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LATE BLIGHT AND BUCKEYE ROT OF TOMATO

Late blight of tomato is caused by the fungus *Phytophthora infestans*. Currently, two physiologic races of the fungus, designated T-0 and T-1, have been identified. There are also potato and tomato strains of the fungus; each is capable of infecting the other host.

Buckeye rot is caused by three species of *Phytophthora. P. parasitica* is most commonly associated with the disease in Illinois; in other areas of the country the disease is attributed to *P. capsici* and/or *P. drechsleri.*

Figure 1. Late blight first appears as water-soaked, greenish black areas on leaves and stems that later turn brown. Often a pale green band surrounds the affected area on the leaf. (Courtesy R.E. Stall)

These two diseases may be widespread and destructive in Illinois during wet seasons when the foliage and fruit are not protected by fungicides. In cool, moist weather the vines and fruit rot very rapidly from late blight. During prolonged warm, wet weather a large percentage of the tomato fruit in contact with the soil may be affected by buckeye rot.

SYMPTOMS

Late Blight

On seedlings, small, dark spots form on the stems or leaves followed by death within 2 or 3 days. On older plants the fungus causes small to large, irregular, rapidly enlarging, water-soaked, pale green to greenish black lesions which usually start at the margins or tips of the leaves. In dry weather, these lesions turn dark brown, dry, and wither. A pale green "halo" often surrounds affected leaf areas (Figure 1). The spots may enlarge until entire leaflets are killed. Lesions can expand rapidly and result in extensive, if not complete, defoliation within 2 weeks. Severely affected plants may appear as if damaged by frost.

Infection of both green and ripe fruit starts near the stem-end or the side of the fruit. It soon spreads over the entire fruit. Infected areas are dark green, brown, or brownish black and "greasy," with a rather firm but slightly wrinkled surface (Figure 2). Secondary organisms commonly invade affected fruit causing a soft, wet rot.

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Figure 2. Late blight attacks both green and ripe fruit. Rotted areas are firm but slightly wrinkled and dark green, brown, or brownish black.

In moist weather, the late blight fungus produces a white, downy mildew mostly on the underside of the leaf lesions and on the surface of affected fruit. The mildew growth is composed of spore-bearing structures (sporangiophores) which bear lemon-shaped spores called sporangia (Figures 3a and b).

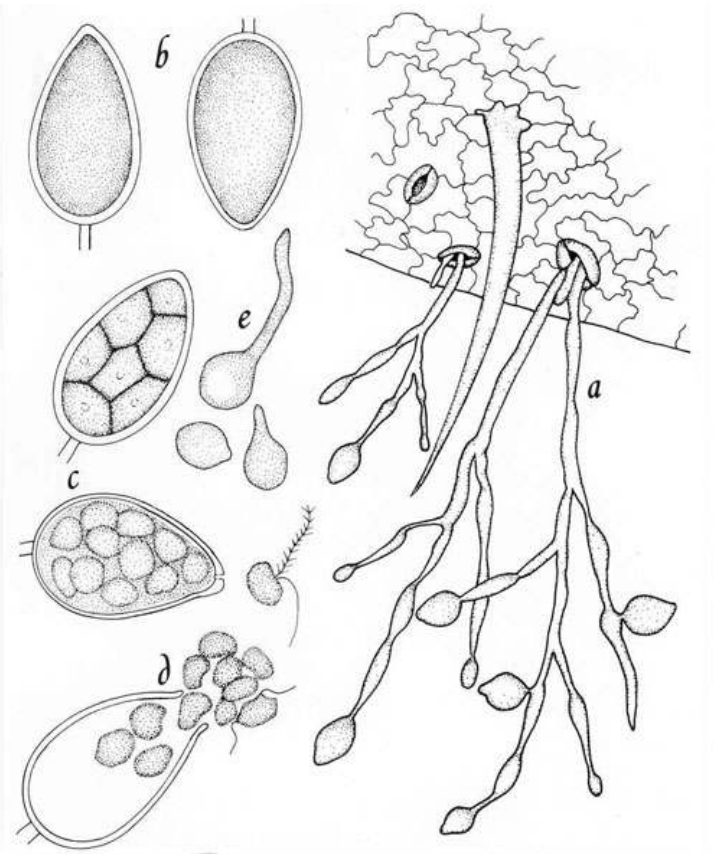

Figure 3. <u>Phytophthora</u> <u>infestans</u>, the late blight fungus, as seen under a high-power microscope: (a) two sporangiophores emerging from stomates on the underside of a potato leaf and bearing a number of lemon-shaped sporangia; (b) two sporangia; (c) sporangial contents dividing up to form zoospores; (d) sporangium releasing zoospores; (e) encysted zoospore with two germinating zoospores (drawing by L. Gray).

DISEASE CYCLE

A primary source of initial inoculum is often from infected potato tubers in cull piles or those left near or on the soil surface. (Potatoes are an alternative host of the fungus). The fungus overwinters in tubers in storage or in the field and resumes growth when the tubers sprout by infecting the seedlings. Under favorable environmental conditions, the fungus produces sporangia. The sporangia are spread by wind or splashing rain to nearby susceptible host plants, infect them, and initiate another disease cycle. The fungus is capable of remaining active during mild winters in southern states on potato, tomato, eggplant, petunia, and numerous other plants in the potato-tomato family (Solanaceae). Prevailing winds transport the sporangia northward. Tomato transplants grown in these areas become infected and serve as a primary source of inoculum in northern states to where they are transported. The fungus also may remain active in northern states during the winter on greenhouse tomatoes. In the spring, sporangia are carried from the greenhouse to the field.

Ideal environmental conditions that favor epidemic development include warm days (70° to 85°F or 21° to 29°C) and a relative humidity near 100 percent, followed by cool nights (45° to 50°F or 7° to 15°C) with heavy dew, fog, or a light, drizzly rain that persists through the morning. Heavy overcast skies during the morning prevent temperatures from rising rapidly and the foliage remains wet. In moist weather, viable sporangia may be carried 20 miles or more by strong winds and rain.

The late blight fungus is a water mold that forms large numbers of microscopic, colorless sporangia (Figures 3a and b). Sporangia may germinate directly by means of a germ tube or by forming motile

Figure 4. Buckeye rot (Purdue University photo).

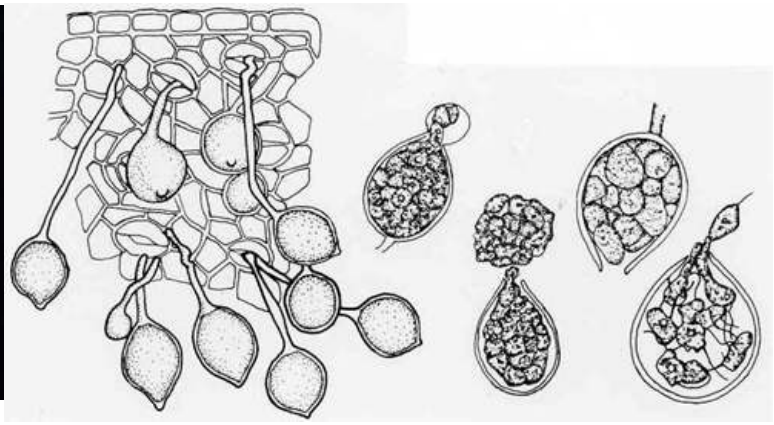

Figure 5. Phytophthora parasitica, a common buckeye rot fungus: (Left) sporangiophores emerging from stomates with immature and mature, lemon-shaped sporangia on their tips; (right) sporangia in various stages of forming zoospores (drawing by Lenore Gray).

zoospores (Figure 3d) that swim freely in water films before settling down (encysting) on leaves to cause infection. The encysted zoospores penetrate a leaf by sending a germ tube (Figure 3e) through a natural opening (stomate) in the leaf surface, or usually by forming a cushion-shaped structure (appressorium) from which an infection peg invades the leaf directly. Once inside the tomato plant, the fungus hyphae grow rapidly between the cells. Food is obtained by finger-like projections (haustoria) that invade the tomato cells and absorb nutrients. After the fungus has started to colonize the plant, initial symptoms (yellowing or chlorosis) may appear in 2 or 3 days, but usually are evident after 5 to 7 days. Soon after symptoms appear, the sporangiophores emerge through the stomates and produce sporangia which serve as inoculum for repeating, secondary disease cycles.

The conditions that favor spore production, dissemination, and infection are those which determine the extent of the epidemic. At temperatures of 45° to 86°F (7° to 30°C), with an optimum of 65° to 70°F (18° to 21°C), and a relative humidity near 100 percent for more than 10 to 15 hours, the fungus forms sporangia. The temperature and number of hours of essentially 100 percent humidity determine the rate of spore production.

The sporangia may germinate in one of two ways determined largely by the temperature. At temperatures of 45° to about 70°F (7° to 21°C), and with 100 percent relative humidity, each sporangium give rise to 8 to 12 or more motile zoospores (Figures 3c and d) in 1 to 3 hours. The optimum temperature for zoospores formation is 54°F (12°C). Each zoospores swims for a few minutes in a moisture film, encysts, then germinates to produce a germ tube and an appressorium from which a penetration peg invades the leaf. The optimum for zoospores germination is 54° to 59°F (12° to 15°C) and for germ tube development it is 70° to 75°F (21° to 23°C). Germination of sporangia occurs directly via a single germ tube at about 70° to 86°F (21° to 30°C) without producing zoospores. The optimum temperature for direct penetration is 77°F (25°C) and takes from 8 to 48 hours. Both types of germination occur at overlapping temperatures. Penetration has occurred, infection and disease development is most rapid at 72° to 76°F (22° to 24°C).

Besides tomato and potato, the causal fungus attacks eggplant, petunia, ground-cherries (*Physalis* spp), and other weeds in the potato-tomato family (Solanaceae).

SYMPTOMS

Buckeye Rot

Symptoms appear on the fruit as a grayish green to greenish brown, water-soaked spot near the blossom end, or where the fruit comes in contact with the soil. The infected area enlarges rapidly in warm weather until half or more of the fruit is affected. When the rot develops slowly, the decayed area shows definite, pale brown, somewhat concentric rings (Figure 4). The discoloration may extend to the fruit center. In staked or caged tomatoes, only the fruit clusters nearest the ground are affected. Commonly, older, diseased fruit is colonized by secondary bacteria and fungi that produce a soft, wet fruit rot. A comparison of the fruit symptoms of buckeye rot and late blight is given in Table 1.

Table 1. Comparison of symptoms on tomato fruit caused by *Phytophthora* spp. (Buckeye Rot) and *P. infestans* (Late Blight)

Host tissue	Buckeye rot	Late blight
Infected tissue	Soft and turgescent	Hard and dry
Wounded fruit	Large brown lesions	Small brown lesions
Unwounded fruit	Endocarp and seed discolored	Exocarp only brown
Around the calyx	Usually infected	Not usually infected
Vascular bundles near hilum	Discolored at an early stage	Discolored only when tissue around the calyx is infected
Reddening of fruit	Slow	Rapid
Appearance of epidermis	Green, water-soaked	Bronzing

The buckeye-rot fungi may also cause a pale to dark brown, girdling stem canker which may be somewhat sunken. Affected plants usually wilt and die. In very wet weather a sparse white mildew appears on both the fruit and the stems.

DISEASE CYCLE

The fungi causing buckeye rot are primarily soilborne and cause disease only in warm, wet weather. Like the late blight fungus, two types of spores are formed. The primary spore, or sporangium, develops first. These lemon-shaped spores are formed at the tips of simple sporangiophores that emerge through the stomates (Figure 5). The sporangia later give rise to motile zoospores. Sporangiophores and sporangia are not formed unless the soil is wet and above 65°F (18°C). At 70°F (21°C) the sporangia may be formed within 24 hours. The sporangia are spread by surface or irrigation water and splashing rains.

They may remain viable for days when conditions remain moist. During wet periods, zoospores are discharged from the sporangia (Figure 5) and are readily splattered by rain from the soil to the fruit. The zoospores swim about in a film of water for a time, encyst, and infect the fruit. Penetration can occur through the unbroken skin. Visible symptoms of the disease may appear within 24 hours and fruit rot develops rapidly. A temperature of 80°F (26°C) or above is ideal for infection and development of the disease (optimum is 75° to 86°F or 23° to 30°C). Fruit with latent infections may decay during transit. The fungi may spread from fruit to fruit in transit and storage if the temperature is 70°F (21°C) or above. The fungi are carried from one part of a field or garden to another by runoff water, farm equipment and tools, and by workers.

Other hosts of the buckeye-rot fungi include beans, corn, eggplant, melons, onions, peppers, potato, pumpkin, rhubarb, squash, and turnip.

CONTROL

1. Before planting, destroy potato cull piles and prevent growth of volunteer potatoes. Plant tomatoes as far as possible from potatoes.

2, Purchase only certified, disease-free transplants or seed. If potatoes are also planted purchase only blue tag tubers certified as disease-free.

3. Plant in a well-drained, porous soil. Follow a 3-year rotation excluding susceptible crops. Where possible, keep tomato fruit off the ground by staking or caging each plant or mulch the ground with black plastic, straw, hay, ground corn cobs, and so on.

4. The soil in plant beds and greenhouses should be disinfested with steam or a soil fumigant.

5. When transplanting, discard and destroy all tomato seedlings with lesions on the stem and leaves.

6. Control all weeds. In commercial fields and home gardens eradicate all diseased potato tubers plus nightshades, Jerusalem-cherry, groundcherries, and other weeds in the Solanaceae.

7. When the foliage is wet with fog, dew, or rain, do not cultivate or work with the plants. This spreads fungal spores from plant to plant.

8. The use of protective fungicides is essential in controlling late blight and buckeye rot. For information on current fungicide recommendations, refer to Midwest Management Guide for Commercial Vegetable Growers. Spray applications should begin no later than 2 weeks after the first tomato flowers are open, and should continue at 5- to 10-day intervals. Five spray applications are usually sufficient in a “dry” season, while 6 to 8 sprays may be required in a “wet” season. When possible, time the applications for maximum deposit on the foliage and fruit just before rainy periods when most infections occur. If late blight is reported in the vicinity, county, or the general area, fungicide applications should be made at once regardless of the stage of plant development. If late blight appears in the field or garden, the interval between applications of fungicide should be shortened to 5 days until no further spread of the disease is noted. Buckeye rot is not apt to be a problem if fungicides are applied for general control of foliar and fruit diseases on a regular 7- to

10-day schedule. It is important, however, to apply fungicides early, and to uniformly cover all fruit. Take extra care to see that the center of each plant and the undersides of the leaves are protected. Follow the manufacturer's directions as regards amounts to use, interval between the last spray and harvest, and the compatibility of fungicides and insecticides.

9. In the home garden, harvest all ripe fruit at each picking. If left in the field, such fruit will decay, and serve as a source of infection for remaining fruit.

10. After harvest is completed, spade or plow under, compost, or burn all tomato vines. Destroy all potato cull piles, volunteer plants, and solanaceous weeds.

11. Rotate 3 or 4 years before planting tomatoes or potatoes in the same area. If buckeye rot is a problem, also exclude other vegetables which are hosts of the causal fungus (see previous item).

13. Cultivars are available with varying degrees of resistance to the late-blight fungus. For more information on recommended varieties, refer to current seed catalogs and trade publications.

14. Several late blight-forecasting systems have been developed to help growers identify periods when the environment favors disease development and fungicide coverage is most important.

Publications available at your nearest Extension office: C1373 Midwest Vegetable Production Guide for Commercial Growers, and C1331 Vegetable Gardening in the Midwest. They can also be purchased from ITCS, University of Illinois P345, 1917 S. Wright St., Champaign, IL 61820.