Cherry Leaf Spot

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Cherry leaf spot, caused by the parasitic fungus *Coccomyces hiemalis*, is one of the major factors that determine the cost of producing cherries and the yield and quality of the fruit.

The disease occurs on the sour cherry, *Prunus cerasus*, sweet cherry, *P. avium*, and the mahaleb cherry, *P. mahaleb*, wherever they are grown under conditions that favor the survival of the fungus. That includes our eastern and central producing areas and the more humid areas in the West. Because it has been most serious on sour cherry in the Eastern and Central States, this discussion largely concerns the experimental work on sour cherry in those regions.

The losses are due primarily to the injury the disease does to the leaves, which become yellow and drop. Failure to control leaf spot on sour cherry, with consequent defoliation of the trees before harvest, usually results in a crop of low-quality and unattractive fruit of light-red color. The fruit often is low in soluble solids, including sugars, has a flat, watery taste, and may be unsalable. While such fruit may mean the loss of the crop for a season, that loss is sometimes less important than other losses brought about by the loss of the leaves.

Studies by W. C. Dutton and H. M. Wells, of the Michigan Agricultural Experiment Station, after the early defoliation of unsprayed trees in 1922, showed that trees that had been maturely defoliated produced fewer blossoms the following year, the flowers were poorly developed and slower in opening, fewer cherries ripened, and the cherries were smaller. Many fruit spurs died, and the crop was greatly reduced on the spurs that survived. By reducing shoot growth and spur development, the defoliation lowered the yield for several years.

Following the worst outbreak of cherry leaf spot on record in the Cumberland-Shenandoah Valley in 1945, thousands of sour cherry trees died and many others had severe injuries.

In Virginia on trees defoliated in May and June of 1945, the average weight of the buds in late summer was 90 milligrams. The buds on trees that had retained their foliage averaged 147 milligrams in weight. The smaller buds did not have enough vitality to survive the winter. All unsprayed trees died. None of the trees died in one orchard where sprays had delayed defoliation 4 weeks or more.

Heavy early defoliation in West Virginia in 1945 stimulated the production of secondary growth on 64 percent of the terminals about 2 weeks after harvest. The secondary leaves were soon lost to leaf spot, and some tertiary growth developed. Following this poor control of leaf spot, an estimated 72 percent of the branches were killed the following winter. Those trees bore almost no fruit in 1946.

Early defoliation in 1945 in Pennsylvania was followed by the death of more than 25,000 trees, besides general killing of shoots, spurs, and branches, and a light crop of poor fruit in 1946. Delay of the first leaf spot spray application until 10 to 12 days after petal fall in one orchard of about 100 acres resulted in general leaf spot infection and death of all of the trees in the orchard, worth, at that time, close to $100,000. In no case in the area did an orchard defoliated in June of 1945 escape without severe injury or death during the following winter. Where defoliation was delayed but virtually complete in July within
3 weeks after harvest, severe injury occurred, but most of the trees survived. If leaf spot was controlled until late September the trees were not injured.

In the block of young trees used for experimental spraying in Pennsylvania in 1945, about one-third of the leaves remained on unsprayed trees 1 week before harvest. The increase in trunk size of the trees during that summer was less than half as great as on trees where leaf spot was controlled. No trees died during the following winter. Killing of shoots and spurs was general on the unsprayed trees, and the bloom in 1946 was very light in comparison with adjacent sprayed trees. The 1946 crop of cherries on the trees unsprayed in 1945 remained of poor color until just before harvest. Then they darkened rapidly and unevenly and shrieveled and dried during an abnormally short harvest season. The yield in 1946 averaged 36.2 pounds to the tree; 56 percent of the cherries on the trees unsprayed in 1945 graded No. 1. Trees on which leaf spot was controlled best in 1945 had an average of 107 pounds each, 79 percent of which graded No. 1.

Those examples illustrate the fact that the losses from premature defoliation in one year by leaf spot on sour cherries may reduce quantity and quality of fruit for 2 years or more or may weaken a tree so that it cannot survive the following winter. Such severe attacks are not general: The disease usually is kept under fair control.

The losses from premature defoliation by cherry leaf spot on nursery stock of the sour cherry, sweet cherry, and Prunus mahaleb are usually caused by failure of many of the buds to grow on the weakened rootstocks and failure of the trees to grow to salable size in a year. Failure to control leaf spot on the rapidly growing seedlings of sweet cherry has been a reason why some eastern nurserymen have been reluctant to propagate sour cherry on rootstocks of sweet cherry.

Little information is available regarding losses from premature defoliation by leaf spot on sweet cherries in the orchard. Orchard trees of sweet cherry commonly are less injured by leaf spot than is the sour cherry. The effects of the disease appear to be like those on sour cherry.

The part of the losses from cherry leaf spot attributable to the cost of the control program varies greatly among the different producing areas. The cost evidently is least in some sections of California and greatest in the sections of the East that have the longest growing season. Some growers spray one or two times; others do so eight or nine times each season, besides cultivating the orchard in the spring. The total cost of the control program often exceeds 75 dollars an acre each year on sour cherries in the Cumberland Valley of south central Pennsylvania. Probably a fair estimate for the Great Lakes districts is 35 to 50 dollars. Those programs also control other diseases and insects. About one-third to two-thirds of the cost could be eliminated if leaf spot were absent.

Leaf spot normally appears on sour cherry on the upper surface of the leaf as a small interveinal spot of dying tissue of variable color. The spot rapidly enlarges, becomes brown to purple, and dies from the center outward. The spots are irregular or round and may occur over the entire surface. The individual spots never become large, but they may merge and so kill large areas of the leaf. The appearance of many spots on the leaf usually precedes rapid yellowing and dropping. The spots may separate from the healthy tissue, drop out, and make a shot-hole condition.

The appearance of the spot on the upper surface usually is accompanied or preceded by a pink mass of fungus spores on the lower surface. The mass may be more or less columnar, following its extrusion through a small hole in the leaf surface or it may be a somewhat hemispherical mass, follow-
ing weathering and drying. It may be absent or difficult to locate after a long period of dry weather or if the fungus in the lesion is killed by a fungicide.

Leaf spot infection on the fruit stems (pedicels) and fruit are unusual and often hard to identify. Such lesions are usually small and brown, without the spore masses of the fungus on them.

The symptoms of leaf spot on other species of cherry are somewhat like those on sour cherry. On sweet cherry, the spots are often larger and more nearly circular in shape than those on sour cherry. The spore masses of the fungus, particularly on sweet cherry seedlings, are often present in large numbers on the upper surface of the leaf. *Prunus mahaleb* has some tendency to show a chlorotic ring around the young lesion, and the dead spots rarely drop out. Other species like the chokecherry, *Prunus virginiana*, are more apt to show shot hole than the sour cherry.

The fungus that causes leaf spot on sour cherry and sweet cherry in the United States conforms generally with the description of *Coccomyces hiemalis*. Probably the fungus is the only common one on *Prunus mahaleb*.

B. B. Higgins, of the Cornell University Agricultural Experiment Station in New York, in 1913 and 1914 divided the various isolates or collections of *Coccomyces* that he studied into three species based on both morphologic and host-range differences: *Coccomyces hiemalis* on sweet cherry (*Prunus avium*), sour cherry (*P. cerasus*), and pin cherry (*P. pennsylvanica*); *Coccomyces prunophorae* on the plums *Prunus americana*, *P. domestica*, and *P. insititia*; and *Coccomyces lutescens* on the wild black cherry (*P. serotina*), the chokecherry (*P. virginiana*), and *Prunus mahaleb*.

G. W. Keitt in Wisconsin in 1918 published the results of more than 1,000 cross-inoculation tests and added others in 1937. He used isolates of *Coccomyces* from all three of the groups of cherries and plums set up by Higgins. In no case did the *Coccomyces* isolate from any two *Prunus* species show exactly the same host relationships. Further, the same isolate commonly infected different hosts with different degrees of severity, varying from slight flecking to abundant production of typical leaf spots. He tentatively grouped the fungi as follows according to the plant from which they were obtained. *Prunus cerasus*, *P. avium*, *P. mahaleb*, and *P. pennsylvanica*; *P. domestica*; *P. virginiana*; and *P. serotina*. *Prunus mahaleb* was susceptible to isolates of all four groups. *P. cerasus* was infected only by isolates from Group 1.

J. B. Mowry, of the Indiana Agricultural Experiment Station, reported in 1951 the inoculation of 66 species, varieties, and hybrids of *Prunus* with single-spore cultures of *Coccomyces*. He added *Prunus fruticosa* to Keitt's Group 1. He obtained infections on sour cherry and *Prunus mahaleb* with the isolate from *P. serotina*, and on both sweet and sour cherry with the isolate from *P. pennsylvanica*. Seedlings of *P. cerasus*, *P. insititia*, *P. mahaleb*, and *P. tenella* were susceptible to most isolates tested. Seedlings of *P. besseyi*, *P. japonica*, *P. pumila*, *P. persica*, *P. salicina*, *P. serotina*, *P. spinosa*, and *P. virginiana* were susceptible to relatively few isolates. Seedlings of *P. glandulosa* and *P. maritima* were resistant to all seven isolates.

While future work may be needed to clear up some aspects of this situation it seems clear that the *Coccomyces* fungi which cause leaf spot on the cultivated cherries, *Prunus cerasus*, *P. avium*, and *P. mahaleb*, form a group which conforms in general with Higgins' description of *Coccomyces hiemalis*. It is evident from the work I have described and that of R. O. Magie in Wisconsin in 1935 that this fungus is able to cause leaf spot on several other *Prunus* species, including the plums, under more or less ideal conditions. No evidence has been found that *C. lutescens* is of any significant importance on cherries. There is no known evi-
dence that the common wild cherries, *P. pennsylvania* and *P. serotina*, are of any importance as a source of the leaf spot fungus in sour cherry orchards.

*Coccomyces hiemalis* belongs to the order Phacidiales of a group of fungi referred to as Ascomycetes because they bear the spores of the perfect or sexual stage in a club-shaped organ called an ascus. Dr. Higgins first described it in 1913. He found the perfect stage of the fungus on the leaves of sweet cherry, *P. avium*, and showed that it was the fungus that previously had been called *Cylindrosporium*.

*Coccomyces hiemalis* passes the winter in the old leaves on the ground as a partly formed, round or somewhat elongated, dark-colored fruit body, which normally extends from the lower to the upper epidermis of the leaf but remains covered above and below by the epidermis.

The fruit body, or stroma, begins to swell toward the lower leaf surface during the first warm days in the spring. Club-shaped asci then form within the stroma. There follows the formation of eight two-celled ascospores within each ascus. As the asci enlarge rapidly within the stroma, the covering of the fruit body is lifted until it ruptures. The ascospores within the asci mature shortly afterwards—normally when the sour cherry is in the pink, or early-bloom, stage of growth. The ascospores are discharged through the end of the ascus in wet weather and are carried upward by wind. If they lodge on a susceptible leaf under favorable conditions, the ascospores germinate and leaf spot results in 1 to 2 weeks. Penetration of the leaf by the germ tube from the ascospore occurs through the stomata of the leaf.

After the fungus invades the leaf, a disk-shaped mass of fungus mycelium is formed beneath the epidermis of the leaf. Secondary spores, the conidia, are borne on the surface of this mass. When they have accumulated in sufficient numbers, the epidermis of the leaf is ruptured and the conidia appear in a pink to whitish-pink mass. The conidia, or summer spores, are borne in large numbers and are spread from leaf to leaf by water. The rapid spread of leaf spot in the summer and fall is usually due to the rapid increase and spread of the fungus by means of repeated generations of conidia throughout the summer and fall.

Besides the regular, or normal, ascospores and conidia, the fungus produces conidia in the overwintering fruit body after the ascospores are discharged in the spring. The conidia cause leaf spot if placed on a susceptible leaf under favorable conditions, but may be of little significance in the normal reproduction of the fungus. The fungus also produces small spores, called microconidia, on the leaves in fall. Their function in the reproduction of the fungus is unknown.

An approach to the problem of control of a disease of this type is based on the knowledge that we are dealing with two plants, the cherry tree and the fungus *Coccomyces* in this case, both of which have their normal manner of development and sensitivity to various influences. The modern orchard sets up a nearly ideal situation for the reproduction of both plants. Our purpose is to interfere in some way with the reproduction of the fungus without seriously injuring the cherry tree.

A healthy sour cherry blooms while the leaves are still small. The leaves are folded along the midrib while small and begin to unfold during the latter part of the blooming period, usually while the flower petals are falling. The growth of the spur leaves is rapidly completed after petal fall, but growth of new leaves on the terminals continues until midsummer. The leaf spot fungus rarely infects the very young leaves, apparently because the stomata through which the fungus enters the leaf are not mature until about the time the leaf unfolds. Once unfolded, however, the leaves are susceptible to infection throughout the summer and fall.

As the fungus overwinters in the old
leaves on the ground, any factor that reduces the prevalence of the fungus one year will reduce the likelihood of serious trouble with the disease the following spring. Thus few infections one year make it less likely that leaf spot will be a problem the following year. Too much faith in this fact, however, has led to trouble. The fungus often spreads rapidly in the fall and may overwinter at a high population level although it was not a problem earlier in the growing season. Too, if the ascospores are abundant enough to establish the fungus on the tree in the spring, it may spread rapidly in wet season.

In dooryard or garden trees outside of orchard districts, the fungus can be destroyed by raking and burning the old leaves on the ground in fall and winter. That work is not practical in commercial orchards because of the labor involved, but part of the same purpose can be served by disk ing or plowing the old leaves under before the ascospores mature in the spring or by spraying the old leaves with one or more chemicals that destroy the fungus in them.

Clean cultivation of the orchard would be desirable if the sole aim were the destruction of the leaf spot fungus, but that is often not practical because of the cost, the shortage of labor, and the desirability of maintaining some sort of trashy soil cover in the orchard. A considerable reduction in the population of the fungus can be obtained merely by disk ing both ways along the tree rows in the orchard.

Good results have been obtained in reducing the production of ascospores in the old leaves on the ground by means of fungicidal ground sprays. The most common spray material used for the purpose has been the sodium salt of dinitro-o-cresol, sold under the trade names of Elgetol and Krenite and used at one-half gallon of the paste to 100 gallons of spray and applied at the rate of about 500 gallons the acre. The mixture seems to have special merit in orchards where cultivation is not feasible, but it has not been generally accepted in commercial practice. The objections to it are usually the extra cash outlay required, the shortage of labor, and inability to reduce safely the number of summer sprays in districts where neighboring growers allow the fungus to overwinter undisturbed.

The difference in sensitivity of the tree and the leaf spot fungus to the action of chemicals often permits a high degree of control with sprays applied to the tree. Such sprays are now the principal means of control in commercial orchards and nurseries.

The time when the first fungicidal spray is needed depends on the presence of leaves large enough to be susceptible, the presence of mature ascospores of the fungus, the presence of moisture for a sufficient length of time to permit infection, and a temperature at which the fungus will grow.

All those conditions normally are met about the time the flower petals fall, and most spray schedules call for the first application then. That has been satisfactory when the population of the fungus is at a reasonable level and the ascospore-induced infections are few. At times, however, the petals are slow in falling and leaf growth is rapid during late bloom. Such a situation, coupled with a high population of the fungus and wet weather near petal fall, may permit many infections. The application of a spray just as the first flowers opened on sour cherry in Pennsylvania in 1947 reduced the percentage of infected leaves 3 weeks later to 1.9, compared to 24.5 with sprays started at petal fall and 92.7 on trees not sprayed at all.

Contrary situations do occur. Few or no infections may occur until a month or more after petal fall, perhaps because of a scarcity of the fungus.

Following the fungicidal spray at petal fall, additional sprays are applied as needed. On sour cherry that normally means a second spray about 10 days after the first, two sprays in June, and the last just after the fruit is picked.
in July. More sprays timed at closer intervals and applied before the long rain periods during the season are often needed on rapidly growing nursery trees, on orchard trees growing in areas with a long growing season, and in places where an attempt is to be made to control a high population of the fungus without the use of a copper fungicide. A combination of all these factors has led to the general use of eight or nine sprays each season in south central Pennsylvania.

It is necessary generally to spray sour cherry trees every year regardless of the size of the fruit crop. To newly planted trees the first spray is applied when the first leaves unfold with additional sprays at intervals as needed to keep the new leaves protected.

Workers in the different cherry districts disagree as to the chemicals to be used for control of leaf spot: The severity of leaf spot varies widely among areas, the length of the season over which protection must be provided is different, and the severity of the injury to the tree by the fungicide varies between districts. The effects of the fungicide on the tree, however, usually are different in degree only. Some general statements therefore apply in most cases.

The early work on fungicides for cherry leaf spot was primarily concerned with bordeaux mixture. Many tests of lime-sulfur solution, elemental sulfur preparations, copper compounds, and organic fungicides followed. Most commercial growers now use sulfur on sweet cherries and one of the proprietary copper compounds on sour cherries, although a considerable amount of bordeaux mixture is still used and the organic fungicides are gaining in usage each year.

The choice of a fungicide for use on sour cherries is partly determined by the effect of the fungicide on the tree and fruit. Fungicidal sprays cause various types of leaf and fruit injury such as leaf scorching, leaf spotting, leaf yellowing and dropping, and fruit scald. They also affect leaf size and photosynthetic activity, the size of the fruit, the solids and acid content of the juice, the color of the fruit, the yield, canning quality, and so on. The aim in any control program is to balance the various factors as precisely as possible in order to control the disease with the least injury to the tree and fruit.

Sour cherries of acceptable size commonly run about 100 to 125 fruits a pound. Variations in size of 10 or 15 cherries a pound have been general in Pennsylvania with different fungicides. The solids content of the juice is normally about 14 percent, with 1.5 to 4.0 percent variation common between fungicides. The acid content of the fruit has varied from 0.8 to 1.5 percent with different fungicides. The weight of pits has varied from 6.5 to 8.3 percent of the total fruit weight. The color of the fruit has varied from a very light to a very dark red.

Those characteristics are related in that any fungicide that reduces size of the fruit usually increases the percentage of solids and acid in the fruit and total weight of pits in a ton of fruit. The color of the fruit does not seem to be closely related to the other effects. All the variations are important because one or more of them affects in turn the yield and grade of raw fruit, the amount of waste and yield of cans of fruit the ton of raw fruit at the canning factory, and the attractiveness of the product to the consumer.

The effects of the fungicide on fruit quality and yield are of major importance in commercial cherry growing and canning where differences of 10 or 15 percent may mean the difference between profit and loss. It should be kept in mind, however, that failure to control leaf spot is usually much more serious than the injurious effects of the fungicide applied for its control.

Bordeaux mixture, at a concentration of 2 pounds of copper sulfate and 6 pounds of hydrated spray lime to 100 gallons of water, has been one of the most effective fungicides. Concentrations varying from about 1.5-3-100 to
6-8-100 are now used. It has caused severe leaf injury when used during wet or abnormally dry weather or on foliage on which aphid honeydew was present. It has dwarfed the fruit more than any other treatment. The fruit has been dark red in color with a high content of solids and acid.

The low cost and high degree of effectiveness of bordeaux mixture has made it one of the best materials for control of cherry leaf spot on sour cherries in the nursery, on nonbearing orchard trees where no more than four or five sprays are required, and in the sprays before bloom, at petal fall, and after harvest on bearing trees. It has given satisfactory results when used all through the season on bearing trees in northeastern Wisconsin and comparable conditions. In other areas the use of bordeaux mixture during the period of rapid fruit growth has caused excessive dwarfing of fruit.

The proprietary copper compounds, of which Copoloid, Copper Hydro, Copper A, Cupro-K, and Bordow are examples, have been used at rates of 8 to 12 ounces of actual copper plus 3 pounds of hydrated spray lime in 100 gallons of water. Properly used, any one of them has given fair to good control. As a group, they have been less effective than bordeaux mixture, but they have caused less leaf injury, and the number of leaves remaining on the tree has often been as high with one of them as with bordeaux mixture. They have sometimes been associated with an injury on the fruit that has occurred as a black line around the stem of the fruit and is very objectionable in canned cherries.

The copper compounds have been the most frequently used materials for leaf spot control on sour cherries since about 1940. They have represented a compromise between the older fungicides, bordeaux mixture and lime-sulfur solution, in that they have given less fruit dwarfing than bordeaux mixture and better leaf spot control than lime-sulfur. They still have considerable merit for use in some of the Great Lakes districts where injury by them is at a minimum, and in other areas where small orchards or garden trees do not justify extra labor and expense with a more complicated spray schedule in an effort to obtain maximum crops of perfect fruit. They have not been satisfactory in south central Pennsylvania because of excessive leaf and fruit injury. With the relatively large number of sprays required there for leaf spot control, crop reductions of 10 to 20 percent by a copper fungicide have been frequent in hot, dry harvest seasons.

None of the copper materials may be used on sweet cherries without danger of injury.

Ferbam preparations sold under such trade names as Fermate, Ferradow, and Karbam Black, have been used both alone and with elemental sulfur, usually one of the sulfur pastes. The usual concentration has been 1.5 pounds to 100 gallons of water of a product containing about 75 percent active ingredient. Two pounds has been the minimum effective concentration in Pennsylvania with the sprays started before bloom and continued at 7- to 14-day intervals until harvest. One and one-half pounds has been adequate when used with one of the elemental sulfurs.

Ferbam has not usually caused any visible injury to the tree or reduction in fruit size. The large fruits have been comparatively low in solids content, largely or entirely because of their size, and have been unsatisfactory to some canners because of this.

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