Late Blight of Potato and Tomato

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Late blight, the infamous disease that in the 1840s devastated the potato crop in Europe and led to the Irish potato famine, continues to be a serious threat to potato and tomato production worldwide. In Idaho, isolated incidences of the disease appeared in potato in 1984 and in greenhouse-grown tomatoes in 1993. In 1995, however, the disease broke out in epidemic form in potato fields in the Treasure Valley and Magic Valley, causing significant losses and increasing the cost of production due to the need for repeated fungicide applications. It is possible that late blight will continue to be a major concern not only of the potato industry but also of home gardeners and of nursery and greenhouse operators.

Figure 1. Late blight lesions on a potato leaf. Note the water-soaked, brown to black tissues and the white fungal growth.

Symptoms

Potato

Late blight can infect leaves, stems, and tubers throughout the growing season. Leaf symptoms appear initially as water-soaked, pale green to brown areas (fig. 1), sometimes bordered by a pale green or light yellow halo. Leaf lesions begin most commonly at the tips and margins of leaflets where moisture collects and expand rapidly under favorable weather conditions. Leaf areas that are killed by the blight may turn dark brown or black.

Under conditions of high humidity, a fine, white, cottony growth of the fungus may appear on the undersurface of the infected area (fig.1). This growth is composed of the spore-bearing structures (sporangiophores) and spores (sporangia) of the fungus. If weather conditions turn dry and hot, lesion expansion stops, and the blighted, dried area is usually bordered by a characteristic light yellow or pale green halo (fig. 2).

Figure 2. Late blight lesion on a potato leaf with the dead, brown area bordered by a pale green halo.

Figure 3. Late blight lesions on petiole and stem of potato plant. Note the white growth of the fungus.

Figure 4. Late blight lesion on potato stem. Note the oily, brown infected area.

Stem symptoms may start at any point, but frequently start in the axil of the first leaf below the growing point (fig. 3). Lesions appear as oily, brown areas that later turn black. They may extend along and around the stem (fig. 4). Sporulation (white, moldy growth) is not as common on stems as on leaves, except under conditions of high relative humidity.

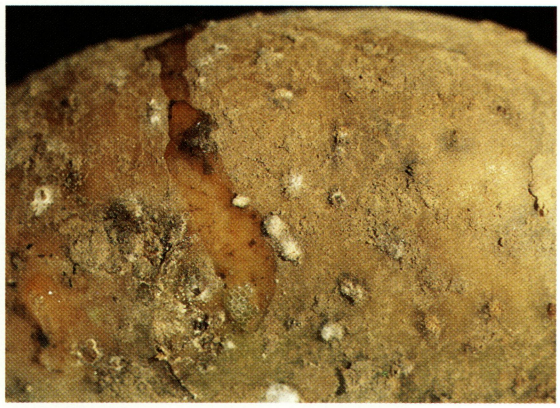
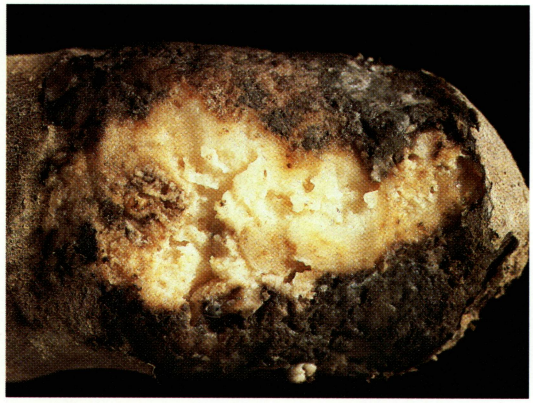


Figure 5. White tufts of late blight fungus emerging from the lenticels of an infected potato tuber.

Figure 6. Late blight infected tuber. Note the rusty brown color and the corky and grainy consistency of the internal tissue.



Infected tubers may rot in the field or may show no distinct external symptoms at harvest except for slightly sunken, water-soaked areas. When infected tubers are stored under humid conditions, tufts of white fungal growth may emerge through the lenticels (fig. 5). Late blight-infected tuber tissue, usually only 1/4 to 1/2 inch deep, is rusty brown or reddish, with a firm consistency and corky or grainy texture (fig. 6). Following invasion by soft-rotting bacteria and molds, the tissue becomes soft and mushy, obscuring the typical late blight symptoms. Although tuber infection usually occurs in the field before or during harvest, most tuber rot becomes apparent only after four to six weeks of storage. Infected potato seed pieces may give rise to sprouts with dark brown to black lesions on the stem, which may be girdled and killed.

Tomato

Leaf and stem symptoms of late blight on tomato plants are similar to those on potato plants. Leaf lesions start as irregular, water-soaked, pale green spots that enlarge, turn brown, shrivel, and dry out (fig. 7). Under moist weather conditions, the undersides of the lesions may be covered with a fine, white, moldy growth. Petioles and stems are also affected, and the whole plant may die (fig. 8). Infected fruits have dark green to brown, greasy, irregular blotches (fig. 9). At later stages, the infected fruit shrivels and, under high humidity conditions, a fine, white, moldy growth may appear on the infected areas.

Figure 7. Late blight infected tomato leaf. Note the brown, shriveled, dried area.

Distinguishing late blight from other diseases

Symptoms of some other potato diseases, such as white mold, powdery mildew, and early blight, may sometimes be confused with those of late blight. White mold symptoms, however, usually appear as a wet rot of infected tissues on plant parts close to wet soil. The water-soaked, zonate areas (fig. 10) have masses of cottony white mold and may contain hard, black overwintering structures (sclerotia) of the fungus inside dried and bleached white stems.

Powdery mildew, unlike late blight, usually appears under hot, dry conditions in furrow-irrigated fields. Brown, superficial blotches appear on stems and petioles (fig. 11).

Early blight lesions are brown and dry, usually delimited by veins, and without any white, moldy growth. They often have concentric ring patterns inside the lesions (fig. 12).

Figure 8. Late blight infected tomato plant with dead, brown leaves and stem.

Table 1. Characteristics of late blight fungus strains common in the United States.

Strain	Aggressiveness		Mating type	Sensitivity to metalaxyl
	Potato	Tomato		
US-1	+++	+	A1	Sensitive
US-6	+++	+++	A1	Insensitive
US-7	+++	+++	A2	Insensitive
US-8	+++	+	A2	Insensitive

In greenhouse-grown tomato plants, gray mold symptoms on leaves, stems, and fruits may be confused with late blight, but the presence of a gray to brownish, moldy growth on infected parts (fig. 13) helps to distinguish gray mold from late blight.

The late blight fungus

Late blight is caused by *Phytophthora infestans*, a fungus that thrives under relatively cool (50°-75°F) and wet or cool and high humidity conditions. The most common type of spores, the asexual spores or sporangia, are lemon-shaped and borne on branches (sporangiophores) of the fungus projecting out from infected tissue. These microscopic spores are easily detached and can be carried by wind for several miles under cool, humid weather conditions to initiate new infections. Sporangia may germinate directly and infect the plant or, under cool (around 50°F) and wet conditions, each sporangium may give rise to three to eight, and occasionally more, swimming spores (zoospores), each of which can initiate a new infection.

Sexual spores (oospores) are rare in nature and are produced only when strains belonging to two different mating types, A1 and A2, come into contact inside plant tissue. If one or more strains of the *same* mating type are present, no sexual spores are produced. Sexual spores can remain viable in plant debris and soil over the winter and can serve as sources of inoculum the following year. Progeny from sexual spores are likely to show more diverse and different characteristics than the currently prevalent strains, due to genetic recombination and segregation.

Figure 9. Late blight-infected tomato fruit. Note the dark green to brown areas.

Figure 10. Potato stem with white mold. Note the water-soaked, zonate area with white moldy growth.

Figure 11. Brown blotches of powdery mildew on petioles and stem of potato.

Based on certain biochemical characteristics, the strains (genotypes) of late blight fungus that commonly occur in the United States have been designated US-1, US-6, US-7, and US-8. Each of the above strains is further characterized as mating type A1 or A2 based on its ability to cross with another strain to form sexual spores. Strains also differ in their aggressiveness toward tomato or potato and sensitivity to the fungicide metalaxyl (or its active isomer, mefenoxam) (table 1).

All samples of late blight fungus from the 1995 epidemic in Idaho were identified as US-8 genotype, A2 mating type, and metalaxyl insensitive.

Figure 12. Lesions of early blight of potato. Note the brown, dry lesions delimited by veins.

Sources of late blight inoculum and spread

The principal sources of primary inoculum are infected seed tubers, infected plants from cull piles, and infected volunteer potato plants from infected tubers left in the ground the previous season. Although severely infected seed pieces may completely rot in the soil and thus not serve as sources of primary inoculum, less severely in-

Figure 13. Symptoms of gray mold on tomato stem. Note the fuzzy, brownish mold growth.

For detailed, current disease management guidelines, consult the *Idaho Action Plan for Potato Late Blight*, available through the University of Idaho Cooperative Extension System office in your county, and your local UI extension educator, fieldman, or industry consultant.

fected seed pieces are likely to give rise to infected sprouts that emerge and provide the initial inoculum. Infected potato and tomato plants in home gardens, greenhouses, and nurseries can also serve as inoculum sources for field infections. Hairy nightshade (*Solanum sarrachoides*), a common weed, can be infected by the late blight fungus and may contribute inoculum to the potato crop.

Sporangia are spread principally by wind and rain, with limited local dispersal possible by irrigation water and insects. Most tuber infection in the field occurs when spores from infected above-ground parts of the plant are washed down into the soil by rain or irrigation water and come in contact with developing tubers, or during harvesting operations. Wet soils and a thin film of moisture on the tuber surface facilitate tuber infection.

Weather conditions that favor the disease

The incidence and severity of late blight are strongly influenced by the prevailing weather conditions. Cool (50°-75°F), rainy weather, high relative humidity, and heavy dew formation favor infection, disease progress, and spore production. If weather conditions turn dry and hot, the disease practically stops progressing. Rain and irrigation, along with cool and wet soils, favor tuber infection.

Optimal conditions for sporangial production are nearly 100 percent relative humidity and temperatures in the range of 60° to 70°F. In the presence of free water and temperatures of 58° to 60°F, sporangia germinate within two hours and complete penetration of the host tissue within the next two to two and one-half hours. Once inside the host tissue, the fungus develops optimally at 62° to 70°F. Under favorable conditions, a new crop of spores is produced within four to five days of infection. This cycle of spore dispersal, infection, and spore production is repeated several times during the season.

Crop losses

Late blight can cause serious economic losses depending on the severity of the disease, the crop variety, and management practices. Losses may be in the form of reduced yield, lower quality (low specific gravity, for example), tuber rots in storage, increased costs associated with fungicide applications, and diminished storability. In experiments conducted during 1995 in southwestern Idaho, a 48 percent yield reduction was documented in the potato variety Shepody. If the disease becomes severe early in the season, and if adequate control measures are not applied, there could be total crop loss.

Control

All currently grown commercial potato and tomato varieties are susceptible to late blight. However, varieties may differ in their level of susceptibility, the impact of the disease on yield and quality, and the extent of tuber infection. Of the various cultural practices influencing disease development, irrigation management is among the most important. Hilling practices and soil type also influence the degree of tuber infection. Vine killing, harvesting, handling, and storage practices can significantly influence the extent of tuber infection and tuber rot in storage. Since the fungus grows and produces spores only in living tissues, tuber contamination with spores during harvest can be avoided by a thorough vine-kill at least two weeks before lifting the tubers.

Use of disease-free seed pieces is essential to prevent the establishment of the disease in the field. Timely and appropriate disposal of cull piles and control of volunteer potato plants will eliminate potential sources of the fungus. Regular scouting of fields for late blight symptoms and timely application of fungicide sprays, depending on the prevailing weather conditions and disease forecasts, help prevent establishment and spread of the disease.

Among the fungicides for control of late blight are two main groups of compounds: (1) protectants (for example, chlorothalonil, dithiocarbamates, and triphenyl tin hydroxide) and (2) systemics (for example, cymoxanil, dimethomorph, metalaxyl/mefenoxam, and propamocarb) mixed with protectants. The most important considerations when applying fungicides are timing, thorough coverage, and continuous protection of plants as long as weather conditions favor the disease.

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