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Diseases of Potato: Late Blight

by Melvyn L. Lacy and
Raymond Hammerschmidt
Department of Botany and
Plant Pathology

Late blight of potato, caused by the fungus *Phytophthora infestans*, is a potentially destructive potato disease in Michigan. When weather conditions are favorable, the fungus can spread rapidly through the foliage and is capable of causing complete blighting of foliage within a very short time. If left uncontrolled, complete destruction of the crop may result. In addition to blighting foliage, the fungus can infect tubers while they are still in the ground or in storage. Because the disease is so potentially destructive, careful attention should be given to the disease cycle and to control practices.

Figure 1. White mildew on late blight-infected leaf.

Figure 2. Potato leaves showing typical late blight lesions.

Symptoms

The first symptoms of late blight in the field are small, light to dark green water-soaked spots of circular to irregular shape on the lower leaves. Lesions may develop at leaf tips or edges, causing young expanding leaves to be misshapen (Fig. 1). During cool, moist weather, these lesions expand rapidly into large, dark brown to black lesions (Fig. 2). Leaves can become blighted and killed within just a few days.

If leaves are examined in the early morning during cool damp weather, a white mildew can be seen on the underside of infected leaves (Fig. 1). A pale green to yellow border is often present around the lesions. Plants severely affected by late blight have a distinctive odor resulting from the rapid breakdown of potato leaf tissue. The same odor may be detected after chemical vine-kill or a severe frost.

Positive identification of late blight can be made by microscopic examination of samples from infected leaves or tubers collected during damp cool weather when the fungus is forming spores. The fungus can be quickly identified by the distinctive size and conformation of spores and spore-bearing stalks (Fig. 3).

On tubers, late blight infection is characterized by irregularly-shaped, slightly depressed areas of brown to purplish color of variable size on the skin (Fig. 4a, page 4). A tan to brown, dry granular rot found under the skin extends into the tuber (Fig. 4b, page 4). How far rotting extends into the tuber depends on susceptibility of the cultivar, length of time after infection, and temperature. The boundary between diseased and healthy tissue is not sharp, as brown, peglike areas may extend into otherwise healthy tissue at various depths. Severely affected tubers may display extensive rot, and there may be evidence of the causal fungus growing on the surface of tubers (Fig. 5, page 4). Secondary organisms, which normally do not cause disease, may follow late blight into tubers, causing extensive tuber rotting that complicates diagnosis.

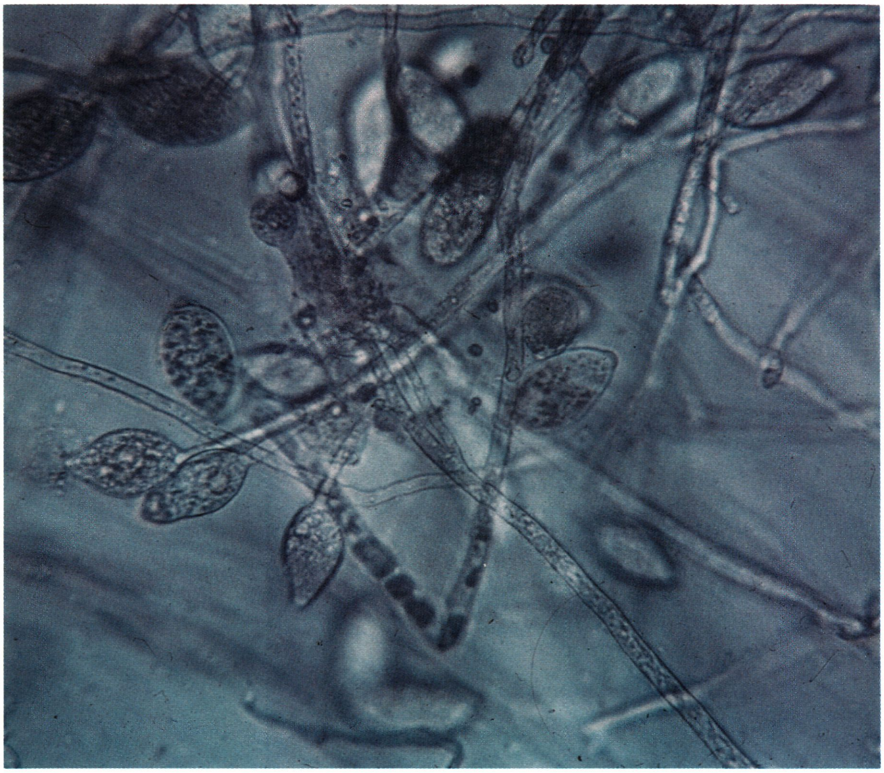

Figure 3. *Phytophthora infestans:* sporangia and sporangiophores.

Disease Cycle and Control

Late blight is a water mold that forms large (21-38 x 12-23 m), clear, lemon-shaped spores called sporangia which are borne on stalks called sporangiophores (Fig. 3). The sporangiophores have periodic swellings at points where sporangia were produced.

Sporangia may germinate by means of a germ tube or by forming motile zoospores that swim freely in water films and encyst on leaves to cause infection. Encysted zoospores enter the leaf by sending a germ tube through a pore (stomate) in the leaf surface, or by forming a cushion-shaped structure called an appressorium that penetrates the leaf cuticle directly. Once inside the plant, the fungus threads grow directly through or between cells. Fungus that grow threads between cells send finger-like structures called haustoria into cells to absorb nutrients from the plant.

Late blight is transmitted year to year from infected tubers that are placed in storage or left in cull piles. Cull piles are probably the most important source of spores in spring from which late blight epidemics start. Infected tubers sprout, spores are formed on the sprouts and are carried by air currents to healthy potatoes. Large numbers of spores can be produced under favorable (cool and damp) conditions.

Secondary spread of late blight occurs when spores are produced on infected potato leaves. The spores are then carried to healthy tissue by rain or wind. Late blight spreads most rapidly during cool, wet weather. At temperatures of 55 to 70°F, and humidities below 100%, the fungus forms conidia which germinate by means of a single germ tube. At temperatures of 45-55°F and with 100% relative humidity, the fungus forms sporangia, each of which gives rise to 8-12 motile zoospores. Each zoospore swims for a time, encysts, and then penetrates the leaf. Night temperatures of 50 to 60°F accompanied by rain, fog or heavy dew, followed by day temperatures of 60-70°F with high relative humidity over a 4-5 day period, are ideal conditions for late blight development.

Tubers may become infected if spores produced on the foliage are washed down into the soil by rain or irrigation water. Tubers may also be infected by air-borne spores during the harvesting operation. When this occurs, tuber rot develops in storage even though the crop appears healthy going into storage.

Several measures should be taken to control late blight:

1) Clean seed, preferably certified, should always be planted.

2) Cull piles should be destroyed. To prevent cull potatoes from sprouting, either bury the culls or feed them to livestock. You can also haul them to a site at least one mile from potato fields.

3) Foliage should be protected with fungicides during periods favorable for infection. Coverage of the foliage should be thorough and sufficiently frequent to prevent infection of new growth.

4) Avoid frequent overhead irrigation of potatoes which maintains leaf wetness and high humidity in the plant canopy.

5) Vines should be killed at least one week before harvest to promote death of any late blight spores on the leaves and prevent tuber infection at harvest. If visible late blight infection exists, vines should be killed two weeks before harvest to allow sufficient time for tubers to either develop visible lesions or rot in the soil.

6) Tubers should be dry when placed in storage. If any infection is believed to be present, forced air ventilation through the storage bin can help minimize spread from tuber to tuber.

7) Some cultivars such as Sebago have a moderate level of field tolerance to late blight, but fungicides must still be used for control.

A new systemic fungicide (Metalaxyl or Ridomil) has proven to be effective in halting development of existing infections or preventing new ones. Since the material is systemic, it is absorbed into the foliage and is not subject to loss by weathering. It is effective at low dosages and its protection lasts for about 14 days. Metalaxyl is sold as a mixture with mancozeb under the trade name Ridomil MZ 58. There are a number of nonsystemic protectant fungicides registered for use on late blight, but they must be applied more frequently and will not control existing infections.

If Ridomil MZ 58 is used for late blight control, and if early blight is a threat, supplemental applications of protectant fungicides should be made between Ridomil MZ 58 applications. Ridomil MZ 58 will not adequately control early blight.

See MSU Extension Bulletin E-312, *Chemical Control of Insects, Diseases and Nematodes on Commercial Vegetables,* for further details on chemical control.

Photography credit: Randall Rowe, Department of Plant Pathology, Ohio State University. Figures 1, 2, and 5.

L. Patrick Hart, Department of Botany and Plant Pathology, Michigan State University. Figure 3.

W. J. Hooker, Professor Emeritus, Department of Botany and Plant Pathology, Michigan State University. Figure 4a and b.

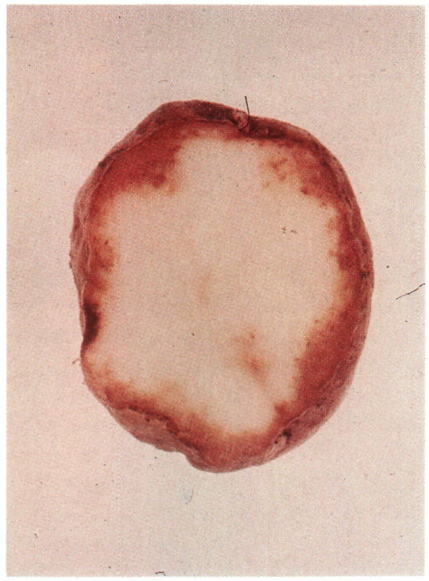

Figure 4a.(left) Late blight-infected tuber.
Figure 4b.(right) Cross-section of blighted tubers showing tan to brown rot found under the skin.

Figure 5. Infected tubers showing the fungus on surfaces of rotting tubers.

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Diseases of Potato: Late Blight

M. L. Lacy and R. Hammerschmidt
Department of Botany and Plant Pathology

Late blight of potato, caused by the fungus *Phytophthora infestans*, is potentially a very destructive disease of potato in Michigan. During favorable weather — periods of moderate temperatures, high humidities, and frequent rainfall — the disease can spread extremely rapidly by means of asexual spores known as sporangia (Fig. 1), and it has the potential of completely defoliating fields within three weeks of the first visible infections if no control measures are taken. In addition to blighting the foliage, the spores of the fungus can infect tubers before or during harvest, and lead to tuber rot.

Late blight has become more difficult to control since the introduction into the United States of new genetic types of the fungus. The four genotypes known to occur in the United States as of 1995 are US-1, US-6, US-7, and US-8 (Table 1).

Table 1.
Four genotypes of Phytophthora infestans occurring in the United States.

Genotype	Mating type	Metalaxyl[1] reaction	Host(s)
US-1	A1	Sensitive	Potato
US-6	A1	Resistant	Potato/tomato
US-7	A2	Resistant	Potato/tomato
US-8	A2	Resistant	Potato

[1] *Sold under the trade name Ridomil.*

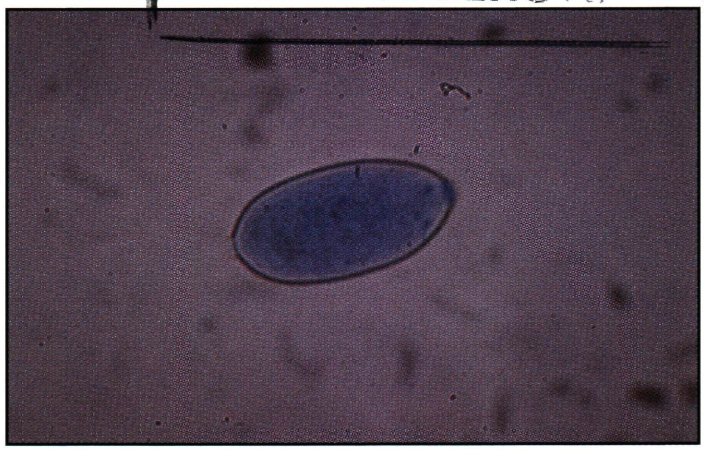

Figure 1. A sporangium (asexual spore) of the late blight fungus *Phytophthora infestans.*

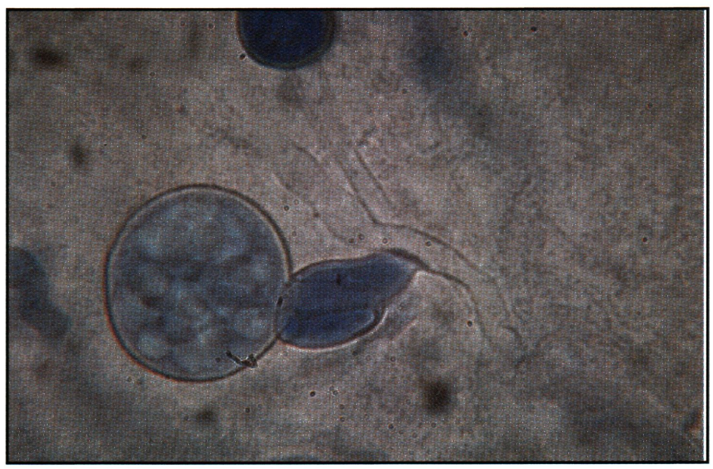

Figure 2. A young oospore (sexual spore) of the late blight fungus *Phytophthora infestans.*

Before 1993, only the US-1 genotype had been found in Michigan. US-1 is sensitive to the systemic fungicide metalaxyl and is mating type A1. The late blight fungus requires two mating types, known as A1 and A2, which have to come into contact to produce a sexual spore known as an oospore (Fig. 2). Oospores are resistant to freezing and other environmental extremes and can survive in diseased leaves or stems, or free in soil. When only one of the mating types is present, the fungus can survive only as vegetative mycelium in infected tubers. If infected tubers freeze and die over winter, or if they are buried too deeply to sprout in a landfill, the disease cycle is broken, and very often the disease does not appear even when weather conditions are favorable. With the arrival of the A2 mating type, the potential exists for the production of resistant overwintering oospores that can survive in dead leaves or free in the soil. Unfortunately, not much is currently known about the length of time these oospores might remain viable under Michigan conditions.

Another complicating factor in control was the appearance in 1993 of insensitivity (resistance) to the systemic fungicide metalaxyl (Ridomil) in late blight fungus populations. Metalaxyl has been a major factor in controlling late blight because of its systemic property that allows it to be absorbed into plant tissue. Once absorbed, the fungicide will not wash off of foliage. On late blight strains sensitive to this fungicide, effectiveness lasted for 10 to 14 days on foliage and the fungicide was translocated into tubers. However, since the introduction of metalaxyl-resistant strains of the late blight fungus, control of late blight with metalaxyl has not been nearly as effective.

New genotypes US-6, US-7, and US-8 appear to be more aggressive and destructive than US-1. In addition, genotypes US-6 and US-7 readily infect tomato as well as potato, so potatoes should not be planted within one mile of commercial tomato fields if possible. Hairy nightshade (*Solanum sarachoides*) has been reported as a weed host of late blight.

Symptoms

The first symptoms of late blight in the field are fairly large, dark, more or less circular spots (Fig. 3). Lesions may be on lower leaves where the microclimate is more humid, or they may occur on upper leaves if weather conditions are favorable and they have been carried into the field by air currents. If you check plants early in the morning during favorable weather, you can observe a white fuzzy growth on the undersides of leaves where the fungus is forming the spores that spread the disease (Fig. 4). Lesions

Figure 3. Young late blight lesions on potato leaflets.

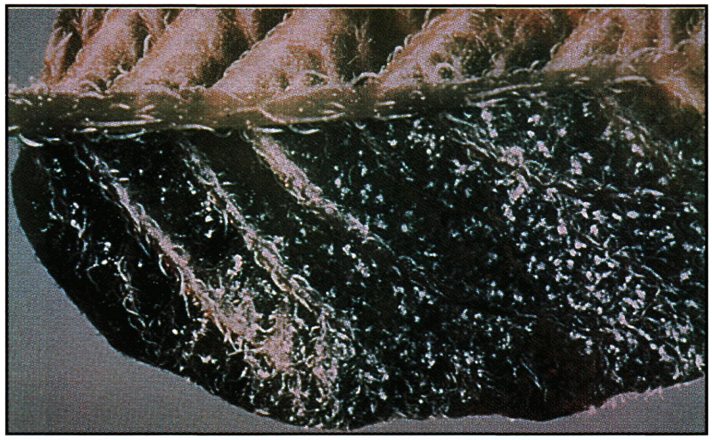

Figure 4. The late blight fungus forming spores on the underside of an infected leaf.

Figure 5. Well developed late blight lesions and curling and cupping of leaflets.

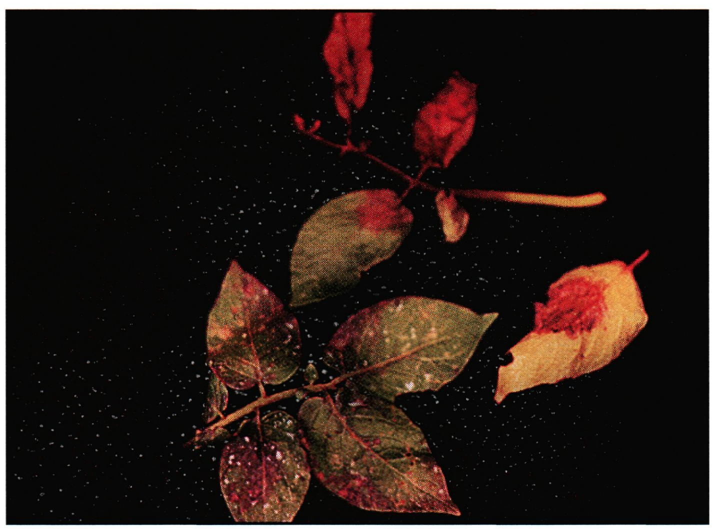

Figure 6.
Lesions on petioles of potato caused by the US-8 genotype.

expand rapidly, and if they are formed at leaf tips or edges, they can cause young expanding leaves to be misshapen (Fig. 5). The new genotypes often cause lesions on leaf petioles or stems (Fig. 6). Lesions on petioles and stems were formerly quite rare. Plants severely affected by late blight have a distinctive odor resulting from the rapid breakdown of potato leaf tissue. It is the same odor evident after chemical vine kill or a severe frost.

Disease Cycle and Control

Late blight is a water mold that forms relatively large, clear, lemon-shaped spores called sporangia (Fig. 1) on stalks called sporangiophores. Though they are relatively large in comparison to other fungi, these spores cannot be seen without the aid of a microscope that can magnify at least 100 times. The sporangiophores have periodic swellings at points where sporangia were produced.

Sporangia may germinate at temperatures of 44 to 55 degrees F when free water is present on leaves by forming 8 to12 motile zoospores each. These swim freely in water films, encyst on leaf surfaces, and infect the plant. Encysted zoospores infect leaves by penetrating leaf surfaces with a germ tube, either through stomata (breathing pores) or by means of direct penetration. At temperatures of 55 to 70 degrees F, sporangia germinate by means of a single germ tube. Night temperatures of 50 to 60 degrees F accompanied by light rain, fog, or heavy dew, followed by days of 60 to 75 degrees F with high relative humidity, are ideal for late blight infection and development.

Tubers may become infected if sporangia produced on the foliage are washed down into the soil by rain or irrigation water. It appears that water-borne spores follow stems and stolons in a water film into the soil, reach tubers, and cause infection. Tubers near the soil surface are more likely to be infected. Late blight infection on tubers is characterized by irregularly shaped, slightly sunken areas of brown to purplish color (Fig. 7). A tan to brown, dry granular rot found under the skin extends into the tuber (Fig. 8). How far rotting extends into the tuber depends on the susceptibility of the cultivar, the length of time after infection,

Figure 7. Well developed symptoms on the exterior of infected tubers.

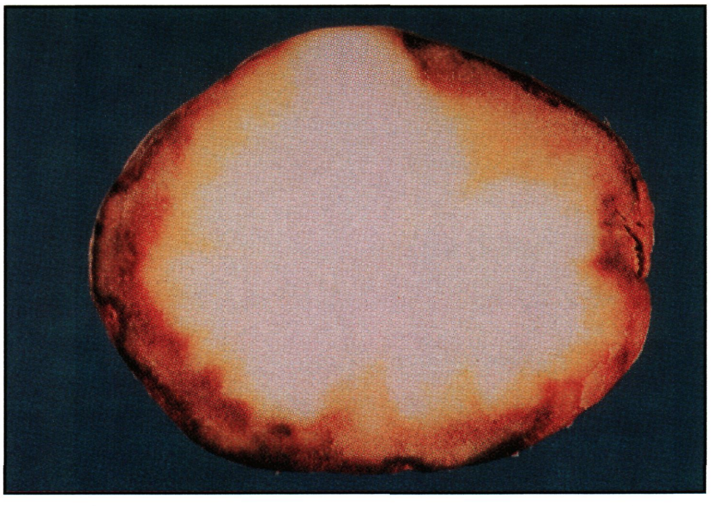

Figure 8. A cross-section of a tuber showing brown, granular tissue beneath the tuber skin.

and the temperature. The boundary between diseased and healthy tuber tissue is not sharp. Brown, peg-like areas may extend into otherwise healthy tissue at various depths.

The late blight fungus usually survives from year to year in infected tubers placed in storage, in piles of cull potatoes, or in volunteer potatoes. Infected tubers in cull piles are probably the most important source of spores in spring to begin the disease cycle. Infected seed potatoes can also initiate disease, so it is very important to plant with blight-free seed. Remember that there has to be more than 1 percent infection of certified seed potatoes before a seed lot can be rejected by an inspector. Some infected tubers may rot in the soil before emergence, and not every potato that emerges from an infected tuber will contract late blight. However, if only a small percentage of potato plants sprouting from infected tubers contract late blight, this is enough to initiate an epidemic when conditions are favorable. Confidence in your seed supplier and use of certified seed are important factors in growing healthy potatoes.

The presence of both the A1 and A2 mating types in Michigan raises the possibility that the late blight fungus can overwinter as resistant oospores in plant debris or free in the soil. It has not yet been proven that oospores are important in the disease cycle, but we must be conscious of the possibility. If the fungus does produce overwintering oospores, the fungus may be able to overwinter more easily and may become a factor in virtually every growing season when conditions favor the development of late blight.

Growers should take several measures to control late blight:

1. Always plant clean certified seed. Try to know your seed supplier so that you have confidence you will not get late blight-infected seed. Carefully inspect all seed lots on arrival at the farm or delivery point. Any tubers suspected of being infected with late blight should be tested to confirm its presence. Contaminated loads of seed should be rejected.
2. Protect foliage with recommended fungicides during periods favorable for late blight development. Blitecast — a computer program that forecasts periods of high risk — can be used to determine when the threshold value of 18 accumulated severity values is reached, which initiates the spray program. If Blitecast is not used, a rule of thumb that sprays begin when plants touch within rows can be used to start the spray program. See Extension bulletin E-312 for fungicide recommendations.
3. If irrigation is applied, try to apply water during the hours of midnight to 8 a.m. to avoid prolonging the length of time leaves are wet. Leaves are often wet with dew during these hours anyway, so irrigation during this period does not unduly prolong the leaf wetness period . Alternatively, apply irrigation during daylight hours, beginning after leaves have been dry for at least two hours and ending two hours before dark, again so leaves have a dry period before and after irrigation. Most disease-causing spores are released into the air between the hours of 9 a.m. and 1 p.m.
4. Kill vines at least two weeks before harvest in blight-infected fields. Make sure vines are completely dead. If blight is present in the field or in the vicinity of the field at harvest, spray foliage after vine killing with labeled fungicides to kill living late blight spores on the foliage (observe the preharvest interval of the fungicides chosen; some can be applied up to the day of harvest). This practice will help prevent contact between tubers and spores during harvest and help prevent infection of tubers.
5. If tubers are stored, they should be dry when placed in storage, and the storage air temperature and humidity should be managed so that the tubers remain dry. Condensation of moisture on tubers, resulting from air circulating through the tubers that is warmer than the temperature of the tubers, will cause any late blight fungus present to form spores, and late blight will spread in the pile. Potatoes should be held at the lowest temperature possible consistent with their ultimate use (table stock or chipping). Most fungi do not grow much at temperatures of 38 degrees F or lower, but some development will occur at higher temperatures.

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