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Spraying Tree Fruits

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Spraying Tree Fruits

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University of Nebraska College of Agriculture

Agricultural Experiment Station

W. W. Burr, Director Lincoln, Nebraska

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Spraying Tree Fruits

C. C. WIGGANS AND E. H. HOPPERT

THE PRODUCTION of sound, clean fruit is unquestionably one of the major problems facing the modern fruit grower. Culture may be neglected and pruning delayed for a time but the omission of sprays for even a single season demonstrates their absolute necessity. This applies equally to the commercial grower and to the farmer or gardener who has only a few trees.

Spray materials and methods have been developed because the fruit grower has been compelled either to find a remedy for his troubles or go out of business. Early in the history of the industry, sprays were not considered essential—in fact were almost unknown. However, the introduction of foreign pests and the increased damage from native ones because of the destruction of native host plants, together with the modern demand for high-quality fruits, have forced the grower to spray in order to have healthy plants and a salable product. Spraying is a fairly expensive process but one which will pay big returns if properly done. It is about the only insurance the grower has against complete failure and it is one which he cannot afford to neglect.

Spraying must be considered as a protective rather than a curative process. A worm inside the fruit or a disease spore already established will develop normally regardless of the number of sprays applied later. This means then that the protective covering must be applied ahead of infection or emergence and the application must be frequent enough to keep all parts, including new growth, well coated with the protective material.

Again, not only must the spray be timely but it also must be adapted to the particular pest or disease and to the fruit being sprayed. For example, Bordeaux mixture and concentrated lime-sulfur are effective as fungicides but cannot be used in peach spraying because of foliage injury. Arsenate of lead will protect fruits against the curculio but not against borers. Bordeaux mixture is more desirable than lime-sulfur against apple blotch, although either will control scab. And still further, certain diseases such as fire blight and blister canker and also certain insects such as the buffalo tree-hopper are not affected by any spraying treatment.

The proper spraying of the small home orchard often presents a problem to the owner because he lacks necessary equipment. Moreover, in the rush of other summer work, the job of spraying a few fruit trees is likely to be neglected. One solution for this problem is found in the formation of a community spray ring. Under this plan a number of small orchard owners combine in the purchase of a good spray outfit which is then operated in a fashion similar to that followed with a community threshing machine. Another plan calls for a single owner for the outfit, who then does custom spraying for his neighbors. Either plan is successful only in case the one doing the spraying uses the right materials at the proper time and does a thorough job.

Methods and Materials

Dust vs. liquid applications.—Nearly all spray materials may now be had in either liquid or dust form. Which one shall the Nebraska orchardist use? Spraying is a disagreeable, tedious job. Dusting is much faster and more convenient on rough ground and also eliminates spray injury. Net costs are very similar, the higher labor costs of spraying being offset by the use of larger amounts of material in dusting. One of the drawbacks to the wider use of dusts is the difficulty of securing good coverage in windy weather. Hence, dusting is frequently done at night.

The value of any spray material, however, depends upon its efficacy in controlling the particular pests or diseases for which it is used. Some preliminary experiments at Shubert, Nebraska, conducted in 1927 by the Department of Horticulture, indicate that spraying is more effective than dusting in the control of the codling moth. Although some other experiment stations have reported fair success in worm control, the satisfactory control of fungous diseases on the apple with dusts has not been secured. On the other hand, dusts are successfully used to control cherry leaf spot in the nursery, to combat peach brown rot, and to destroy plant lice.

In view of the variable results already reported, it would seem wise for the Nebraska fruit grower to continue the use of liquid applications, at least until dusting materials and methods are better developed. However, dusting might prove to be very profitable as a supplement to spraying in very rainy seasons when it is difficult or impossible to apply sprays.

Arsenate of lead.—This is the most commonly used and the safest arsenical for fruit trees. It is effective against chewing insects only. This material comes in powdered form and is generally used at the rate of **1½ pounds to 50 gallons of water.** In order to insure uniform suspension it is advisable to mix the poison in a small quantity of water before it is placed in the spray tank. It can be combined safely with either Bordeaux mixture or lime-sulfur.

Nicotine sulfate.—This is the commercial form of tobacco extract and is approximately 40 per cent nicotine. It is used in combating sucking insects, such as plant lice, and may be distributed either when dissolved in water or as dust when mixed with hydrated lime as a carrier. The standard liquid dilution is **1 part to 800 (½ pint in 50 gallons),** while the ordinary dust is made by mixing 1 pound of nicotine sulfate with 20 pounds of hydrated lime. This dust is 2 per cent nicotine, commonly known as 2 per cent dust.

The fumes from nicotine dust are sufficient to kill plant lice, but if the liquid is to be effective it must come in contact with the insect. Since the lice are generally found on the lower leaf surface, it is necessary to direct the spray upward in order to reach them. The liquid form is more effective and spreads better if 2 pounds of laundry soap are dissolved in each 50 gallons. Nicotine sulfate may be combined with other insecticides and with fungicides, though in this case no soap should be added.

Liquid lime-sulfur.—This is a concentrated solution of lime and sulfur in chemical combination and is available from several reliable manufacturers. It can be made satisfactorily at home, but the commercial product is much more uniform in concentration, and, in quantity, can be purchased at a reasonable price. When diluted **1 gallon of solution to 8 of water,** it is the standard remedy against scale insects, but at this strength it can be used only during the dormant season, on account of foliage injury. For summer spraying against fungous troubles the regular dilution is **1 to 1½ gallons in 50 of water,** the amount depending upon the time of application and the fruit being sprayed. It should never be used as a summer spray on peaches.

Recent experiments have definitely proved that both liquid lime-sulfur and dry lime-sulfur slow up food-making in the leaves at temperatures above 80°F. even though no burning of the foliage is visible. The safest procedure therefore is to use lime-sulfur only in the cool weather of spring, shifting to wettable sulfur as soon as the weather becomes warm. An added advantage of lime-sulfur is that it burns out scab infections in addition to preventing spores from germinating. If infections have taken place before an early spray has been applied, the safe thing to do is to use liquid lime-sulfur either alone or in combination with wettable sulfur. A mixture commonly used is **½ gallon liquid lime-sulfur and 2 pounds of wettable sulfur to 50 gallons of water.**

Dry lime-sulfur.—Lime-sulfur solution when dried and powdered is sold by a number of concerns as dry lime-sulfur. Early tests with this material did not give as satisfactory results as with the liquid form, but there has been considerable improvement in its manufacture in recent years. The home orchardist will probably find the dry form more readily obtained and more convenient to handle. The ordinary recommendations call for the use of **3 pounds to 50 gallons of water** for the summer spray and **12 pounds to 50 gallons** for the winter application. Approximately four pounds of the powder contains active ingredients equal in amount of those in one gallon of the commercial liquid.

Bordeaux mixture.—This well-known efficient fungicide is a chemical combination of copper sulfate, lime, and water. While it may be used at various strengths for specific purposes, the standard formula is 4-4-50, or

4 lbs. copper sulfate (bluestone—blue vitriol)
4 lbs. stone lime
50 gals. water

The copper sulfate is dissolved in 25 gallons of water and the lime slaked and suspended in the other 25 gallons. The solutions are then poured together into a third container or into a spray tank. Fresh hydrated lime (6 pounds) may be substituted for the stone lime, if desired.

Bordeaux mixture must be freshly made for each application and used at once since it deteriorates rapidly. Prepared Bordeaux mixtures in either paste or powdered form are not as satisfactory as the fresh home-made product. Copper sulfate should be handled in wooden or earthenware con-

tainers and all working parts of the sprayer in which Bordeaux mixture is used should be of brass to prevent corrosion.

In recent years a method has been developed that is much less cumbersome. A finely powdered form of copper sulfate known to the chemical trade as "snow" takes the place of the old crystalline form. This material is poured into the tank as it is being filled with water. Then as the tank fills up the mixture is agitated either by stirring it vigorously or, in the case of power outfits, by keeping the engine running. When the tank is full, sufficient hydrated lime is added to insure an excess. The mixture should be agitated for a period of about five minutes before the spraying begins.

The use of Bordeaux mixture in the early summer sprays will cause russeting on apples if the weather is cool and damp. On the other hand, for the control of late summer diseases, such as apple blotch and black rot, it is more effective and less dangerous than lime-sulfur.

Dry-mix sulfur lime.—This spray mixture was originated at the New Jersey Experiment Station and is recommended to replace self-boiled lime-sulfur for use on peaches. It is simply a mechanical mixture of sulfur and lime. The formula by weight is as follows:

8 lbs. superfine sulfur
4 lbs. hydrated lime
½ lb. calcium caseinate

The materials are screened and then thoroughly mixed. The mixture may be stored indefinitely if kept dry. **Twelve and one-half pounds of the dry mix is sufficient for 50 gallons of spray.**

Wettable sulfur.—Wettable sulfur is simply finely divided sulfur compounded with a wetting agent to make it mix readily in water. It is a mild fungicide, suitable for controlling such diseases as brown rot of peaches, plums, and cherries, black rot of apples, and mild outbreaks of scab on apples. It also controls red spider. It is not dependable in seasons extremely favorable for scab. Neither does its use guarantee absence of sulfur burn though it is safer than either liquid or dry sulfur. In hot humid weather wettable sulfurs can produce russeting of the fruit. The usual proportions are **2 to 4 pounds to 50 gallons of water.**

Oil sprays.—Various oil mixtures, home-made and commercial, have been used effectively during the dormant season against scale insects and aphids and, during the growing season, against red spiders. The Nebraska grower is seldom interested in these sprays because of the relative scarcity of dangerous scale insects in this state.

Recently, however, certan proprietary brands of oil have been recommended for summer use on apples as ovicides or egg-killing agents. **One gallon of oil to 100 gallons of spray** is usually recommended, but it can be combined successfully with few materials, aside from arsenate of lead. In hot dry weather there is some danger of burning the leaves and hence the quantity suggested above should not be increased. The value of these mixtures as ovicides may be questioned but they do serve as spreaders

for arsenate of lead. They probably should not be employed in late summer sprays because they tend to interfere with the proper coloration of red varieties and also because they increase the amount of spray residue left at harvest time.

Spreaders.—In addition to the oils mentioned above, other materials may also be used as spreaders. These agents all tend to distribute the spray as a thin film over the entire surface rather than as distinct drops. Soap will accomplish this purpose, though commercially the calcium caseinate compound is generally used. The latter is sold under the trade names Kayso, Spreado, etc., and is used at the rate of **½ pound to 100 gallons of spray.** It can be used safely in any combination spray.

Spreaders also tend to make spray material—especially lead arsenate—stick more tenaciously. The recent agitation against the presence of excessive arsenical residues on ripe fruit indicates that it may be unwise to use spreaders, especially oils, late in the season. The commercial grower will do well to keep himself informed as to the amount of arsenical residue tolerated on interstate shipments of apples.

Quantity of material needed.—The quantity of material needed for a single tree depends upon its size and the number and thoroughness of the applications. Assuming that four sprays are given, an average-sized 20-year-old apple tree will require 20 to 25 gallons for the season. Multiplying this amount by the total number of trees of similar size will give the total amount of diluted spray needed. From this figure the number of pounds or gallons of spray materials to order can be computed. The spray schedules given later indicate the materials recommended and the number of applications advisable for the various fruits.

Table of Dilutions

The table given herewith indicates the amounts of the various materials needed to make up small quantities of spray at the dilutions given.

MATERIAL AND STRENGTH	AMOUNT OF MATERIAL NEEDED FOR—			
	1 gal.	3 gals.	10 gals.	50 gals.
Lead arsenate—				
1 lb. to 50 gals	1 T.	3 T.	3⅕ oz.	1 lb.
1½ lbs. to 50 gals	1½ T.	4½ T.	4⅘ oz.	1½ lbs.
Liquid lime-sulfur—				
1 gal. to 50 gals	3 fl. oz.	⅔ pt.	⅘ qt.	1 gal.
1½ gals. to 50 gals	4 fl. oz.	1 pt.	1⅕ qt.	1½ gals.
1 gal. to 8 (dormant)	1 pt.	3 pts.	1⅛ gal.	5½ gals.
Dry lime-sulfur—				
3 lbs. to 50 gals	1 oz.	3 oz.	10 oz.	3 lbs.
4 lbs. to 50 gals	1 oz.	3⅓ oz.	11 oz.	4 lbs.
12 lbs. to 50 (dormant)	3 oz.	10 oz.	4¼ lbs.	12 lbs.
Bordeaux mixture 4-4-50—				
Copper sulfate	1 oz.	3⅓ oz.	10 oz.	4 lbs.
Stone lime [1]	1 oz.	3⅓ oz.	10 oz.	4 lbs.
Nicotine sulfate—				
1 part in 800	1 tsp.	1 T.	3⅓ T.	½ pt.

[1] Fresh hydrated lime may be substituted by increasing the quantity one-half.

Spraying Equipment

A spraying outfit consists essentially of a pump, hose, cut-off, rod, and nozzle. Nearly all types of pumps are equipped with an air chamber to provide a more steady pressure, and the larger ones also have an agitator to keep the spray materials in uniform suspension.

There are many types of such outfits, and one can be found to fit almost any need. Several of the more common ones are described briefly below. In the selection of an outfit, among the features to be considered are its ability to deliver the needed quantity of material at a satisfactory pressure, and also its durability.

Small capacity outfits.—In this classification are included all atomizers, bucket pumps, and knapsack sprayers. Their capacity is limited and they are not well adapted to the spraying of large fruit trees. The bucket pump, however, can be used with a fair degree of success where only a few trees are to be sprayed. It should be equipped with at least 15 feet of hose and an extension rod so that the top of the tree can be properly sprayed without using a ladder or climbing the tree. The rod may be the ordinary bamboo type or even a quarter-inch gas pipe properly threaded. A cut-off between the hose and rod is very convenient. The best nozzle for general use is one of the 45-degree disk type. The angle between the rod and the nozzle enables the operator quickly and easily to change the direction of the spray so that all parts of the tree and fruit can be reached. If the angle nozzle is not available, the same results may be secured by using a straight nozzle and a 45-degree elbow or by bending an iron extension rod.

Barrel outfits.—The greater capacities and higher pressures of these outfits make them more suitable for farm orchard use. They may be had with either single or double action pumps—the latter type being suitable for use in orchards of 250 trees or less. Such outfits may also be used by small spray rings. They should be mounted on skids or they may be placed on a wagon. All accessories named for the smaller outfits should be included and the hose should be at least 25 feet long.

Power outfits.—A power sprayer is an essential part of the orchard equipment of a commercial grower. A large spray ring will also find its use advisable. A gas engine furnishes the power and a multiple-cylinder pump delivers a large amount of spray material at a uniform, high pressure. Two or more 50-foot leads of high pressure hose are employed and the rod and nozzle may be replaced with the spray gun. They vary greatly in size, capacity, and cost.

Rods, spray guns, and brooms.—In recent years an appliance known as the spray gun has come into general use with power sprayers. It replaces the spray rod, nozzle, and cut-off and is so constructed that either a fine or a coarse spray may be had at the will of the operator. Considerable controversy has arisen as to the relative values of the two types of equipment. A careful operator can do good work with either, but the average operator will possibly be somewhat more efficient with the rod.

The gun is somewhat wasteful of material but the saving in time offsets this undesirable feature. Because of its large capacity the gun can be used only on outfits maintaining high pressure.

Unless the operator is willing to regulate the gun according to the distance from the part being sprayed, considerable damage to the fruit or foliage may result. For close spraying the fine mist should be used, while the top of the tree can be reached only with the coarse spray. With heavy use, the opening in the disk of the spray gun becomes enlarged, thus increasing the amount of material passing through and also the coarseness. Hence this disk should be replaced whenever necessary.

Even more recent than the spray gun is the so-called "broom." The broom is a short rod with a short cross arm to which are attached from three to six large disk nozzles. This type of spray rod is rapidly replacing all other forms of appliances for putting on spray materials with power machines. It breaks up the material into a fine mist which carries a good deal farther than the mist produced by a spray gun or old-fashioned spray rod. If the trees are very tall either a section of pipe is added or the tops of the trees are sprayed from the top of the spray tank or from a tower built on the spray outfit.

Dusters.—Outfits for the application of spray dusts are also available in both hand and power types. With these the spray materials are distributed by being slowly fed into a stream of air generated by a fan. It is doubtful that anything except a power duster should be considered for use with tree fruits.

Spraying Management

The right material and the proper equipment for applying it by no means insure satisfaction in spraying results. Timeliness of applications and thoroughness of coverage are of prime consideration.

Timing the sprays.—Unless the material is on the tree before the infection or infestation occurs, its value is likely to be small. On the other hand, if it is applied too soon, new growth is entirely unprotected or rains may wash off the greater portion of all materials on the tree. Proper timing is therefore of great importance.

Through the years that spraying has been in general use, the so-called spray schedules have developed. In accordance with such programs, sprays are applied to the various fruits at rather definite stages of development. For average seasons such schedules are quite satisfactory. Frequently, however, failures to control the codling moth, or some other pest, have been encountered and are explainable largely as due to weather variations. Hence, the careful fruit grower no longer relies entirely on the old established schedules but supplements these by actual observation of emergence and by temperature records. These measures have special value in codling moth control in apples, since they enable the grower to determine very definitely when the cover sprays will be effective.

Such observations made in connection with spraying experiments at Shubert showed that moth emergence was about three weeks later in 1927 than in 1926. Thus a spray schedule adapted in 1926 would have been entirely inadequate in 1927. The only way to secure such information is through the use of observation cages or by observing moth traps.

Handling observation cages.—In late summer the larvae of the codling moth crawl down the trunk of the trees and spin their winter cocoons in some protected place. In the spring the moth emerges and lays eggs, which in turn hatch into worms that enter the fruit. The question in the mind of the fruit grower is, "At just what time are egg laying and hatching taking place?"

In order to determine this, some larvae—50 to 100 in number—should be collected in April and placed in an observation cage. (Collection of larvae may be greatly simplified if a few trees are banded in August, since many of the descending larvae will seek protection under the burlap band.) The cage may be any sort of container which will keep the moths from escaping and at the same time permit them to be watched. A fruit jar with some holes in the zinc lid or a tight wooden box with a fine screen cover will serve nicely. Some small pieces of corrugated packing board placed in the cage furnish excellent places for pupation.

The cage is then placed under as nearly orchard conditions as possible—in fact it is often placed in a more or less shady place in the orchard itself. Daily observations of moth emergence are made. The appearance of moths within the cage—usually about the time the calyx spray is applied—means that moths are also flying in the orchard. The emergence period may be prolonged for a considerable time, depending upon weather conditions, and it is not uncommon to find the late moths of the first brood appearing along with the early ones of the second.

Life cycle studies of this insect have shown that egg laying normally begins about three days after moth emergence and that these eggs hatch six to eight days later. Observations have also shown that egg laying occurs mainly in the evening but does not take place if the temperature at 8 P. M. is less than 60°F. Therefore, in a cool season emergence is delayed, and along with it the egg-laying period. On the other hand, unduly high temperatures hasten both phenomena. Hence, it is only by keeping observation cages and temperature records that the orchardist may know about such occurrences and judge the proper time for cover spray operations.

Similar records of emergence for the second brood may be obtained by collecting wormy apples in early summer and placing them in a similar cage. Here, however, temperature records are not as important. Normally these moths will emerge in early July. Such observations indicate when the later cover sprays will be most valuable.

Moth traps.—A more convenient method of determining when the moths are emerging is to place a moth trap in each of several trees immediately after the petals have fallen. An easy way to make such a trap is to place a quart of water, a cupful of cheap cane molasses, and a small

piece of yeast in a gallon pail. A heavy cord about 30 feet long is attached to the pail. A screw eye is fastened to the underside of a large horizontal limb in the top of a large apple tree and the cord run through the screw eye. The pail is then pulled up till the handle touches the screw eye and

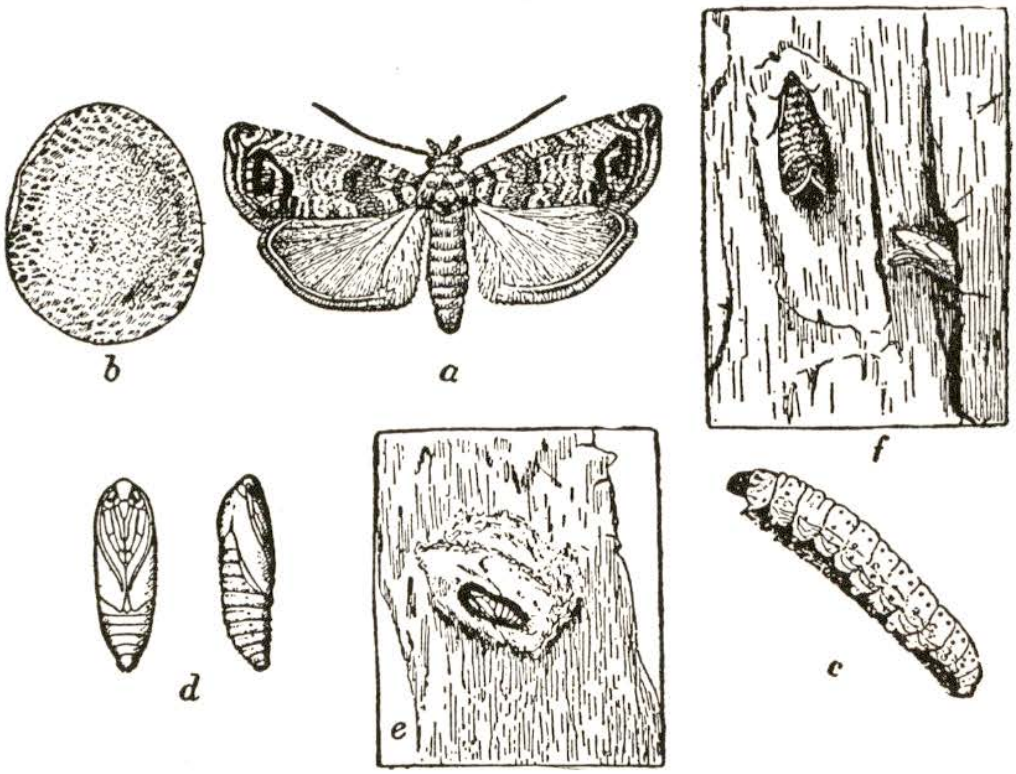

FIG. 1.—The codling moth; *a*, adult moth; *b*, magnified egg; *c*, full grown larva; *d*, pupa; *e*, pupa in cocoon, reduced one-half; *f*, moth on bark, natural size. (From Simpson, Farmers' Bulletin No. 171, p. 6.)

the cord is tied securely to a low limb of the tree. The fermenting syrup solution attracts the moths and they fall into the liquid and drown. Unfortunately many other moths besides the codling moth are attracted by this bait. Very few are as small as the codling moth, however. Figure 1 in this circular gives a good idea of the appearance of this insect; but unless the orchard owner is well acquainted with the moth he may not be able to positively identify the insect after it has been caught in the trap. It would be well therefore to find several larvae and put them in a covered fruit jar in the house until they hatch out into moths. When two or three moths are caught on consecutive days in each trap, and the temperature is 60°F. or above at dusk, the female moths will begin to lay eggs and then the first cover spray should be applied.

Thoroughness.—Too much emphasis cannot be placed upon the necessity of doing a good job of spraying. All parts of the fruit and foliage and even of the branches and trunk of the tree should be reached or complete protection is not secured. Spraying time is no time to get in a

hurry. Too often the grower is content to cover only the outer parts of the tree, forgetting that the central portions must also receive attention. It is especially important in the control of the codling moth that the top of the tree be thoroughly sprayed since here is where the greater share of the eggs are deposited. Hence, the use of a tower on the sprayer in mature orchards may be almost a matter of necessity.

In the hands of careless operators, the high pressures and large capacities of the modern spray gun have not increased the thoroughness of spraying. A coarse spray resulting from worn disks often leads the man manipulating the gun to think that the job is finished before it really is.

Number of applications.—The number of applications required depends upon the season and the fruit under consideration. Also, the commercial grower will use a larger number than the home orchard owner because of the greater necessity of keeping his fruit clean. Then, too, one season may develop pests not present in damaging numbers the previous year. An orchard regularly sprayed will not require as many applications as a previously neglected one. Young orchards can also be kept clean with fewer sprays than older ones. The same statement would hold with respect to new orchard regions as compared with longer established districts. The spraying program is more important in years of light crops than is generally realized because of its effect in holding in check the infestation of the following year.

Spray Schedules

The spray schedules recommended for use with the various fruits in Nebraska are given herewith. These are based upon experiences of the past and ordinarily will give satisfactory control of pests and diseases which regularly occur. It is not expected, however, that they will fit all conditions in a given season or all seasons. They are simply suggestive and must be adapted to fit particular conditions.

SPRAY SCHEDULE FOR CHERRIES

NUMBER AND TIME OF APPLICATION	MATERIALS USED	PESTS AND DISEASES CONTROLLED
1. Immediately after the petals fall	Lime-sulfur (1½ gals. liquid or 4 lbs. dry) Lead arsenate 1½ lbs. Water 50 gals.	Curculio Leaf spot Brown rot
2. 10-14 days later	Same as above	Same as above
3. 10-14 days after No. 2	Same as above but omit lead arsenate	Same as above
4. After fruit is harvested. Necessary only if leaf spot is troublesome	Bordeaux 2-3-50	Leaf spot

SPRAY SCHEDULE FOR APPLES AND PEARS

NUMBER, NAME, AND TIME OF APPLICATION	MATERIALS TO USE	PESTS AND DISEASES CONTROLLED
1. Cluster bud—2 to 6 days before flower opens	Lime-sulfur (1¼ gals. liquid or 4 lbs. dry) Lead arsenate 1½ lbs. Water 50 gals.	Scab Curculio Leaf-eating insects Blackrot
2. Calyx spray — immediately after petals fall	Lime-sulfur (1 gal. liquid or 3 lbs. dry) Water 50 gals.	Same as above Codling moth
3. 1st cover spray — varies with season — normally about 10 days after calyx application	Lime-sulfur (1 gal. liquid or 3 lbs. dry) Lead arsenate 1½ lbs. Water 50 gals. Spreader (if desired) ½ lb.	Same as above Blotch Sooty blotch
4. 2nd cover spray—2 weeks later	Bordeaux 1½-3-50 Lead arsenate 1½ lbs.	Same as above
5. 2nd-brood cover spray—normally early in July	Same as above	Same as above Green fruit worm
6. 2nd cover spray—2 weeks later	Same as above	Same as above

For home orchards, applications Nos. 1, 2, 3, and 5 are most important.

In bad codling moth years a third cover spray two weeks after the second may be necessary. Where blotch is severe, Bordeaux 2-3-50 should be substituted for lime-sulfur in the third and subsequent sprays. If scale infection is present, lime-sulfur 1 to 8 should be applied just before the leaf buds open.

In orchards where several varieties are found, the calyx spray is timed for the late-blooming sorts rather than the early bloomers. This application may be applied effectively for a period of 8 or 10 days. Never spray when trees are in full bloom because of the injury done to honey bees.

SPRAY SCHEDULE FOR PLUMS

NUMBER AND TIME OF APPLICATION	MATERIALS USED	PESTS AND DISEASES CONTROLLED
1. Immediately after the shucks or husks have dropped	Lime-sulfur (1½ gals. liquid or 4 lbs. dry) Lead arsenate 1½ lbs. Water 50 gals.	Curculio Brown rot
2. About 3 weeks later	Same as above	Same as above
3. About middle of July	Wettable sulfur, 3 lbs. to 50 gals.	Brown rot

If plum pocket infection was bad the preceding season, lime-sulfur 1½ to 50, or Bordeaux 4-4-50, should be applied just before the flower buds open.

SPRAY SCHEDULE FOR PEACHES

NUMBER AND TIME OF APPLICATION	MATERIALS USED	PESTS AND DISEASES CONTROLLED
1. Immediately after the shucks or husks fall	Lead arsenate 1 lb. Stone lime 3 lbs. Water 50 gals. If brown rot is present add 3 lbs. wettable sulfur	Curculio Brown rot
2. About 2 weeks later	Same as above	Curculio Brown rot Scab

If peach leaf curl was present the preceding year, a special spray of 5-5-50 Bordeaux or 2½ to 3 gallons of lime-sulfur to 50 gallons of water should be applied just before the buds swell.

Commercial peach growers should investigate zinc lime sprays to lessen damage to buds and twigs from lead arsenate.

Insect Pests[1]

Aphids.—Aphids or plant lice are present almost everywhere and in some form are found attacking the various fruits. These pests suck juice from the plant parts, thus making the leaves and fruits misshapen and hard to cover with spray material. These insects multiply very rapidly and hence incomplete control measures soon mean a new infestation. Aphids on the plum are very common, although as a matter of fact certain species which live on the roots of tree fruits may be of more serious economic importance.

Seldom do these pests demand special attention, but where they are present in damaging numbers they can be controlled by spraying with **nicotine sulfate, ½ pint to 50 gallons of spray.** This substance may be applied along with the other spray materials. Each individual insect must be hit with the spray or it will not be destroyed.

When aphids alone are present, the use of nicotine dust is also satisfactory.

Codling moth.—This is undoubtedly the worst pest with which the Nebraska apple grower must deal and in recent years the orthodox control measures have not been working well. The small grayish-brown moths emerge from the overwintering cocoon about apple blossoming time, and about 10 or 12 days later the tiny worm starts into the apple. Dry warm weather hastens both moth emergence and egg hatching, while cool weather delays these processes. After about three weeks of burrowing around the core of the fruit, the full grown worm, one-half to two-thirds of an inch long, emerges and spins a cocoon in some protected place on the tree trunk.

[1] The following brief descriptions of the more common orchard diseases and insect pests are given so that the grower may learn to recognize the various orchard enemies. The list is by no means complete, but in controlling the troubles here discussed the orchardist will likewise control most of the others. A few pests and diseases are included for which there is no specific spray remedy, but other means of control are suggested in such instances.

The second-brood moths appear from these cocoons in early July and a second life cycle, similar to the first, is then begun. A partial third brood may appear in hot dry seasons. The larvae of the second and possible third broods are the ones which overwinter in cocoons and produce the spring brood the following year.

Emergence data show that the various broods overlap somewhat—the stragglers of one group appearing with the early ones of the next. This means that worms are present in greater or lesser numbers from late May until harvest time. Since the worm stage does all of the damage, control measures are directed largely toward the destruction of the worms although sanitation will also destroy appreciable numbers of pupae and some adult moths may be trapped. *The control of the first-brood worms is of special importance.*

The use of **lead arsenate, 1½ pounds to 50 gallons of water,** offers probably the best means of controlling this pest. The calyx spray, the first and second cover sprays, and the early July sprays are of special importance. A severe infestation may call for additional applications at two-week intervals.

Adult moths may be trapped in considerable numbers during the season of heavy flight. Moth traps made of shallow pans baited with freshly fermented cider are placed in the tops of trees about the time of the first moth emergence. Moths are attracted in considerable numbers and are drowned in the cider. The bait should be renewed daily. This also helps in supplying information as to when sprays should be applied.

Still another method of some value in helping control codling moth consists in the destruction of the larvae. The prompt removal and the disposal of all culls take many worms so far away from the orchard that the adult moths cannot return. Also, a clean-up campaign in and near the packing shed will destroy many overwintering larvae. Extra sprays or extra heavy dosages near the packing sheds may also be advisable.

Banding trees.—Chemically treated bands are being used with success in some apple sections where the codling moth has proved difficult to control with sprays. These bands are applied to the trunks of the trees in June about two feet from the ground and after the rough bark has been scraped off. They consist of corrugated strips of paper two or three inches wide which have been soaked in chemicals which will kill the moths that hide under or in them. In the experimental orchard at Lincoln some of these treated bands killed almost 100 per cent of the larvae that tried to overwinter under them. Chemically treated bands may be bought or the materials may be bought and bands made up at home.

The bands should be made of one-faced corrugated cardboard, four inches wide with four or five corrugations per inch. The two chemicals that have proved most effective are alpha-naphthol-oil-parawax, and beta-naphthol-oil.

The following materials are needed for the treatment of 50 bands:

Alpha-naphthylamine, 1 pound
Paraffin oil, 1½ pints
Parawax, 1 cake

These materials should be put in a small tub over a hot fire. Soon after the alpha-naphthylamine has melted, small yellow bubbles begin to form on the surface and then the rolls of corrugated paper may be dipped in the mixture. If sufficiently hot the mixture will foam up through the paper. When the foam has spread out over the entire surface the roll should be raised and allowed to drain. It should be laid aside where it can be turned over every minute or two to keep the material from running out of the bands during the cooling process.

The chemicals used will burn and the fumes are dangerous. Therefore the work should be done outdoors. Moreover, they will injure the skin; therefore gloves should be worn while handling the bands. To facilitate handling the rolls of corrugated paper a heavy cord is tied to each side of the roll.

Beta-naphthol-oil may be used in place of the alpha-naphthylamine. It is a little cheaper but is also slightly less effective in killing the larvae. The beta-naphthol-oil bands are made as described above with the exception that the parawax is omitted from the formula.

In applying the bands the corrugations are placed next to the tree, and care must be used to make them fit snugly against the trunk. Large-headed carpet tacks are used to hold the bands in place. A magnetized tack hammer will be found very practical to facilitate handling the tacks with gloved hands.

Curculio.—Two snout beetles, the plum curculio and the apple curculio, do considerable damage to fruits. The plum curculio is by far the more important and does great damage to plums, cherries, peaches, and apples, but the apple curculio confines its activities almost entirely to the apple. The apple curculio is found now only along the southern border of the state but in time it may become a rather serious pest to apple growers.

These beetles pass the winter as adults, hibernating in rubbish about the orchard. They appear in early spring, soon after the blooming period, and begin feeding upon the young fruits. The crescent-shaped punctures made for egg-laying purposes also soon appear. The egg hatches in a few days, and the larvae begin to burrow about in the fruit. Infested apples generally drop, or if they remain on the tree, develop into misshapen, lop-sided culls. On the other hand, attacked stone fruits usually remain on the tree but at harvest time are found to be wormy. The plum curculio grub pupates in the ground and emerges as an adult of the next generation in July. It is at this time that the main damage to the apple occurs. In addition to the damage already noted, the curculio punctures also serve as entrance points for disease spores and the larvae of other insects.

Lead arsenate, 1½ pounds to 50 gallons of water, offers a means of partially, but not entirely, controlling these pests. The apple curculio is

apparently somewhat harder to handle than the other species. Spraying in either case should be supplemented by clean culture and general orchard sanitation so that winter quarters for the adults are not readily found. The destruction of adjacent wild plum thickets is also of value and the disposal of fallen fruits is recommended. One Iowa grower has reported that pasturing hogs in his apple orchard has practically eliminated apple curculio injury. Spray applications should be made just after the shucks or husks drop off of stone fruits and again about three weeks later. The cover sprays are the effective ones in the case of the apple.

Leaf-eating insects.—The caterpillar or larval stage of various insects, such as tent-caterpillar, cankerworm, etc., lives upon the foliage of various fruit trees. Many of these appear in colonies but seldom is the infestation general enough to be serious.

Arsenate of lead, 1½ pounds to 50 gallons of water, will control these pests. Generally, in an orchard that is regularly sprayed, they require no consideration, since the arsenicals in the regular sprays hold them in check. In young orchards, however, it is sometimes necessary to make a special application to care for the situation. Control measures must be prompt or the tree will be defoliated. Individual colonies may be destroyed, either by removal of the branch or by the use of a torch.

Scale insects.—Certain sucking insects known as scale insects protect themselves through the formation of a downy or waxen scaly covering, and hence must be controlled through the use of a caustic or penetrating spray. Fortunately for the Nebraska orchardist, scale insects are seldom of importance in this state. The oyster-shell scale—so called because of the shape of the mature insect—is perhaps most common.

These insects, regardless of the particular species, are controlled by using either **concentrated lime-sulfur, 1 gallon to 8 of water, or an oil spray.** The application must be made during the dormant season. Just before growth begins is probably the most effective period. All parts of the tree, especially the younger portions, must be thoroughly drenched or the application will not be effective. In cases of light infestation, annual applications may not be necessary.

Borers.—Certain types of insects, instead of devouring portions of the foliage or fruit, burrow their way under the bark or into the wood of the tree. The peach-tree borer is the most serious of these, although frequently apples may also be damaged considerably by other species. They remain in the tree trunk for varying periods of time, weakening or killing the tree through partial or complete girdling.

Sprays are of no value in the control of these pests. They must be either dug out by hand or killed through the use of fumigating agents. **Paradichlorobenzine, ¾ to 1 ounce** per tree, can be effectively used on peaches to control the peach-tree borer, but only in case the tree is five years of age or older. This material is placed in a ring about 2 inches from the tree about October 1 and covered with 2 or 3 inches of soil. All younger trees must be wormed by hand.

An emulsion of ethylene dichloride has also been found to be effective in borer control and may be used safely on both young and old trees. It is available in a 50 per cent stock solution to be diluted with from 1 to 6 parts of water according to the age of the tree. Dosage is from ⅛ to ½ pint of the diluted solution. It is applied evenly to loose soil around the tree and some should be sprayed on the lower part of the trunk. A few shovelfuls of soil are then placed about the trunk to prevent dissipation of the killing fumes. Treatment is given in the fall, preferably in October.

Borers that are working in the trunk above ground or in the larger branches may be killed by applying a paint made by dissolving one pound of the paradichlorobenzine (also known as P. D. B.) in two quarts of cottonseed oil.

Buffalo tree-hopper.—This insect, in common with several others, deposits its eggs in the small twigs of an apple tree and thus weakens the twig. It does no other damage.

Since this pest when young feeds upon weeds and grasses, control measures consist in keeping the orchard clean, especially when the trees are young. Even in cases of non-cultivated orchards, the damage can be materially lessened by frequent mowing of the weeds or grass.

Orchard Diseases

Apple blotch.—This fungous trouble does considerable damage in certain seasons, especially to such varieties as Northwestern, Duchess, Missouri, and Ben Davis. It affects fruits, twigs, and leaves. An irregular star-shaped splotch appears on the fruit surface in midsummer and becomes darker as it gets older. Infected fruits often become misshapen. Small black pimples containing spores develop on them. Such spores are largely responsible for the later or secondary infections. Twig infection occurs on new growth as a canker with roughened bark. This canker encircles the twig and later gives off spores to cause the fruit and leaf infections. Spore formation may continue in such cankers for several years. Leaf infection often occurs in the petiole which in turn causes twig infection at the node.

Bordeaux 4-4-50 is more effective in the control of blotch than lime-sulfur. Lime-sulfur is satisfactory in mild cases, but it must be used cautiously in hot weather. Protective measures against this disease are combined with the codling moth cover sprays—that is, they are applied two to three weeks after petal fall and two weeks later. Later applications at intervals of two weeks may also be necessary although as a rule blotch in Nebraska is not severe enough to justify more than one additional spray.

Pruning off the cankered portions during the dormant season is a very important means of control and should be employed whenever feasible.

Apple scab.—This disease is found on the fruit and leaves, causing the characteristic grayish scab spots on the fruit and the light brown areas on the leaves. Affected fruits often become dwarfed and cracked and may even drop. Leaves drop prematurely and thus weaken the tree.

The disease passes the winter on dead fallen leaves. Early in the spring spores are produced in enormous numbers and are distributed by the wind to young leaves, blossom buds, blossoms, and young fruits. A relatively small number of infections on old leaves are capable of causing widespread infection the following spring if environmental conditions are just right. Cold wet seasons are very favorable for scab development.

A crop of summer spores from these early infections produces the "late-scab" on fruit and leaves. Infections rarely occur after warm weather begins.

Scab is essentially an early summer disease. The control of the early infections means almost complete absence of disease later. **Bordeaux mixture or lime-sulfur at the usual strengths** are effective control agents, but lime-sulfur is to be preferred in the fore part of the season. Ordinarily three spray applications are sufficient—the first being applied just before bloom, the second just after petal fall, and the third two to three weeks later. A July application may also be of value when late scab is prevalent and even a fifth application in August may be advisable for susceptible varieties at such times. Varieties vary widely in their susceptibility to this trouble, the Delicious and Winesap being quite susceptible, the Jonathan moderately resistant, and the Grimes quite resistant.

Sooty blotch and flyspeck.—In low places and in damp seasons, apples, especially the uncolored varieties, may develop a flyspecked or even a clouded appearance. The blotches appear in midsummer. The damage is only superficial but the appearance of the fruit is greatly marred.

Lime-sulfur or **Bordeaux mixture** when used in the scab and blotch sprays will also keep this trouble under control.

Black rot and frogeye leaf spot.—Black rot attacks the branches, fruit, and leaves of the apple tree. It is also found on other fruit trees and even on forest trees like ash, linden, maple, and oak. The disease has become established in most of the orchards in southeastern Nebraska and therefore must be reckoned with in arranging spray schedules.

Black rot enters the bark of fruit trees, particularly apple trees, through wounds of various kinds or through bark that has been killed by fire blight or injured by low temperatures. The fungus spreads slowly into the healthy bark, the diseased parts becoming darkened and sunken. Each year a new area is attacked, there being a distinct crack between the infection of one year and that of the next. Finally the infected limb is girdled and dies. Fruit infections are occasionally found in Nebraska orchards. The most common form of fruit infection is blossom-end rot. Infections may also enter the fruit through wounds made by hail or by insects. As the season advances the spots enlarge and finally the fruit shrivels into a black mummy which may hang on the tree all winter.

Leaf spot, or frogeye, as it is usually called, is the most conspicuous and by far the most injurious form of black rot infection found in Nebraska orchards. The overwintering mummies and cankers produce spores which are disseminated by winds and rain throughout the growing season. The

spores that come to rest on apple leaves quickly germinate when the leaves are moist and grow into the leaf tissues. Within ten days following the infection, small purplish spots appear. As these spots develop the center becomes gray, presenting the peculiar appearance which has given rise to the name "frogeye." On some varieties, notably Jonathan, the infected leaves may turn yellow and drop prematurely.

During the pruning season badly cankered limbs should be removed and destroyed. If the cankered area is small and the limb valuable, the diseased bark is trimmed off and burned. All wounds made in this way and all other pruning wounds over an inch in diameter should be covered with good tree paint. Asphalt and coal-tar paints are good as well as cheap.

No special early sprays need be applied to the trees where the cluster bud and petal-fall applications are made for scab. However, as the season advances and the weather becomes hot, scab is no longer feared and furthermore there is danger of russeting the fruit with sulfur sprays. For this reason some growers omit the fungicide entirely following the first cover spray. But this practice is dangerous where black rot is as well established as it now is in the counties along the Missouri river. There are several courses that may be followed for the first cover spray and other summer sprays.

1. If the temperature is below 80°F., **liquid lime-sulfur** may be used with safety at the rate of **1 gallon to 50 gallons of spray mixture.** Three or four pounds of dry lime-sulfur may be substituted for the liquid lime-sulfur.

2. If the temperature is above 80°F., **Bordeaux mixture 1½-3-50** is the safest material to use. If blotch is also to be controlled, the Bordeaux should be increased in strength to 2-4-50. Bordeaux is generally conceded to be more effective for the control of blotch and frogeye than are the sulfur compounds.

3. Wettable sulfurs sold under various trade names are sometimes used in the summer sprays.

Blister canker.—This disease has killed great numbers of apple trees in Nebraska, especially of the Ben Davis and Gano varieties. The disease is distinctly a heartwood parasite and may be working internally long before it can be seen on the surface, usually of the larger branches and trunk. In the earliest visible stages the bark takes on a dark brown color and is depressed slightly below the healthy portion. This canker, usually centering around a wound, increases in size, principally in a longitudinal direction. In these cankered areas or at the edge of old cankers, small blister-like protuberances are formed in the late summer. Later spores are liberated from these areas.

As the cankers increase in age, these protuberances develop into the characteristic "nail head" stage. Here also spores are produced which serve to infect wounds on the same or adjacent trees. The infection may grow for from one to many years before it shows up on the surface, the in-

terval depending upon the variety and vigor of the tree. The branch or the entire tree dies whenever the canker girdles that portion.

Spraying will not control this disease. Orchard management designed to keep canker out of the planting is the most effective means of combating it. Among the measures to be considered in this connection are: First, avoid the susceptible varieties. Second, keep the trees in a vigorous growing condition by spraying and cultivation. Third, prune carefully, avoiding large wounds as much as possible. Disinfection of pruning tools used on cankered areas is also worth while. Trees with canker in the heartwood should never be pruned heavily. Pruning-wounds on cankered trees should be covered with either a pruning compound or an asphalt paint to retard girdling as long as possible. Fourth, prevent the spread of infection by removing and destroying all branches which show cankers. Cankered areas on the trunk may be shaved away or covered with asphaltum. An affected tree is doomed but may produce several profitable crops before it finally dies. Fifth, spray well the trunk and larger branches in early summer so as to kill any spores which may be exposed on pruning wounds and old cankers.

Cedar rust.—This disease is found quite commonly wherever the red cedar grows. It passes two winters and one summer on the cedar in the form of "cedar apples" and then passes to the apple or a related species. There is no infection from cedar to cedar or apple to apple.

Long, yellow, jelly-like projections are sent out from the galls on the cedar during rainy periods in early spring. These produce millions of dust-like spores which may be carried even three or four miles by the wind. They germinate on the leaves and fruit of the summer host, producing orange-colored spots. Infections on the leaves may be so numerous as to lessen leaf efficiency materially. The infections on the fruit are usually near the calyx end. From the apple, in due course of time, spores are carried back and reinfect the cedar.

Spraying is not considered a practical means of controlling cedar rust, although sprays applied according to the regular schedule may be of some value. The destruction of cedar trees or the removal of the galls before the spores are distributed presents the only absolutely effective means of dealing with this trouble. Certain varieties, such as Jonathan, Wealthy, York, Golden Delicious, and most of the crabs, are much more susceptible than the Winesap and Delicious. Where cedars are too abundant or too valuable to be cut out, the very susceptible apple varieties should not be planted.

Fire blight.—This bacterial disease attacks the blossoms, leaves, and woody parts of various species. The damage is often quite severe in the case of the pear; and a few varieties of apples, such as Yellow Transparent and Jonathan, are sometimes seriously injured. Ordinarily it is confined to the blossoms, fruit spurs and young twigs of the apple but winter or "hold over" cankers on the trunk are sometimes found. Whenever any part of the tree becomes girdled the portion beyond the girdle dies. This girdling frequently occurs on the trunk of the pear and thus the whole

tree is lost. Fire blight is also responsible for the "collar blight" and "root blight" sometimes found.

The bacteria gain entrance to the host either through blossom tissue or through wounds on the twigs or leaves. Infection is carried to the blossoms largely by insects. Other agencies, such as wind-blown rain, are also partially responsible for the spread of this disease. From the initial infection the disease progresses down the spur or twig and usually forms a canker on the larger branch. This canker frequently serves as a "hold over" canker, thus allowing for infection the following year. Fire blight is easily recognized by the browning or blackening of the leaves and bark. The leaves also are very persistent. Blighted pear trees often show premature autumn coloration of the foliage.

Because this infection is found only in the cortex of the plant no spray program will control it. Removal of sources of infection during the dormant season offers the only effective way of combating it. Hold-over cankers should be located and destroyed and all blighted twigs and small branches removed. Also, all fruit spurs and water sprouts coming directly from the trunk or main branches should be cut off. This is especially desirable in the case of the pear. Very vigorous trees are more likely to become blighted than those making a slower, better matured growth. Hence, pear trees are usually grown in sod and often in relatively poor soil.

Plum pockets.—Elongated, swollen fruits are frequently found on plum trees in early summer. These are hollow and contain only a partially developed seed. The life history of this disease is not definitely known but its presence in or on the plant in early spring has been established.

Lime-sulfur, 1½ gallons to 50 gallons of water or **standard Bordeaux** will control this disease if it is applied just before the blossoms open. Diseased twigs should also be removed and destroyed.

Brown rot.—This disease is responsible for the rapid rotting of peaches, plums, apricots, and even cherries, just before or after they ripen. A small, circular, grayish-brown decayed area, usually at an insect puncture, appears and rapidly enlarges until the whole fruit is involved. Hot, damp weather is very favorable for its spread. Affected fruits may either drop or dry up and hang on the tree until spring. From these come the spores for the next year's infection.

Lime-sulfur, 1½ gallons to 50 gallons of water, can be successfully used on cherries and plums but the **dry-mix sulfur lime, 12½ pounds to 50 gallons of water,** can be applied to peaches. **Wettable sulfur, 3 or 4 pounds to 50 gallons,** is more convenient to use and is safer in hot weather. Liquid lime-sulfur should never be used as a summer spray on peaches. In bad seasons three applications may be necessary—just after the husks drop, three weeks later, and in early July. Controlling the curculio will aid materially in lessening the loss from brown rot.

Dusting may be used successfully to control this trouble on the peach.

Cherry leaf spot.—In early summer small purplish spots appear on the upper surface of cherry leaves. These later become brown and the center

drops out, thus giving a "shot-hole" effect. The whole leaf generally turns yellow and drops prematurely. Early infections come from spores produced on old leaves but the midsummer spread is from spores produced on the living leaves. Damp, cloudy weather in mid-summer greatly increases the infection. Badly infected trees, especially of the Early Morello type, may be entirely defoliated. Young trees are affected more severely than older ones.

The most effective spray for controlling cherry leaf spot is **liquid lime-sulfur** at the rate of **1½ gallons to 50 gallons of water.** The first spray is applied just after the petals fall. A second spray of the same material is applied 10 to 14 days later and a third one 10 to 14 days after the second. Usually **1½ pounds of lead arsenate** are added for each **50 gallons** of spray to control insect pests. After the fruit is picked another spray is applied consisting of **Bordeaux mixture 2-3-50.**

Both Bordeaux and lime-sulfur have a dwarfing effect on the fruit but that caused by lime-sulfur, particularly in hot weather, is more serious because of its interference with the assimilative functions of the leaves.

Peach leaf curl.—This fungus attacks the current season's growth, doing the chief damage to the leaves. Very early the infected leaves become wrinkled and malformed, and yellow and reddish in color. They later drop off, thus forcing the tree to form a new set of leaves. The crop may also be a total or partial loss. Several such defoliations may cause the death of the tree. The disease is most severe in cool seasons and in the cooler peach-growing regions.

Since this is a very early disease, control measures should begin during the dormant season. **Lime sulfur, 2½ to 3 gallons to 50 gallons of water,** or **Bordeaux 5-5-50,** may be used satisfactorily and with safety any time before the spring growth begins.

Peach scab.—Peach fruits are often severely damaged by peach scab. This disease is also found on twigs and leaves. A portion of the peach becomes blackened and shriveled and may even crack open. Infection occurs three or four weeks after bloom.

Wettable sulfur, 3 pounds to 50 gallons of water, should be applied about two weeks after the shucks drop and at two-week intervals as the severity of the disease demands.

Dusting has been successfully used for the control of this disease in some sections.

3-28—5M; 3-32—5M; 3-35—5M; 3-40—5M.