shall be restricted to the slip-bud method.

The mosaic quarantine provides for certification of nurseries when no mosaic infection is found in the nursery stock and when mosaic-infected trees found within a mile of the nursery are removed before May 16 of each year. Because mosaic may be transmitted by means of buds from infected trees, all budwood sources must meet the same requirements as the nursery stock. The California quarantine prohibits movement of nursery stock from the regulated area.

Through the application of inspection and elimination of infected trees over a period of years, substantial reductions in the incidence of both phony and mosaic have been achieved. The practice has resulted in the apparent eradication of phony disease from Illinois, Indiana, Maryland, Oklahoma, and Pennsylvania, and from more than 100 counties in other lightly infected States. Mosaic has apparently been eliminated from 21 counties of the known infected States. All areas in which eradication apparently has been accomplished were lightly affected by the diseases when controls were first applied. In areas of general infection, control has been more difficult, but a persistent application of approved practices has achieved and maintained a sufficiently low level of infection that commercial fruit production has continued to be profitable.

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Brown Rot of Peach

John C. Dunegan

Brown rot has been the scourge of peach growing in the more humid sections of the United States since Colonial times. Sometimes it is called simply *the rot* because it occurs so commonly and affects so adversely the fortunes of all who handle and eat peaches.

Its first symptom on the fruit is a small, brown spot, which rapidly enlarges and soon destroys an entire peach and all peaches near it. Masses of gray spores form on the surface. As the fungus develops best in warm, humid weather, brown rot long was considered merely the aftermath of such conditions. By 1880, however, people realized that rot did not develop solely as the result of the "delicate" nature of the peach but that a fungus caused it.

Now we know also that a common insect, the plum curculio, is implicated in the spread of the brown rot disease. The punctures the insect makes when it feeds and lays eggs furnish ideal points of entry for the spores of brown rot. Although brown rot can be very serious even if the plum curculio is absent, it cannot possibly be controlled during harvest periods of warm, rainy weather if the insect is prevalent in an orchard.

For many years the fungus, *Monolinia fructicola*, was considered to be identical with a brown rot fungus that attacks plums, apples, and pears in Europe. The two are distinct, however. The fungus on peaches, plums, cherries, and (only rarely) apples and pears in the eastern part of the United States is a native of the region. Probably it occurred as a disease of wild plums long before the settlement of the Western Hemisphere.

The European brown rot fungus is now known to be present in California, Washington, and Oregon and in a few scattered localities east of the Rocky Mountains. Its activities are described by E. E. Wilson in another article in this volume (p. 886). I shall discuss only the common brown rot fungus so prevalent in the eastern part of the United States.

The life cycle of the brown rot fungus is a vicious circle: The fungus constantly multiplies its sources of infection so that the disease can become more destructive, given proper weather conditions, each succeeding year. To control the fungus, by interrupting its development at some point, one has to know its life cycle.

As I indicated, brown rot starts as a speck that rapidly enlarges and may involve the whole peach in a few days with a brown, rather firm rot. Masses of spores—conidia—are soon formed on the rotten surface. The spores may be blown by wind, washed or splashed by raindrops, or carried by insects or man to other peaches, which in turn develop the characteristic brown spots and eventually are destroyed. Sometimes the destruction of the fruit can involve one-half or more of the crop in less than a week. Complete destruction of the crop occurs less often now than 50 years ago, but it may still occur during periods of favorable weather in orchards that are poorly cared for.

The fungus completely penetrates the tissues of the peach. The rotten peach left hanging on the tree loses moisture and shrivels. By the end of the growing season it becomes a dry, distorted object that is aptly called a mummy. The peach stone is covered by the tough, leathery remains of the peach cells held in place by the fungus threads (mycelia), which have spread all through the flesh. The skin remains as a covering. Just beneath the skin the fungus threads are closely interwoven and form a hard rind. The mummy can withstand very adverse conditions.

If the infected peach had dropped to the ground immediately instead of drying up in the tree, very likely it would have disintegrated under the action of various molds and bacteria. Only rarely do rotting peaches on the ground form mummies. Once the peach has dried into a mummy, however, it may fall to the ground, but in that condition it is not affected by soil organisms, and many persist for several years.

If the mummy is partly or completely covered by soil, the fungus produces another stage in its life cycle the following spring when the peach blossoms begin to open. Small, brown, goblet-shaped structures—the apothecia—develop from the part of the mummy embedded in the soil and unfold on the surface of the ground.

The apothecia are never formed on mummies lying only on the surface of the ground. Some part of it must be buried in the soil for apothecia to form. The mummy, however, does not have to be intact, as numerous apothecia will develop from buried fragments. That phenomenon will be repeated for several years. In a series of experiments I once made, I observed apothecia produced from the same group of peach mummies for six successive seasons. J. B. Pollock reported finding apothecia in Michigan from plum mummies 10 years old.

The upper surface of the apothecium is the spore-bearing layer. It consists of closely packed vertical sacs—the asci—each containing eight spores (ascospores). The asci are separated from each other by sterile, threadlike structures (paraphyses), so that each sac or ascus stands as a separate entity, with its apex pointing upward.

When the individual spores are mature, the base of the ascus absorbs moisture and the spores are forcibly ejected into the air above the apothecium. There they are swept away by air currents, and some may be carried upward into the peach trees. As the formation of spores takes several days, the discharge of ascospores into the air is more or less continuous. Often a blow on a group of apothecia will bring about the sudden release of a whole group of ascospores, which will be visible for an instant as a smokelike cloud above the apothecia. The number of ascospores discharged into the air in an orchard soon reaches astronomical proportions, but, fortunately, only a few land on the unfolding peach blossoms. The ascospore that happens to lodge on the sticky surface of the pistil of the blossom germinates and sends a mycelial thread down the style into the very small peach, causing the phase of the disease called blossom blight. Having destroyed the young peach, the fungus grows down the stem and into the twig, killing the tissues and forming a stem canker.

Unless the conditions are extremely favorable for the growth of the fungus, the number of blossoms blighted or destroyed by the fungus is not enough to effect materially the size of the peach crop. Blossom blight is an important and serious phase of the brown rot disease, however.

Its importance lies in the fact that the blighted blossoms and the cankers on the twigs soon are covered with masses of spores—conidia—which can infect and blight other blossoms. Moreover, the twig tissue killed by the fungus decomposes into a gummy substance, which oozes to the surface, surrounds the blighted blossom, and prevents it from dropping.

Every time it rains during the rest of the spring, a fresh crop of conidia is produced on the blighted parts. The green peaches are not readily infected by the fungus, but as the peaches start to mature they become extremely susceptible. Conidia formed on nearby blighted blossoms are scattered by the wind and raindrops to the maturing peaches, which soon develop the telltale spots.

Experimental data indicate a correlation between the number of blighted blossoms (that is, the centers of conidia production) and the number of mature peaches infected at harvesttime. The spores can germinate and infect uninjured peaches through the hair sockets—the tiny pits in the skin where the hair develops. Punctures caused by the plum curculio provide additional sites for the spores to germinate and penetrate the flesh of the peach.

Once infection has taken place, conidia begin to develop upon the surface of the peach in a few hours. The appearance of those spores completes the cycle which started the preceding year on a maturing peach that eventually mummified and dropped to the ground: Apothecia produced by the mummy ejected ascospores into the orchard air; the unfolding blossoms were infected; and conidia formed on the blighted parts finally infected the maturing fruit of the new crop.

Several variants in this cycle may occur. In mummied peaches that remained on the tree instead of falling to the ground, apothecia would not be formed. But often conidia are produced on the mummies in the trees the following spring; those spores, like the ascospores, can produce blossom blight. Occasionally the twig cankers formed one season can also produce spore tufts on their surfaces the following spring and may serve as a source of blossom infections. Spore production the second season on twig cankers, however, is rather uncommon in the case of the common American brown rot fungus, *M. fructicola*. It is common in the far West on twigs infected by the European fungus, *M. laxa*.

The American brown rot fungus grows best at temperatures between 70° and 80° F. and is killed by a temperature of 127°. It is not killed by exposure to freezing temperatures;

it has been known to produce symptoms of rot in 12 days on peaches held at 36°. Periods of rainy weather encourage infections of blossoms and fruit and the production of spores on the infected parts.

THE FUNGUS would be serious enough if its effects were confined to the orchard. Unfortunately, though, it continues to destroy the fruit after it has been harvested. Conditions that favor the development of brown rot on the maturing fruit also scatter conidia throughout the tree. Some of those spores germinate immediately. Others may not start to grow until after the fruit is picked. In favorable seasons, a grower may deliver what he considers disease-free fruit to shippers, only to learn later that his fruit developed rot in transit and was quite rotten when it reached the market. Moreover, even apparently sound fruit may show brown rot infections and spoil after the housewife has bought it from the grocer. The destructive effects of the fungus are indeed far-reaching—in some seasons it destroys more than 2 million bushels of peaches.

Considerable work has been expended on ways to combat the disease.

Unfortunately the removal of rotted fruit, cankers, and infected twigs cannot be depended upon to control brown rot. These sanitary measures do reduce materially the sources of infection and should be practiced along with pruning and removal (thinning) of fruit to make it feasible to protect the remaining fruit with fungicidal sprays or dusts—the main control procedure.

Before 1907, peach growers used bordeaux mixture, potassium sulfide, and occasionally flowers of sulfur with only indifferent success. W. M. Scott discovered in 1907 that a mixture of sulfur and stone-lime (called self-boiled lime-sulfur) gave effective control of the brown rot fungus.

The discovery was of great importance. The use of sulfur ended the possibility of injury that accompanied the use of bordeaux mixture for brown rot control during the growing season. Although self-boiled lime-sulfur has been replaced by mixtures of sulfur, lime, and a wetting agent, or by finely divided sulfur pastes, elemental sulfur in some form is still the most effective fungicide we know of to combat brown rot.

To control blossom blight, one has to apply sprays every 3 or 4 days during the blossom period. The development of high-capacity, rapid-delivery types of spray machinery has made it feasible to control blossom blight.

Wettable sulfur (6 pounds to 100 gallons), lime-sulfur (1 gallon to 100), ferbam (1½ pounds to 100), and Phygon (2 pounds to 100), are all effective materials to use for blossom blight control if a sufficient number of closely spaced applications are made during the bloom period.

If all the blossoms on a peach tree opened in a day, they could all be protected by a single spray. As the blossom period generally extends 7 to 15 days, however, one has to spray at regular intervals to protect the blossoms as they open.

The control of blossom blight is of such fundamental importance that every peach grower should aim to do so. It is true that in some seasons the lack of rain at harvesttime greatly retards the development of fruit rot and a good crop may be harvested despite the blighting of many blossoms scattered through the trees. But the weather at harvest cannot be foreseen at the beginning of the season—hence the need for the protection given by control of blossom blight.

Experiments over many years have standardized the control procedures after the blossom season. There may be local variations, but the general schedule calls for spraying at petal fall, when most of the shucks have dropped, 2 weeks later, and approximately 1 month before harvest.

Sulfur, 6 to 12 pounds, depending on the composition of the sulfur preparation and its degree of fineness, is added to 100 gallons of water for the sprays. Appropriate amounts of insecticides are added for the combined control of disease and insect pests.

Some growers apply sulfur, lime, and insecticides as dusts instead of as sprays. Properly applied, dusts give adequate control of the fungus and can be applied rapidly to large acreages during critical periods. Frequently the light dusting machines can be used when waterlogged soils make it impossible to move the heavy spray machines through the orchards.

In orchards where blossom blight has not been controlled (particularly in humid sections) additional protection against brown rot results from the application of preharvest dusts or sprays. One may use wettable sulfur, 6 pounds to 100 gallons of water; dilute lime-sulfur, 1 gallon to 100 gallons; or sulfur-lime dusts. The application of the fungicide should start about 3 weeks before harvest and should be repeated at intervals of not more than 7 days until the fruit is picked. Dusting is a particularly advantageous procedure for these preharvest applications, as the entire acreage can be treated rapidly and the dust does not leave an objectional deposit on the fruit.

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The attention of the reader is directed to the section of color photographs, in which appear pictures of peaches infected with brown rot, anthracnose, and bacterial spot. Diseases of apple, pear, citrus fruit, strawberry, grape, and cherry are also illustrated.

Scab or Black Spot on Peach

John C. Dunegan

Peach scab is also called black spot or freckles—apt names because the black spots on a badly infected peach do make it look freckled.

Cladosporium carpophilum, the fungus that causes the disease, occurs throughout the world on peach twigs, leaves, and fruit. In the United States and probably elsewhere fruit trees grown in dry sections are rarely affected, but in more humid sections the fungus is so persistent that growers must undertake control measures every year to protect the fruit. The fungus occasionally attacks plums and cherries but is of little importance on them.

The disease appears on the fruit as small, greenish, circular spots, one-sixteenth to one-eighth inch across, which become visible about the time the fruit is half-grown. The spots usually are most numerous near the stem. At times they cause an excessive dropping of the fruit by killing the stem tissues. The spots slowly increase in size, turning olive green to black and velvety as the result of the mass of dark spores that form on the surface. If the spots are especially numerous, they may coalesce into a crustlike covering over most of the fruit, which interferes with the normal growth of the peach as it matures. Badly infected fruit may crack open to the pit and be destroyed by the brown rot fungus.

On twigs of the current season's growth, the fungus produces many small oval, brown lesions or cankers that