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report on
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PHYTOPHTHORA COLLAR ROT OF APPLE

Phytophthora collar rot or crown rot is normally caused by *Phytophthora cactorum*. Other species of *Phytophthora*, including *P. megasperma* and *P. cambivora*, can sometimes be involved in collar rot. *Phytophthora cactorum* is a common, widely distributed, soilborne fungus with a very wide host range, attacking about 200 different species of plants in over 80 genera. It is a serious disease of certain cultivars of apples and pears, but the fungus will also infect stone fruits and strawberries. The disease was a minor problem when apple trees were propagated on seedling rootstocks except where 'Grimes golden' apples were grown. Phytophthora collar rot has become a serious problem on certain clonal, dwarfing rootstocks which have largely replaced seedling rootstocks. The disease is primarily a problem on sites that are poorly drained or are irrigated by flooding. High soil moisture is essential for the survival and movement of, and infection by, the *Phytophthora* fungus.

Figure 1. Phytophthora collar rot at base of apple tree.

Trees are most susceptible in spring about the time of flowering. They begin to become relatively resistant during the period of shoot growth. Collar rot lesions expand rapidly during spring and slowly during the remainder of the growing season. The period of spring susceptibility coincides with the period of greatest activity of the *Phytophthora* fungus. The fungus was once thought to attack only mature trees. Research has shown that trees of any age, including seedlings, are susceptible.

The greatest losses invariably occur 3 to 4 years after planting as the trees are beginning to bear fruit. Diseased trees usually live on in a weakened condition for 2 or 3 years before dying. If conditions are optimal for disease development, however, trees can be killed in a single growing season. Older trees (10 to 12 years) appear to develop some sort of resistance. Trees that are growing vigorously often seem more likely to become infected than trees in fair to poor vigor.

SYMPTOMS

Phytophthora collar rot attacks the lower 30 inches (76 cm) of apple trunks (Figure 1). Infection generally occurs between the soil line and the root-crown area. Most infections start at the junction of a lateral root

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with the trunk. Young cankers at ground level are difficult to detect; but as they enlarge, they darken and become depressed and roughly oval with an abrupt margin. Infected bark becomes brown and is often soft and mushy or slimy when wet (Figure 2). A brown to reddish brown discoloration of the wood and a gummy exudate under the dead bark of the canker indicate the presence of *Phytophthora*. Dark streaks often occur near the cambium and extend beyond the canker margin. If a canker enlarges for several years, only the marginal areas show the typical color and texture of newly killed tissue.

Figure 2. Closeup of Phytophthora collar rot showing brown, often soft and mushy area.

The development of the canker is rapid, horizontally and vertically. The ultimate effect of collar rot is to girdle the affected limb, roots, or trunk, resulting in the death of that organ or of the entire tree. A general lack of vigor, poor terminal growth, and the premature production of small, sparse yellow leaves in summer or reddish bronze leaves in early autumn are frequently the first indications of the disease. Early fruit ripening and the formation of small, highly colored fruit are common symptoms of disease. Foliar symptoms may appear only on branches directly above the canker, while the remainder of the tree appears normal and continues to bear fruit. Severely infected trees eventually die.

Phytophthora collar rot is commonly confused with cankers caused by secondary or opportunistic invaders. Many fungi and bacteria, which ordinarily would not cause such an infection, can gain entrance if the tree is damaged by mechanical or winter injury, or by fertilizer contact with the trunk. Laboratory isolation of the *Phytophthora* fungus, using baiting techniques and selective media, is often required before a positive diagnosis can be made.

Phytophthora collar rot is sometimes confused with Armillaria root rot. Armillaria infections start at the roots, move up to the crown, and kill patches of bark tissue producing white, fan-shaped sheets of mycelium under or over the bark and eventually developing clusters of typical honey-colored mushrooms at the base of the trunk. Phytophthora infections occur at the crown, spread downward toward the rootlets, and develop a ground-line lesion. If the scion cultivar is susceptible, the disease may extend to the bud union or possibly beyond. The canker forms a definite outline when the bark dries out and callus tissues develop at the margins.

The *Phytophthora* fungus can also attack the fruit of susceptible cultivars. Infected apples on or close to the ground develop a firm, light tan rot. Phytophthora fruit rot is most common in orchards, especially where ‘grimes golden’ are grown, where contaminated surface water is used in overhead irrigation systems, and where clean cultivation is practiced.

DISEASE CYCLE

The pathogen overwinters as mycelium in trunk cankers or for several years as thick-walled oospores (Figure 3a) or chlamydospores in the soil. The oospores and chlamydospores occur in greatest numbers in old orchard soils. These thick-walled structures resist periods of unfavorable environment such as drought or freezing temperatures, and are relatively resistant to chemical treatment. In the early spring, oospores may germinate in bark crevices; or the mycelium may penetrate the bark at the ground line or

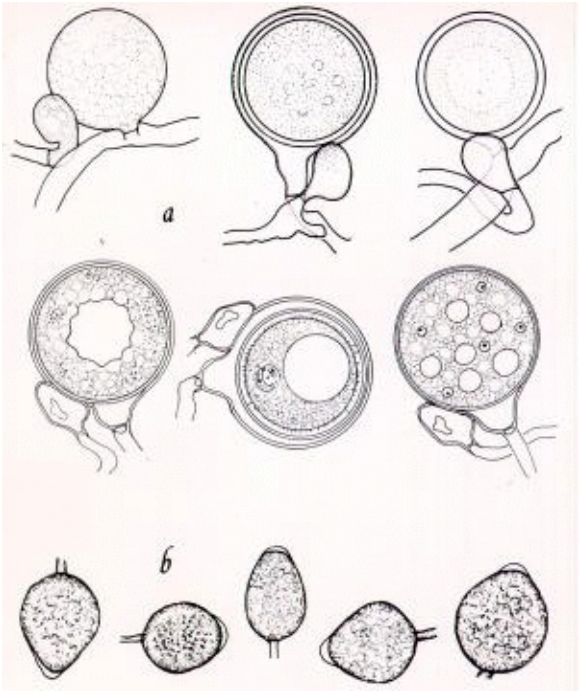

Figure 3. Phytophthora collar rot of apple, as it would be seen under a high-power laboratory microscope: (a) Oogonia, oospores (some containing oil globules), and antheridia; (b) sporangia. The contents of the lemon-shaped sporangia divide up to produce large numbers of motile zoospores (drawing by L. Gray).

root collar. Infection is direct and does not require an entrance wound. The fungus rarely produces sporangia (Figure 3b) on the surface of cankers, but many zoospores are produced in the late spring or early summer from sporangia in the soil; or these may be found in surface irrigation water. The zoospores swim in films of water or irrigation water and contact the lower portion of the trunk or are splashed on the fruit close to the ground, causing new trunk cankers or fruit rot. The ability to produce large numbers of spores (primarily zoospores) allow the *Phytophthora* fungus to build up to high levels from a few oospores.

Fungal growth and infection are favored by wet soil and moderate temperatures. *Phytophthora cactorum* grows best at 56°F (13°C), but is active up to 70°F (21°C). In the Midwest, susceptible apple cultivars seem to be attacked most frequently about or during blossoming time and again during late August or early September and into October (at the onset or dormancy). These periods are believed to reflect the time when the fungus is most active in the soil, and would represent the time when the host is most susceptible.

CONTROL

Phytophthora collar rot is erratic and therefore very difficult to control. The disease may not occur for several years; then, after a season of prolonged cool, wet weather prior to bloom, an orchard may be severely affected (Figure 4). Replanted and wet, poorly drained orchard sites invariably show a high incidence of collar rot infection. Protective measures are likely to be required. When infections are discovered, it is frequently too late to eradicate the disease and save the tree.

Figure 4. Apple orchard infected with Phytophthora collar rot.

The following control practices, when used in combination, are useful in preventing or decreasing collar rot.

1. **Choose resistant cultivars and rootstocks**. This is the most effective means of control. Susceptible rootstocks should especially **not** be planted where the soil is heavy and poorly drained. Of the cultivars most commonly grown in the Midwest, 'Dutchess', 'Grimes Golden', and 'Lodi' are extremely susceptible. Seedling rootstocks of 'Golden Delicious', 'Jonathan', 'McIntosh', and 'Rome Beauty' are moderately resistant. 'Melba', 'Red Delicious', 'Wealthy', and 'Winesap' are considered to have good resistance. Only disease-free nursery stock should be planted, since infected nursery stock has been shown to be an important source of the disease.

Dwarfing rootstocks vary in their susceptibility to Phytophthora collar rot. East Malling (M) rootstocks M-4 and M-9 are considered reasonably resistant. The Canadian rootstock Ottawa-3 has M-9-type resistance. Of the other rootstocks, M-25, M-26, Malling-Merton (MM) 103, MM-104, MM-106, MM-107, MM-109, MM-110, MM-111, MM-113, and MM-115 are quite susceptible. M-2, M-7, and MM-112 are intermediate in resistance. M-9 and M-26 rootstocks, however, are extremely susceptible to fire blight.

Grafting resistant apple cultivars onto resistant rootstocks provides the best control measure.

2. **Avoid low-lying sites when planting an orchard**. Phytophthora collar rot is most prevalent in sites that are damp and low and have poorly drained soils high in clay. New orchards should be planted on slopes for maximum water drainage. Level terrain can be artificially sloped with a plow. This will improve drainage for young trees when planted on the ridges. Tiling of wet areas in an otherwise well-drained orchard often improves internal soil drainage sufficiently to avoid the disease. Do **not** allow a soil "saucer" to form around the trunk or place trickle irrigation outlets so that the tree base is flooded during irrigations. Always channel water **away** from the trunk.

3. **Plant shallow**. Do not plant apple trees deeper than trees grown in the nursery. This can result in increased collar rot and may cause the cultivar to "strike" roots that result in losing both the tree uniformity and dwarfing.

4. **Avoid winter injury**. Some dwarfing rootstocks, especially MM-106, are susceptible to winter injury. Do not fertilize trees in late summer or early fall. This practice induces late growth and lowers cold tolerance. Carry out practices that favor early maturity in the autumn to avoid growth continuing into mid or late fall.

5. **Provide tree support**. Young trees, especially, that are not properly supported by a stake or trellis will "rock" in the wind, resulting in an open area around the trunk base. This leads to increased susceptibility to cold injury and collar rot.

6. **Once infection has occurred**, some success in arresting and eradicating the disease may be obtained if the grower will:

    a) **inarch one-year-old whips of a resistant cultivar into the trunk well above the cankered area**. This treatment is of little value if 25 to 50 percent or more of the circumference of the trunk is infected.

    b) **remove soil from around the base of a recently infected tree to expose the entire cankered area**. Cut away all diseased tissues and leave the trunk area open to permit drying of the infected area and prevent further disease development. In late autumn, refill the area around the trunk with good fresh soil.

7. Applications of a *Phytophthora*-specific fungicide (1) at the time of planting or in the spring before growth starts, and (3) in the fall after harvest, have proven effective when used in conjunction with good cultural practices and resistant rootstocks. Applications should be made **before** symptoms appear, especially in areas of the orchard favorable for disease development. Fungicide treatments will **not** revitalize a tree showing moderate to severe crown rot symptoms.