 1-percent summer oil emulsion.

American strawberry leaf roller is a native insect that causes considerable damage to strawberries in Kansas and occasionally attacks the brambles. As the name indicates, the larvae fold the strawberry leaflets and feed within the folded leaves. The insect overwinters in the larval stage in the folded leaves. There are

usually three generations in Kansas. According to Parker and Lamerson,[3] plants bearing a crop should be sprayed at five-day intervals with nicotine sulphate, one-half pint, and one pint summer oil emulsion to fifty gallons of water, beginning as soon as the first larvae appear. Plants not producing a crop should be sprayed as needed with lead arsenate, 1½ pounds to 50 gallons of water, or Bordeaux mixture to which is added a pint of summer oil emulsion per 50 gallons of spray.

The unspotted tentiform leaf miner which attacks apple, pear, quince, and cherry leaves has done considerable damage to these fruit plants in recent years. Injury from this insect was first noticed in the Agricultural Experiment Station orchard in the summer of 1932. The larvae of this insect feed between the epidermises of the leaves and cause blisterlike spots. Several mines may be found on a single leaf. Arsenicals may enter these mines and cause still further injury to the leaves so that damaged leaves drop early. Fortunately, the damage does not start until early summer. Nicotine sulfate and a summer oil emulsion added to the second and third cover sprays will give commercial control of the leaf miner. The destruction of trash and leaves during the fall and winter will destroy many overwintering insects.

Leafhoppers attack many fruit plants, especially grapes and apples. The insects feed on the underside of leaves causing the leaves to have a mottled appearance, due to whitish spots from which chlorophyll has disappeared. Those severely injured appear grayish-green from the upper side.

The adults are difficult to kill with sprays as they fly away as soon as application starts. A nicotine sulfate oil emulsion spray should be timed for the immature insects when they hatch. A thorough clean-up of trash in and around orchards will destroy overwintering quarters.

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

3. Parker, Ralph L., and Lamerson, Paul G., Small Fruit Insects. Biennial Report of the Kansas State Horticultural Society, 44:107-115. 1938.

150 pounds may be maintained. Good barrel sprayers may be used to advantage in spraying small plantings of fruit.

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 50 gallons per minute with engines ranging from 1½ to 22 horsepower. 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. 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 usual dilution is from 1½ to 2 pounds of the poison to 50 gallons of water or spray. For small amounts a tablespoonful may be mixed with a gallon of water. Lead arsenate does not dissolve to any appreciable extent. This makes it necessary 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.

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 drugstores or any of the spray supply houses. It is marketed as a heavy dark brown liquid. It may be applied to plants at strengths sufficientto 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 are generally used as dormant sprays for the control of San José scale. 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 percent oil while the miscible oils contain from 90 to 95 percent oil. For dormant spraying both classes of oils are diluted so that the solution applied to the trees contains from 2 percent to 4 percent oil. To prepare 100 gallons of spray containing 2 percent 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. 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. The use of one-fourth of one percent summer oil emulsion with the midsummer codling moth sprays is now an established practice.

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 pur-

chase this product. Those interested may secure special information concerning the home manufacture of lime-sulfur on request.

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

Pyrethrum and Derris extracts are toxic to insects and practically noninjurious to higher animals. Their use in combating orchard insects has been greatly limited because the killing agents, pyrethrins and rotenone, are volatile, and frequent applications are necessary. At present these materials are too expensive to use in orchards.

FUNGICIDES

Lime-sulfur concentrate diluted at the rate of 1 part to 35 to 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 greater 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 powder form. Although not quite as effective as freshly prepared Bordeaux mixture, the commercial preparations are very convenient. They are recommended where small amounts of Bordeaux are needed.

Bordeaux-oil emulsion is a combination used as a dormant spray on peaches. Add 1½ gallons of a commercial oil emulsion to 50 gallons of Bordeaux mixture.

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 copper 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. Zinc-lime is also effective in preventing arsenical

injury to foliage, twigs, and fruit and is recommended instead of lime whenever peaches are sprayed with an arsenical spray.

Other copper compounds such as Coposil, Basicop, etc., have been introduced recently and apparently are safer on such tender foliage as the peach tree than the regular Bordeaux mixture.

Spreaders and stickers are various materials such as calcium caseinate, soap, soybean flour, and some of the oil emulsions to use with lead arsenate and other sprays to increase the spreading and adhering qualities of the latter. The materials decrease the surface tension of the spray mixture and may cause excessive drip and waste of spray materials. Soybean flour has proved satisfactory in some recent work, but has caused damage to apple leaves where excessive amounts were used.

Dilutions of spray materials vary with the seasons, the plants sprayed, and the pests to be controlled. Occasionally it is desirable to mix small amounts of spray. The table on page 23 presents dilutions in amounts from one gallon to 200 gallons.

TECHNIQUE OF SPRAYING

Some definite system of procedure in spraying is necessary to avoid missing trees or portions of trees. Large trees are sprayed on the inside first. The operator walks in under the overhanging branches to the trunk and sprays toward the outside first and then finishes the tree by encircling it from the outside. Special care should be exercised to cover the tops and outer twigs of tall trees.

The large-capacity, high-pressure machines are designed to move slowly but continuously through the orchard. One or two operators ride on the machine and direct the spray, usually through clusters of nozzles, at the trees, covering and penetrating them from one side at a time.

A coarse, driving spray must never be aimed directly at the fruit. The abrasive spray particles are sure to injure the finish of the fruit and may cause serious russeting. 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.

SPRAY SCHEDULES

The following schedules are presented to the fruit grower merely to help in planning his spray program. Any schedule prepared in advance of the spray season is only approximately correct because the orchards of Kansas present a wide range of conditions. Each grower must adapt these schedules to his own local needs and conditions.

DILUTION TABLE FOR SPRAY MATERIALS

NAME OF MATERIAL AND STRENGTH.	Number gallons of diluted spray material.					
	200.	100.	50.	10.	5.	1.
Liquid lime-sulfur, Dorman' spray strength	25 gals.*	12½ gals.	6¼ gals.	5 qts.	5 pints	1 pint
Liquid lime-sulfur, Cluster bud spray	6 gals.	3 gals.	6 qts.	2½ pts.	1¼ pts.	¼ pint
Dry lime-sulfur, 4 lbs. in 50 gallons	16 lbs.	8 lbs.	4 lbs.	13 ozs.	6 ozs.	1¼ oz.
Dry lime-sulfur, 3 lbs. in 50 gallons	12 lbs.	6 lbs.	3 lbs.	10 ozs.	5 ozs.	1 oz.
Lead arsenate, 1½ lbs. in 50 gallons	6 lbs.	3 lbs.	1½ lbs.	4½ ozs.	2¼ ozs.	2 tablespoonfuls.
Lead arsenate, 1 lb. in 50 gallons	4 lbs.	2 lbs.	1 lb.	3¼ ozs.	1½ oz.	1 tablespoonful.
Bordeaux mixture, 3 lbs., copper sulfate, 6 lbs hydrated lime, 50 gallons water	12 lbs. 24 lbs.	6 lbs. 12 lbs.	3 lbs. 6 lbs.	In small amounts, use prepared dry Bordeaux according to manufacturers' recommendations.		
Nicotine sulfate (40%) ½ pint to 50 gallons (1 to 800) ('Black Leaf 40").	1 qt.	1 pt.	½ pt.	3 tablespoonfuls.	1½ tablespoonfuls.	1 teaspoonful.
Oil emulsion 1 percent	2 gals	1 gal.	½ gal.	¾ pint	12 tablespoonfuls.	3 tablespoonfuls.

* This figure, in each case, denotes the amount of concentrated spray material needed to make the amount of diluted spray designated at the top of each column.

SPRAY SCHEDULE FOR APPLE TREES

No. 1: Dormant Spray-For San José and other scale insects

The dormant spray is applied just before the buds swell in the spring. This spray is intended for the scale insects, but may have added value in destroying some overwintering aphid and red spider eggs. If none of these pests is present this spray may be omitted.

Oil emulsion at the rate of 3 gallons in 100 gallons of spray is recommended. If miscible oils are used the spray should contain 2 to 3 percent oil when applied.

Liquid lime-sulfur, 1 gallon to 7 or 8 gallons of water may be used, although it is not as effective in controlling scale insects.

If the orchard is heavily infested with aphids, it may be advisable to delay this spray until the "green tip" stage of the apple and add nicotine sulfate at the rate of 1 pint to 100 gallons of the oil emulsion spray.

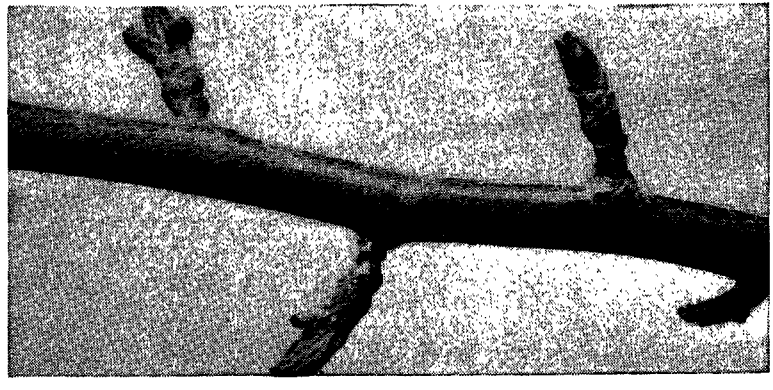

FIG. 12.—Apple buds at the stage of development at which the delayed dormant or "green tip" spray should be applied.

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..	1½ pounds
Water	50 gallons

This spray is applied when the buds have separated in the cluster and show pink, but before the blossoms open. (Fig. 13, upper and lower left.)

When arsenate of lead is to be used with lime-sulfur sprays, the water and lime-sulfur 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.

FIG. 13.—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.

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)	
(Or wettable 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 should be finished before the calyx cups close. (Fig. 13, right, and fig. 14, 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. Dry lime-sulfur or the wettable sulfurs will cause less burning in warm weather than liquid lime-sulfur.

FIG. 14.—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.

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

This spray is about the same as No. 3 unless warm weather prevails.

Liquid lime-sulfur	1½ gallons
(Or dry lime-sulfur. ....4 pounds)	
(Or wettable sulfur. .... 4 pounds)	
Arsenate of lead	2 pounds
Water	50 gallons

The spray is applied about 10 to 14 days after petal fall. It is an important apple scab and blotch spray. If the weather is warm, Bordeaux mixture, 3-6-50, can be substituted for the sulfur sprays, as it is less likely to burn. The choice will depend largely on the previous experience of the grower. It is also possible to reduce the strength of lime-sulfur during unseasonably warm weather.

Wettable sulfur such as Flotation sulfur may be used on varieties which are susceptible to injury by lime-sulfur or Bordeaux.

Bordeaux is more likely to cause injury during cool, damp, foggy periods, but is very effective in controlling blotch.

No. 5: Second Cover 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 2 pounds to 50 gallons of water and 1½ pounds of hydrated lime. If Bordeaux mixture is used the lime may be omitted. If codling moth caused serious damage in the past, add 1 pint of summer oil emulsion to 50 gallons of spray. 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 Cover 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 spray 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 2 to 50, arid 1½ pounds of hydrated lime at this time. Summer oil emulsion may be added as indicated in No. 5. 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: Fourth Cover Spray—For Apple Blotch and Codling Moth

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 larva begin hatching in large numbers. It should consist of arsenate of lead, 1½ or 2 pounds to 50 gallons, plus 1 pint of summer oil emulsion 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, addition to the arsenate of lead.

No. 8: Fifth Cover Spray—For Codling Moth and Sooty Blotch

This spray will consist of arsenate of lead, 1½ or 2 pounds to 50 gallons of water. During rainy seasons when the arsenical deposits are washed off, or if codling moth are bad, add a pint of summer oil emulsion. 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.

A spray for the third brood of codling moth is applied when the need is shown by the codling moth cage, usually during August and early September, using 1½ pounds lead arsenate to 50 gallons of water.

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 homemade. 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 homemade formula. Oxo-Bordeaux, 4 pounds, and hydrated lime, 4 pounds, may be used as the fungicide.

No. 1: Dormant Spray—For San José Scale

Oil emulsion, 3 percent, 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

Either of the following combinations may be used:

1. Commercial liquid lime-sulfur	1¼ gallons
(Or dry lime-sulfur	4 pounds)
(Or wettable sulfur	4 pounds)
Lead arsenate	2 pounds
Water	50 gallons
2. Bordeaux	3-6-50
Lead arsenate	2 pounds

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 the same materials given for spray No. 2 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 No. 2 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. A weak Bordeaux mixture, 1½-3-50, or one of the insoluble copper compounds, such as Coposil, can be used.

SPRAY SCHEDULE FOR PEACHES

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

Use Bordeaux, 3-4-50, and add 1½ gallons of oil emulsion to each 50 gallons.

If San José scale is not present, liquid lime-sulfur, 1 gallon to 7 or 8 gallons of water, can be used for peach leaf curl. Either combination may be applied in the fall after the leaves have dropped or in the spring before growth starts.

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

Use white Bordeaux, 4 pounds of zinc sulfate, 4 pounds of hydrated lime, 50 gallons of water, and add 1½ pounds of lead arsenate. The zinc lime will prevent arsenical injury and also act as a fungicide.

Dry-mix lime and sulfur, or wettable sulfur may be used instead of the white Bordeaux. If wettable sulfur is used add 1½ pounds of hydrated lime to avoid arsenical injury.

This spray is applied after blooming when most of the shucks have fallen.

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

Apply the same materials as given in No. 2 about 10 to 14 days later.

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

This spray is applied if curculio still persist and if brown rot threatens using same materials as No. 2. It is applied a week or ten days after No. 3.

No. 5: Fourth Summer Spray-For Brown Rot

Use wettable sulfur, 2 or 3 pounds to 50 gallons. This spray is applied two or three weeks before harvest.

SPRAY SCHEDULE FOR APRICOTS

The schedule for apricots is about the same as for peaches except that the dormant spray is omitted unless scale is present.

SPRAY SCHEDULE FOR SOUR CHERRIES

Home orchardists may find it convenient to substitute dry lime-sulfur or wettable sulfur for the liquid form specified in this schedule, and manufactured Bordeaux for the homemade. 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

Either one of the following combinations may be used:

1.	Commercial liquid lime-sulfur	1¼ gallons
	Lead arsenate	1½ pounds
	Water	50 gallons
2.	Bordeaux	3-6-50
	Lead arsenate	1½ pounds

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 lime-sulfur 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 lime-sulfur or wettable sulfur or the Bordeaux recommended under No. 1 may be used at this time. The sulfur sprays are probably better as Bordeaux may decrease the size of the fruit.

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 affected by leaf spot.

Although Bordeaux mixture seems to decrease the size of fruit somewhat, it usually gives better control of 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. 8) 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 combination 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 roller. (See, also, page 16.)

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.

Frequent spraying with lead arsenate, 2 pounds, 1 pint of oil emulsion, and 50 gallons of water, keeping the new leaves covered before they are folded by the insect, will keep the leaf roller in check during the first year or in renovated fields after harvest when new runner plants are setting. Plants bearing a crop can be protected by frequent spraying with nicotine sulfate, ½ pint, 1 pint of oil emulsion, and 50 gallons of water, beginning as soon as the first larvae appear. Since there are three broods of the insect each season, it is essential to watch the plants carefully all summer.

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-sulfur applied as follows gave good results.[4]

1. In early spring before growth starts, apply concentrated lime-sulfur diluted at the rate of 1 gallon in 10 gallons of spray.

2. When new shoots are 6 to 8 inches high, 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.

4. Unpublished data, Department of Botany, Kansas Agricultural Experiment Station.

SOME PESTS CONTROLLED BY METHODS OTHER THAN SPRAYING

Diseases

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 heartwood. Usually only the trunks and

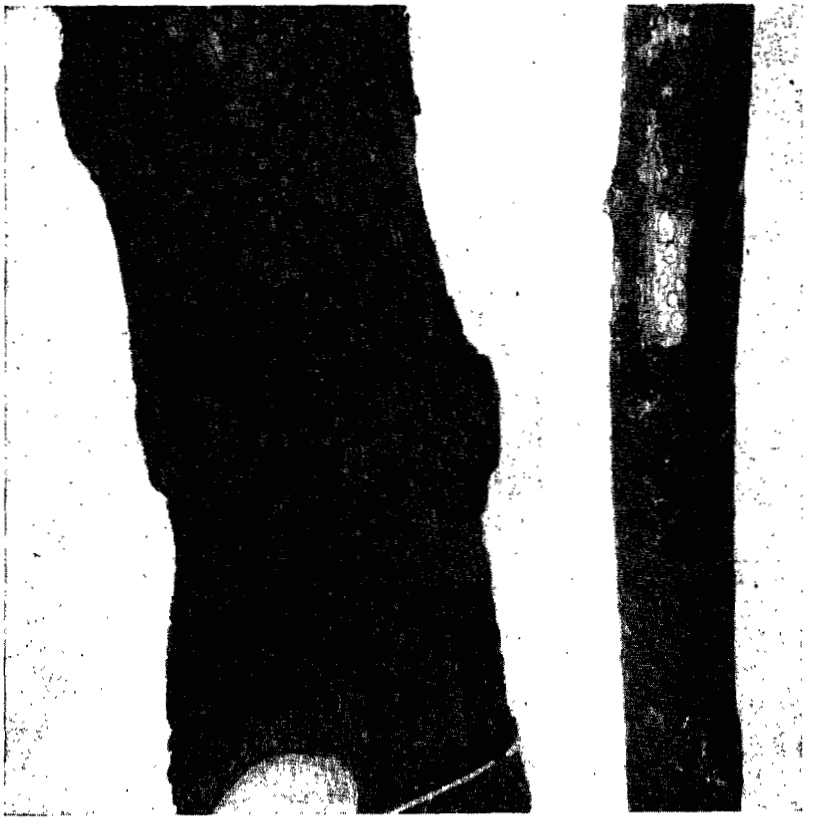

FIG. 15.—Blister canker on apple.
A. Early stage.
B. Late stage.

large scaffold branches are affected. The disease first appears as a dull brown spot somewhat elongate in the direction of the long axis of the branches. Later circular, blisterlike fruiting bodies appear on the surface. (Fig. 15A.) When the bark scuffs off of the dead area the blisters persist and appear as "nail heads" on the canker. (Fig. 15B.) Blister canker is difficult to control once it is established on a limb. Since infection usually enters through wounds,

care should be taken in pruning to avoid large wounds where possible and protect wounds until healed. Frequent disinfecting of pruning tools is helpful. Severely affected branches should be removed.

FIG. 16.—Apple twig infected with fire blight.

Keep susceptible varieties of apple trees growing as vigorously as possible, as vigorous trees are seldom attacked by this disease.

Fire blight is a bacterial disease of apples and pears. The disease affects young, vigorous shoots and blossoms and occasionally causes cankers on larger limbs. One characteristic of fire blight is that

leaves cling to the twigs long after the twigs are dead. (Fig. 16.) The disease is spread from cankers and dead twigs by insects and rain.

The best control of fire blight is to rid the orchard of the disease

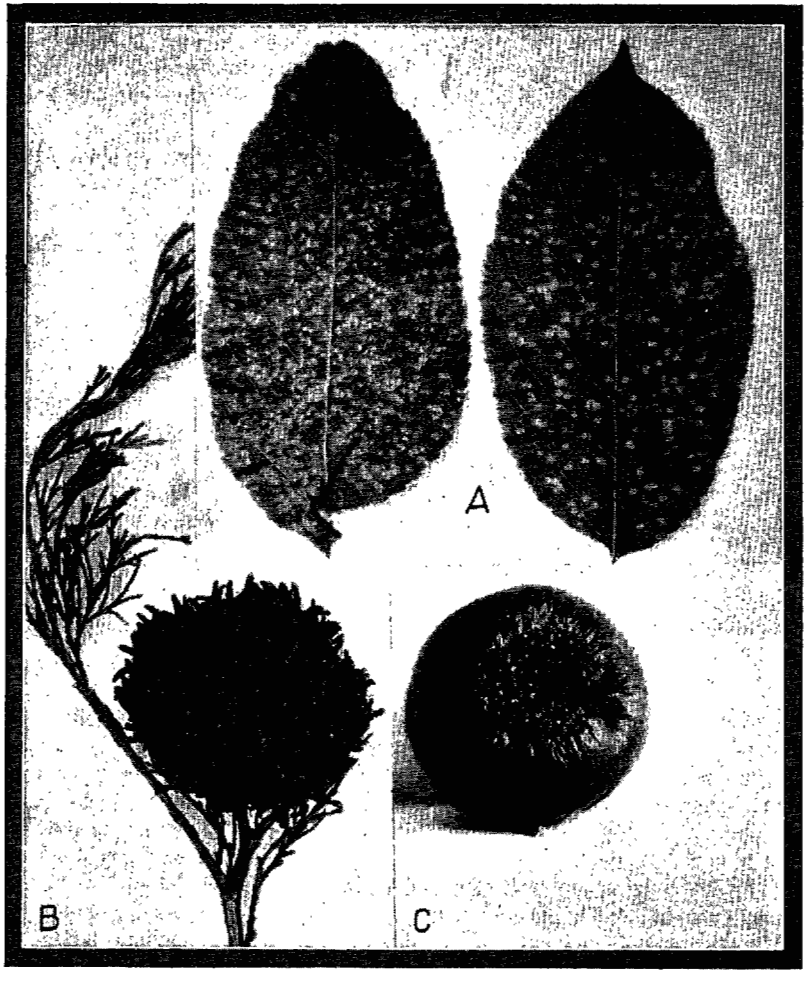

FIG. 17.—Cedar-apple rust. (A) Lesions on apple leaves; (B) gall on red cedar; (C) infection on apple.

by pruning out and destroying the affected twigs and cankers, thus removing the sources of infection. Regulating tree vigor is helpful as the disease is more destructive to vigorous succulent twigs. Controlling such insects as aphids, which spread the disease, will indirectly aid in preventing fire blight.

The removal of diseased twigs at pruning time is advised. If fire blight cankers form at the base of twigs, they can be cut out by carefully removing the bark to the wood out beyond the diseased area and disinfecting the wound. A disinfectant is made by dissolving 2 tablets of mercuric bichloride and 2 tablets of mercuric cyanide in a quart of water. A convenient swab for applying the material to wounds and pruning tools can be made by tying a wad of cloth on the end of a stick. ***Keep the disinfectant solution in a glass container. The material is extremely poisonous and must be kept from children and livestock.***

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

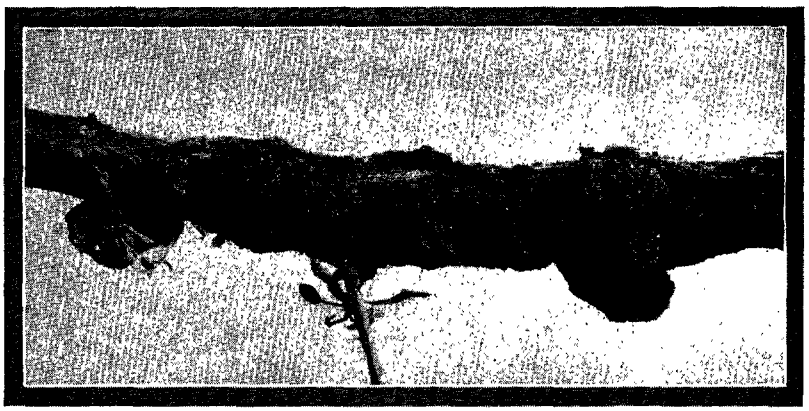

FIG. 18.—Canker on plum branch produced by black knot.

disease is of primary importance on the foliage of Wealthy and Jonathan trees. (Fig. 17, A.) Occasionally lesions are produced on apples as shown in figure 17, C. Spraying is of little or no value in controlling this disease in Kansas. 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 17, B. The removal and destruction of these galls on cedar trees tends to reduce infection on apples. This, of course, is practical only on a small scale.

Black knot and plum pockets (figs. 18 and 19) are fungous diseases of the plum which, in some seasons, cause considerable damage.

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.

FIG. 19.—Plums infected with plum pockets.

Insects

The apple curculio occasionally is a serious pest in Kansas. At present its damage is greatest in the northeastern counties. 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 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. 20.) The egg punctures are bottle-shaped. Soon after the larvae hatch many of the infested fruits fall and the larvae complete their feeding and pupate in the fallen fruit. The adults of the new brood appear in late June and early July and attack

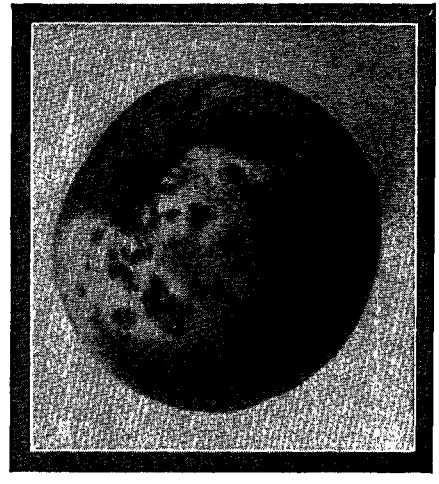

FIG. 20.—Fruit injured by apple curculio.

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 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 burning of leaves and rubbish in the early winter. Some orchardists pick up and destroy the "June drops" which contain the matured larvae and the pupae. This method is only partly effective.

The flat-headed apple-tree borer is one of the most widely distributed of the several kinds of wood-boring insects. The adult of this species is a flat semioval-shaped beetle about one-half inch

long and one-fourth inch wide. The larvae is a dirty yellowish grub, that when fully grown, is about one inch long. Three segments next to the head are enlarged and flattened, which gives the borer the name "flat head."

This insect is native to the American forests and attacks a wide range of host plants. Among its hosts are the following fruit plants: Apple, pear, peach, apricot, plum, quince and currant. In orchards planted near groves of forest trees, the young fruit trees are often attacked by borers before they have a chance to establish themselves. The shock of transplanting decreases the vigor of the newly planted trees and this is exactly what the borers like.

Keeping the trees in a vigorous, healthy condition is the most important measure in the control of the flat-headed borer. All practices such as fertilization, spraying, pruning, and cultivation that tend to keep the trees growing vigorously, help in controlling borers. It seems that the young larvae are unable to establish themselves on normal healthy trees, probably for the reason that the burrows become filled with sap as soon as they extend into growing tissues, and the larvae are either drowned or driven out.

All nursery stock should be carefully examined when obtained for planting and all trees showing signs of borer injury discarded. Newly planted trees, being weakened by the shock of transplanting, are extremely susceptible to borer attacks. Such trees should be watched carefully during the first season. Young trees can be protected by wrapping their trunks with burlap or paper in the spring and mounding soil up over the lower part of each wrapper. The burlap or paper prevents females from laying eggs on the trunks. These wrappers should be removed when the egg-laying season is past unless one of the "crinkled" types of paper is used. The crinkled paper will expand with the growing trunk and will not girdle it.

Low-headed trees in Kansas frequently escape borer attacks. Such trees afford more shade to the trunks and hence are less likely to sunscald. Borers often enter trees along the edges of sunscald cankers. Then, too, females seem to avoid laying eggs in shady places.

Thus far no satisfactory chemical control has been developed for the flat-headed borer on apple. The larvae work beneath the bark where they are protected from stomach poisons or contact insecticides. Various sprays, washes, protective coatings, repellents, etc., have been tried, but none have given reliable results. Paradichlorobenzene, the chemical used for peach-tree borers, is apparently toxic to apple tissues. Where these borers attack other species of trees, it is possible that this chemical, dissolved, 1 pound in 4 pounds of paraffin, might be used to kill the larvae in burrows by painting the mixture, while warm, onto the infested parts. This should be done on a small scale at first to see how the chemical will affect the tree. This treatment is applied during July or August.

The round-headed apple-tree borer causes damage much like the flat-headed borer, but usually attacks tree trunks near the ground. It is more likely to attack healthy, vigorous trees. Control measures are about the same as for the flat-headed borer. Wrapping young tree trunks at planting time with one of the crinkly papers has been successful in preventing damage from this pest.

The peach-tree borer is one of the serious insect pests of the peach in Kansas. The larvae of this insect tunnel through the bark and feed under the bark near the soil level. Small trees may be girdled in one season. Larger trees are severely damaged, and if several larvae attack a tree, it may be killed in a year or two.

Paradichlorobenzene crystals placed around the base of each tree about two inches from the trunk and covered with a mound of moist soil will give commercial control on trees over five years old. Young trees are damaged by this chemical. Trees six to ten years old require from three-fourths to one ounce of the dry crystals per tree. Treatment is usually applied in August or early September.

Workers in the United States Department of Agriculture[5] have recently conducted experiments with ethylene dichloride emulsion for the control of the peach-tree borer. They find that it can be used on young trees and is more effective at lower temperatures than paradichlorobenzene. A stock solution of ethylene dichloride is prepared by emulsifying 1 part of fish-oil soap with 9 parts ethylene dichloride. When thoroughly emulsified add 8 parts of water. This makes a 50-percent solution. For use dilute according to the following table:

AGE OF TREES.	Stock solution (gallon).	Water (gallon).	Dosage per tree.
1 year	1½	8½	One-eighth pint
2 to 3 years	3	7	One-fourth pint
3 to 6 years	4	6	One-half pint
Over 6 years	5	5	One-half pint

This material can be either sprayed or poured on the base of the trunk and the soil immediately surrounding the tree. The treatment is applied in late summer.

Grasshoppers often cause serious damage to fruit plants by feeding on the leaves and fruit. Even the bark may be eaten off of twigs and smaller branches during a severe outbreak.

5. Snapp, O. I., Control of the Peach Borer. American Fruit Grower 59: p. 9. Feb. 1939.

Poison bran mash has proved the best control for grasshoppers. The Kansas formula[6] is as follows:

	Large Amounts	Small Amounts
Bran	20 lbs.	1 lb.
White arsenic or Paris Green	1 lb.	1 oz.
Syrup or cheap molasses	2 qts.	3 ozs.
Oranges or lemons	3	½
Water	3 gals.	1¼ pints

In preparing the bran mash, mix the bran and white arsenic or Paris green thoroughly while dry. Squeeze the juice of the oranges or lemons into the water, chop the remaining pulp and peel into tiny bits and add them to the water. Dissolve the syrup in the water and then wet the bran and poison with the liquid. Stir the bran thoroughly so as to dampen all the mash. The prepared bran mash is scattered around the edges of the orchard in the early morning before the grasshoppers start moving into the orchard.

Cutworms, especially the so-called "climbing" types, occasionally damage fruit plants. Poison bran mash prepared in the same way as for grasshoppers is a practical way to control cutworms. Since cutworms feed at night, the poisoned bran should be scattered under fruit plants in the evening of still, warm days.

Rodents

Rabbits cause considerable damage to unprotected trees by eating the bark from the trunks and lower branches. The damage is most likely to occur during long cold spells in winter when other food is covered with snow.

The following suggestions will be helpful in preventing rabbit damage:

1. Trees may be protected by cylinders of one-fourth inch mesh galvanized hardware cloth placed around the trunk of each tree. The cylinders should be large enough to permit the trees to grow for several seasons and about 18 inches high. Two or three hog rings can be used in securing the overlapping wire cloth.

The trunks may also be wrapped with newspapers or one of the commercial "crinkly" papers. The crinkled paper is elastic and waterproof so it will last at least two seasons.

2. Paint tree trunks with one of the following repellents:

Sulfonated Linseed Oil.—This formula was developed by Dr. R. B. Harvey of the University of Minnesota. Heat linseed oil to 470° F. in a container five times the volume of oil heated. Either heat the oil outside or take out as soon as it reaches 470° and slowly add flowers of sulfur to the hot oil, adding one part to 10 parts of oil or about 12 ounces per gallon. The temperature will go up and the mixture will foam, hence the precautions of a large container and working outside. As soon as the sulfonated oil is cool, it can

6. Dean, George A., Protect Gardens from Grasshoppers and Cutworms. Kansas State Horticultural Society Biennial Report. 44: p. 235-236, 1938.

be applied with a paint brush to the trunks and larger branches. It can be thinned with turpentine and sprayed on. A gallon of sulfonated oil is sufficient for about 200 trees.

Resin-alcohol Paint.—This formula is recommended by the Ohio Agricultural Experiment Station.

Resin	1 pound
Denatured alcohol	1 pint

Heat the resin slowly until it melts. Heat alcohol (on a water bath to keep it away from an open flame) to about same temperature and add to the resin and stir to an even consistency. Keep the paint sealed when not in use, as the alcohol will evaporate. Apply with a brush when bark is dry.

3. Leave pruning on the ground or snow. Rabbits will feed on the prunings.

Mice often girdle trees near the ground or roots near the trunks of fruit trees. The most effective means of controlling are sanitation, poisoning and trapping.

The removal of all trash and leaves from around tree trunks will destroy many hiding places for mice and will clear a place where poisons can be applied.

The following poison baits are recommended by the United States Department of Agriculture in Farmers' Bulletin No. 1397[7]:

a. Poisoned rolled oats.

"Mix together, dry, one-eighth ounce of powdered strychnine and one-eighth ounce of baking soda. Sift the strychnine-soda mixture over 1 quart of rolled oats, stirring constantly to insure an even distribution of the poison through the grain. Thoroughly warm the poisoned rolled oats in an oven and sprinkle over them 6 tablespoonfuls of a mixture of 3 parts of melted beef fat and 1 part of melted paraffin, mixing until the oats are evenly coated. When the grain is cool it is ready for use."

b. Starch-coated grain.

"Mix 1 tablespoonful of gloss starch in one-half teacup of cold water and stir into three-fourths pint of boiling water to make a thin clear paste. Mix 1 ounce of powdered strychnine with 1 ounce baking soda and stir into the starch to a smooth creamy mass free of lumps. Stir in one-fourth pint of heavy corn sirup and 1 tablespoonful of glycerine. Apply to 12 quarts of wheat or to 20 quarts of steam-crushed whole oats and mix thoroughly to coat each kernel."

The use of traps is also discussed in the bulletin mentioned above.

7. See also: "Control of Mammals Injurious to Agriculture in Kansas." Circular No. 198, Kansas Agricultural Experiment Station.

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