During the period of spore discharge from the overwintered cankers, which starts approximately 3 weeks after the petals have dropped and continues for about 6 weeks, the young leaves, fruit, and twigs must be protected from infection. Many field experiments have shown that lime-sulfur solution and the wettable sulfur preparations used to control the apple scab fungus are only partly effective in controlling the blotch fungus. The standard procedure therefore, is to use bordeaux mixture (4-4-100) or ferbam (ferric dimethyl dithiocarbamate) at the rate of 2 pounds in 100 gallons of water. The first spray should be applied 2 weeks after the petals have fallen, followed by three applications at intervals of 2 weeks or only two applications at 3-week intervals.

If properly applied, those sprays will protect the leaves and fruit from blotch infections and prevent new cankers from forming on the current year’s growth. Because the cankers formed the preceding season will ooze spores for at least two more seasons, however, the spray program must be carried on for at least three or four seasons. After that the fungus can be kept under control by one or two sprays—with materials at half the strength I recommended—each season.

An objection to the use of bordeaux mixture to control blotch is the injury that is apt to accompany the continued use of a copper-containing spray. In some seasons that injury to leaves might be worse than the injury caused by the blotch fungus. In other seasons the use of a copper spray 2 weeks after the petals have dropped may cause serious russetting of the fruit. Ferbam, therefore, is preferred. On light-colored apples it may leave a dark residue that must be removed, but that is a minor drawback, compared to the injury that may result from the use of bordeaux mixture.

**Bitter Rot of Apples**

**John C. Dunegan**

Bitter rot, a destructive disease of apples caused by the fungus *Glomerella cingulata*, has long been feared by growers in Maryland, Virginia, West Virginia, Arkansas, and southern Illinois, Indiana, and Missouri.

An account published in 1870 in the Transactions of the Illinois Horticultural Society said: “Last year the orchard . . . had at least one thousand bushels on and the proprietor did not get a bushel of winter apples. The bitter rot blasts them like the breath of ruin and the promise of spring ends in disappointment and decay. . . .”

Seventy-seven years later, near Centerton, Ark., I found 96 percent of the crop on some trees destroyed by the fungus.

The disease is not entirely unknown in northern orchards, but usually it is unimportant except in seasons when unusual weather favors the development of the fungus on neglected trees. Temperatures above 70° F. and abundant rain favor the development and spread of the fungus. Bitter rot is distinctly a warm-weather, midsummer disease. The fruit infections rarely appear before the middle of June but continue to develop until early September. Losses vary from year to year but once the fungus becomes firmly established in an orchard, control is difficult.

The bitter rot fungus is a microscopic plant that can live in the tissues of the apple. The fungus filaments—myce-
lia—penetrate the skin, kill the individual cells of the apple pulp, and cause a breakdown or rot of the tissue.

Small, light-brown, circular spots under the skin of the apple are the first sign of the disease. When the spots are one-half inch or more across, concentric rings of pink pustules appear on their surfaces. The pustules are masses of spores—conidia. As the fungus penetrates more and more of the apple tissue, the area of invaded tissue, originally conical-shaped, becomes enlarged, until finally the entire apple is involved. Sometimes, however, the growth of the fungus is checked and the only effect is a cone-shaped cavity of varying depth, covered by the skin, which has turned dark and papery.

When only one or two infections occur on an apple, the individual spots grow rapidly in favorable weather; the concentric rings of spore masses soon develop, facilitating the spread of the fungus to adjacent fruit.

Occasionally one encounters apples with 500 to 1,000 individual infections. They have a peculiar peppered appearance. The individual spots often remain small and blisterlike. Under those conditions, the fungus does not extend very far into the fruit tissue.

Aside from that unusual symptom, the disease usually is easily identified, especially when the rings of pink spores (which later turn dark brown or black) are present on the fruit. One other common rot of the apple, black rot, is sometimes confused with bitter rot. The black rot fungus, however, causes a less watery type of rot, and, although concentric bands of color are also present on the apple, the fungus never produces concentric rings of spore masses.

Infected apples frequently remain in the trees. As the season advances they shrink into hard masses called mummies. The fungus can remain alive in them until the following year and then produce spores to infect the new crop of fruit. The removal of the mummies, therefore, is important in control.

The bitter rot fungus also persists from season to season in dead twigs and branches. Sometimes the fungus actually kills the twigs and causes cankers but usually it merely invades tissues weakened or killed by other agencies—the black rot and blotch fungi, the pear blight bacillus, mechanical injuries, and injuries due to low temperatures.

Once established in the dead twig and branch tissues, the fungus survives for several years and is a continuing source of spores to infect the succeeding crops. Frequently the first fruit infections of the season occur in a cone-shaped area below a dead twig producing bitter rot spores. The newly infected apples produce more spores, which spread the fungus through the tree. The cone-shaped pattern of the primary infection is obliterated as the season progresses.

The bitter rot fungus occasionally produces spots on apple leaves, particularly on neglected trees, but that phase of the disease is not important.

Sometimes the fungus forms a different type of fruiting body on the fruit and twig tissues. Numerous sacs (asci), each containing eight spores (ascospores), are formed within a hard, black, spherical case called a peritheciun. The ascospores can be seen only through a microscope. They are forcibly ejected from the peritheciun and, like the spores produced in the pustules (acervuli), can infect other apples.

Apple varieties vary considerably in susceptibility. Golden Delicious, Jonathan, Yellow Newton, Northwestern Greening, and Grimes Golden generally are more susceptible than Rome Beauty, Stayman Winesap, Delicious, York Imperial, and Winesap. Even normally resistant varieties, however, may be seriously affected in hot, rainy weather. The degree to which different varieties are infected depends largely on climate and their proximity to sources of infection.

I do not mean to imply that every apple tree in the country is constantly threatened with a destructive attack.
of the fungus. Actually, the fungus spreads very slowly and many orchards remain entirely free from the disease. But when the disease does appear in an orchard, control measures must be promptly instituted lest in a favorable season the fungus runs wild in the orchard and "... the promise of spring ends in disappointment and decay. ..."

The control of the fungus depends on proper orchard sanitation, to remove sources of infection, and the use of effective fungicides, properly applied in a definitely timed schedule to insure thorough coverage.

Persistent cases of bitter rot can be traced at times to the presence of a few infected trees of a susceptible variety remaining in the orchard from an earlier planting. Those old trees must be removed as the first step in control: The value of the fruit they produce is apt to be much less than losses they cause by serving as a reservoir of bitter rot spores that infect the adjacent and more valuable trees.

The removal of mummies from the trees, particularly if the disease has been serious the previous year, and proper pruning to eliminate the dead twigs that harbor the bitter rot fungus are also essential in the control program. In fact, unless those sanitary measures are practiced, the control of the fungus by spraying will be difficult and at times impossible.

Because the first infected apples are rarely noted before the middle of June, the spray program usually starts with an application between June 10 and 15, a second spray is applied July 1, a third application about July 15 to 20, and a fourth application during the first week in August.

During cool, dry seasons the intervals between the spray applications can be increased 7 to 10 days, and only three instead of four applications need be made during the season.

Since all spraying leaves a residue on the fruit which may interfere with its sale, no fruit should be sprayed later than 1 month before its ripening date.

If the bitter rot is rampant in the orchard, it may be necessary to violate that precaution to obtain control of the fungus. Then the fruit must be washed or brushed to remove the spray residues before it is offered for sale or used at home.

It is essential to apply the spray before infections appear on the fruit. In orchards where almost the entire crop has been ruined for several years, it may be necessary (depending on the season) to start spraying earlier than June 15 and apply sprays at intervals of 2 weeks until the fungus is under control. All the spraying operations for bitter rot control must be thorough and every effort should be made to cover the apples by spraying from both sides of the trees.

Bordeaux mixture before 1944 was the only material that had controlled the bitter rot fungus successfully. This spray preparation, consisting of 8 parts of copper sulfate, dissolved in water and added slowly to a suspension of 12 parts of hydrated lime in 100 gallons of water, was effective.

In 1944 scientists found that some of the organic spray materials, particularly Phygon (2,3-dichloro-1, 4-naphthoquinone) and ferbam (ferric dimethyl dithiocarbamate), used at the rate of 1 and 1½ pounds, respectively, to 100 gallons, were equally as effective as bordeaux mixture for the control of the bitter rot fungus.

Later experiments confirmed those results and the organic materials are now used in preference to bordeaux mixture to avoid the chemical injury that was so commonly associated with the use of bordeaux mixture. The number of spray applications required to control the bitter rot fungus remains the same, however, irrespective of the material used in the sprays.

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