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report on
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LATE BLIGHT OF POTATO

Late blight, caused by the fungus *Phytophthora infestans* is potentially the most destructive disease of potato. The disease causes death of foliage and stems and a rot of tubers in both field and storage. Under favorable conditions for disease development, entire fields can be lost to the disease within 10 to 14 days.

Figure 1. Late blight fresh lesions on lower leaf surface.

The Irish potato famine (1845-1848) bears stark evidence to the destructive potential of this disease. Favorable weather for blight development and the almost total dependence of the Irish population on the potato for food resulted in an estimated one million persons dead of starvation and in the emigration, mostly to the United States and Canada, of over one and a half million Irish.

Late blight often severely affects tomatoes (see Report on Plant Diseases No. 913) and occasionally is found on eggplant and many other members of the nightshade family (Solanaceae).

SYMPTOMS

Leaf symptoms are highly variable, depending on temperature, moisture, light intensity, and the potato variety. Typically, small pale to dark olive green, angular to irregular, water-soaked spots appear first on the lower leaves of a few plants. Lesions may develop at the leaf tips or edges, causing young expanding leaves to be misshapen. During cool, moist weather, these lesions rapidly expand into large, dark brown to purplish black dead areas (Figure 1). Under conditions favoring rapid spread, entire vines can be blighted and killed within just a few days.

Figure 2. The causal fungus fruiting on the underleaf surface.

If leaves are examined early in the morning, during cool damp weather, a sparse, white, downy mildew can be seen mostly on the underside of infected leaves (Figure 2). A pale green to yellow border is commonly present around the lesions.

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Plants severely affected by late blight give off a distinctive odor due to the rapid breakdown of potato leaf and stem tissues. The same odor may be detected after chemical vine killing or a severe frost.

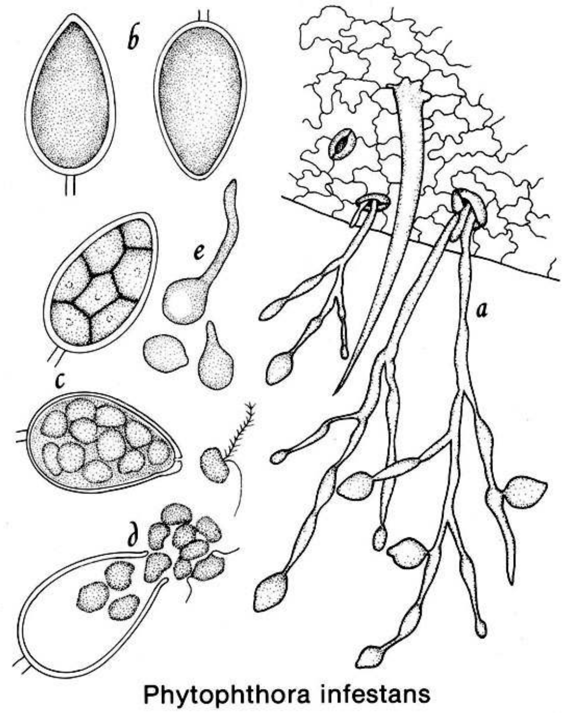

Figure 3. Phytophthora infestans, the late blight fungus, as seen under a high-power microscope: a, two sporangiophores emerging from stomates on the underside of a potato leaf and bearing a number of lemon-shaped sporangia; b, two sporangia; c, sporangial contents dividing up to form zoospores; d, sporangium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

Positive identification of late blight requires confirmation made by a microscopic examination of samples from infected leaves or tubers. The plant samples are incubated overnight in a moist chamber. The fungus can be easily and quickly identified by the distinctive size and shape of the spores (sporangia) and the spore-bearing structures, the sporangiophores (Figure 3).

On tubers of susceptible varieties small to large, irregular, slightly depressed, red to brown or steely purple areas are evident on the surface. A tan to dark reddish brown, dry, granular rot characteristically extends into the tuber (Figure 4). How deep the rot extends into the tuber depends on the susceptibility of the variety, length of time after infection, and the temperature. The boundary between diseased and healthy tissue is not sharp; delicate, brown, peglike areas extend into otherwise healthy tissue to variable depths. If storage conditions are cool and dry, tuber lesions develop slowly and may become slightly sunken after several months. Severely affected tubers may show extensive rot, and the late blight fungus may be seen growing on the surface of the tuber under damp conditions. Secondary bacteria and fungi commonly invade late blight lesions (Figure 4, right) causing a wet, partial to complete tuber decay that complicates diagnosis.

DISEASE CYCLE

The late blight fungus is a water mold that forms large numbers of microscopic, colorless, lemon-shaped sporangia (Figure 2a and b). Sporangia may germinate directly by means of a germ tube or indirectly by forming motile zoospores (Figure 2c). The zoospores 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 2d) through a natural opening (stomate) in the leaf surface or by forming a cushion-shaped structure (appressorium) from which an infection peg invades the leaf directly (Figure 2e). Once inside the potato plant, the fungus hyphae grow rapidly

Figure 4. Late blight lesions on tubers. Left, external symptoms; right, internal symptoms (courtesy E. Wade, Wisconsin).

between the cells. Food is obtained by fingerlike projections (haustoria) that invade the potato cells and absorb nutrients. After the fungus has started to colonize the plant, initial symptoms (yellowing) may appear in 2 or 3 days, but usually are evident after 5 to 7 days. Soon after symptoms appear, sporangiophores emerge through the stomates and produce sporangia which serve as inoculum for repeating, secondary disease cycles.

Figure 5. Late blight-infected sprouts from a potato cull pile (courtesy University of Wisconsin).

The late blight fungus overwinters in infected tubers (1) placed in storage, left in the field, or dumped in cull piles, and (2) in diseased tomato transplants from the south. Cull piles are probably the most important source of spores in the spring from which late blight epidemics start. If cool, damp conditions occur when the tubers are sprouting, the fungus grows systemically into the new sprouts and forms large numbers of sporangia on the young leaves and stems (Figure 5). These spores are carried by air currents and rain to nearby healthy potato plants.

Secondary spread of late blight in a field occurs when sporangia are produced on diseased potato leaves and stems. The spores are then carried to healthy tissue primarily by wind and rain. Sporangia are very delicate and require continuous moisture or 100 percent humidity for survival. The spores can be blown long distances during moist weather. Under dry, sunny conditions the sporangia are killed within a few hours by drying or ultraviolet rays.

The conditions that favor spore production, dissemination, and infection are those which determine the extent of an 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 70°F (7° to 21°C), and with 100 percent relative humidity. Each sporangium gives rise to 8 to 12 or more motile zoospores (Figure 2d) in 1 to 3 hours. The optimum temperature for zoospore formation is 54°F (12°C). Each zoospore 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 zoospore 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 occurs at temperatures between 50° and 85°F (10° to 29°C). Once penetration has occurred, infection and disease development is most rapid at 72° to 76°F (22° to 24°C).

Night temperatures of 50° to 60°F (10° to 15°C) accompanied by light rains, heavy dew or fog, followed by day temperatures of 60° to 75°F (15° to 23°C) with high relative humidity over a 4- to 5-day period, are ideal conditions for late blight development.

Tubers often become infected when rain or irrigation water washes spores off the leaves and stems and down into the soil to the tubers. In addition, air- or water-borne spores may infect tubers during harvesting if the tops are still green. When this occurs, tuber rot develops within the first weeks of storage even though the crop appears healthy going into storage.

CONTROL

1. **Destroy cull pines after harvest by burning, burying, feeding them to livestock, or spraying with a contact-type herbicide.** Rogue out and destroy volunteer plants and weeds in the nightshade family. Follow recommendations outlined in Illinois Agricultural Pest Management Handbook 2002.

2. **Plant only blue tag, blight-free, "Certified Seed Potatoes."** Large commercial growers should visit seed potato fields from which they will buy their seed. Such visits during the season preceding planting will help avoid problems.

3. **Apply protective fungicides.** Spray schedules for control of foliar diseases should be based on maximum disease control at the lowest cost. No single program is best for all situations and for all growers. Several suggested programs are given. Grower experience and the information available will largely determine the schedule to be used. Also, consider the presence or absence of the late blight fungus in a field or in the vicinity. Field inspection for diseases, weather conditions, growth stage of the plants, time during the season, and other factors should be considered. A day-to-day evaluation of the situation is often more effective and economical than a routine time schedule of fungicide application. Pesticide sprays for other purposes, such as insect control, must be coordinated with fungicide applications. The cost of applying fungicides is a large part of the total cost of growing potatoes.

Suggested Spray Schedules

a. **Application at 7- to 14-day intervals.** This program requires a minimum of information and planning and is usually both inefficient and costly.

b. **Application after each accumulated 1/2 inch of rain**. This schedule is based on the assumption that 1/2 inch of rain will remove about half of the fungicide applied at the last treatment. Also, a reduction in treatments is logical during hot, dry periods. Periods of heavy dew with cool nights may indicate the need for treatment, even though rain does not fall. Fungicides deteriorate from **weathering** and **new vine growth needs protection.** The maximum period between applications may be set at about 16 days.

c. **Application based on disease parameters conducive for disease development.** This could be the most effective and economical means of applying fungicides; however, it requires the greatest amount of information, planning, and judgment. Applications of fungicides are based on the need for protection on a day-to-day basis. The following factors are used in arriving at a decision:

(1) **Presence or absence of the late blight fungus.** Surveying grower's fields and checking reports of late blight in the vicinity, county, state, and region are important. It is more economical to walk through fields in search of the disease than to treat when treatment is not needed. A careful survey is required, however, since a trace of the fungus can

multiply rapidly if conditions become favorable. A note of caution: The fungus may be present even though it is not found.

(2) **Stage of growth of the potato plants.** Older potato vines overgrow the rows and cover the ground staying moist longer than younger vines, thus providing conditions suitable for infection for a longer period of time.

(3) **Number of days since the last fungicide application.** The fungicide deteriorates with weathering, leaving new vine growth without protection. About 16 days under dry conditions should be the maximum period between sprays.

(4) **Rain.** Several hours of high humidity and free water on the foliage usually follow a rain. If this is 10 hours or more, an infection period has probably occurred. Rainfall also disseminates the spores by splashing action and removes fungicides from the foliage, making new applications necessary for protection. Roughly 1/2 inch of rain is likely to remove half of the fungicide applied previously.

(5) **Occurrence of infection periods based on forecasting methods (temperature-humidity) or the rainfall-temperature methods.** Because of our knowledge concerning the rather precise conditions required for spore production, germination and infection, it is possible to forecast "blight infection periods." These are times when the fungus is producing spores and infection is possible. Fungicide applications should be timed to provide the best possible chemical protection just before and when infections are occurring.

d. **Thorough and uniform coverage of all aboveground parts of plants with each spray is essential** if late blight is to be controlled. Commercial growers should use ground sprayers calibrated to apply 300 to 400 pounds per square inch of pressure and 100 to 200 gallons per acre; aerial applicators should use a minimum of 5 gallons per acre. Apply sprays when conditions are favorable for blight and when blight is present. Under such conditions when blight is present, shorten the spray interval to 4 to 5 days, rather than the "standard" 7 to 10 days.

A listing of fungicides recommended for applying to potato is given in <u>Report on Plant Disease</u> No. 900, "Controlling Diseases in the Home Vegetable Garden" and <u>Midwest Vegetable Production Guide for Commercial Growers</u> (revised annually). Follow the manufacturer's directions regarding amounts to use, the interval between the last spray and harvest, and compatibility between fungicides and insecticides.

4. **Irrigate in the morning when the temperature is rising, so the foliage will dry before nightfall**. Avoid frequent irrigations which maintain leaf wetness and high humidity in the plant canopy.

5. **Plant resistant varieties, particularly those developed to control certain races or strains of the late blight fungus.** It is **not** sufficient to rely completely on varietal resistance to control late blight. Certain varieties have "field resistance," which is important, particularly during mild infections. The varieties adapted to Illinois and recommended for growing are given in the Midwest Vegetable Production Guide for Commercial Growers. Also consult current seed catalogs and trade publications. Even the late blight-resistant varieties require some fungicide applications.

6. **When proper tuber size has been achieved, the vines should be killed before harvesting since tuber infection is possible as long as the potato vines are alive.** Kill the vines by burning them using a suggested vine-killing chemical, or by mechanical beating. Vines destroyed by mechanical means, such as the rotobeater, should be sprayed with a strong copper sulfate solution (20 to 30 pounds of copper sulfate per 100 gallons) prior to digging. If possible, wait 10 to 14 days after killing the vines before digging the tubers. Early killing of the vines destroys any late blight spores on the foliage and prevents tuber infection at harvest.

7. **Wait for the tubers to dry before grading.** Immediately after grading, place the tubers in a dry, cold (32° to 36°F or 0° to 2°C),. well-ventilated storage for about 60 days. If the tubers are suspected of being blight-infected in the field, or if rot is developing and spreading in storage, dry them further by forcing dry air through the storage area soon after harvest.

For information concerning how and where to obtain any of the publications mentioned above, contact your nearest Extension adviser or University of Illinois, ITCS P 345, 1916 S. Wright St., Champaign, IL 61820.