Late blight of Potato (*Phytophthora infestans*)

SYMPTOMS

Late blight of potato is identified by blackish/brown lesions on leaves and stems, may be small at first and appear water-soaked or have chlorotic borders but expand rapidly and the entire leaf becomes necrotic. In humid conditions, *P. infestans* produces sporangia and sporangiophores on the surface of infected tissue and the resulting white sporulation can be seen at the margins of lesions on abaxial (lower) surfaces of leaves. As many lesions accumulate, the entire plant can be destroyed in a matter of days after the first lesions are observed if the appropriate fungicide applications are not used.

Potato tubers can become infected in the field when sporangia are washed from lesions on the foliage and enter into the soil. Infections generally begin in tuber cracks, eyes or lenticels. Infected tuber tissues are copper brown, reddish or purplish in color. Sporulation may occur on the surface of infected tubers in storage or on discarded cull piles. Infected tubers are often invaded by soft rot bacteria which rapidly convert adjoining healthy potatoes into a smelly, rotten mass that must be discarded

DISEASE CYCLE

In the absence of the oospore stage, *P. infestans* survives between potato crops as mycelium in infected tubers or tomato fruit. If infected tubers are left behind at harvest or dumped at the edges of fields, sporangia may be produced on the infected tubers or new volunteer sprouts that appear the following spring. Air currents carry sporangia to healthy potato foliage. Sometimes seed potatoes can become infected and stem lesions occur that can kill the plant. Freshly cut seed tuber surfaces are especially susceptible to infections from airborne spores in contaminated storage facilities. If infected seed are planted, local infection can occur. The pathogen spreads by movement in infected tuber tissues and asexual reproduction.

In the presence of water and at cooler temperatures, sporangia germinate indirectly by the production and release of zoospores. At warmer temperatures, the sporangia germinate directly by the production of a germ tube. Several days after infection, new sporangia are produced on sporangiophores which emerge from stomata. The deciduous sporangia may be dispersed by wind or water to new parts of the same potato plant or new plants. Sporangia may also be washed through the soil to infect tubers. If both mating types come into contact with each other, thick-walled oospores may be produced to persist in soil or plant tissues. In areas where asexual reproduction occurs, oospores usually germinate by producing a sporangium.

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CONTROL MEASURE

1. **Use of good cultivar**: No potato cultivar is immune to all lineages of *P. infestans*, but some cultivars are more resistant than other. If the climate in which the potatoes are grown is relatively dry, even low levels of resistance may significantly reduce disease severity. Likewise improved host resistance can be combined with timely foliar fungicide sprays to enhance effective disease management. Transgenic potatoes have been developed that were modified with genes from wild *Solanum* species and these transgenic potatoes require fewer fungicide applications and are more environmentally friendly than spraying weekly
2. **Site selection:** Good drainage and good air movement will help reduce moisture levels in the crop canopy. Fields bordered by trees and dense vegetation should be avoided. The shape of the field may affect the ease and frequency of fungicide applications.
3. **Crop rotation:** Rotations of two to three years to non-host crops are recommended to control late blight. Besides potato and tomato, several weeds and ornamental plants in the Solanaceae family are known to be susceptible to late blight including nightshades. If oospore production becomes widespread, rotation plans may need to be modified to accommodate this new source of inoculum. The pathogen survives in infected tubers which decay relatively quickly, but oospores may survive in soil for many years (Stevenson, 1993).
4. **Elimination of overwintering inoculum:** In the absence of oospores, tubers infected during the previous season are the most important source of initial inoculum. Surviving tubers may be found in cull piles and tubers left in the field at harvest. Culled potatoes should be left on the soil surface to freeze, trucked to a landfill, or buried at least 1 m (3 feet) deep.
5. **Planting of pathogen-free tubers:** Only certified seed tubers should be planted. However, even certified seed tubers may be allowed to have up to 1% incidence of late blight. That is enough inoculum to cause an outbreak.  Diagnostic methods including PCR, real time PCR and LAMP assays have been developed that can be used to confirm the presence of *P. infestans* in infected tubers. Fungicide treatments are available for protecting freshly cut seed tuber surfaces.
6. **Fungicide applications**: Fungicide applications are an important means of late blight management, particularly in humid areas. Contact fungicides are effective and have not resulted in pathogen resistance after many years of use. They coat the leaves to prevent infection, but cannot stop infections once they occur. Therefore, they must be applied before plants are exposed to spores. Systemic fungicides can offer some post-infection control

RUST OF WHEAT(*Albugo candida*)

SYMPTOMS

**Symptoms** of white rust caused by **Albugo** typically include yellow lesions on the upper leaf surface and white pustules on the underside of the leaf. The pathogen is spread by wind, water, and insects. The pustules may enlarge and grow together to form larger, irregularly shaped lesions filled with the white spores. The upper surface of affected leaves shows a distinct mosaic pattern. Sometimes the disease results in clublike swellings on roots.

DISEASE CYCLE

White rust is an [obligate parasite](https://en.wikipedia.org/wiki/Obligate_parasite). This means it needs a living host to grow and reproduce. The Albuginaceae reproduce by producing both sexual spores (called [oospores](https://en.wikipedia.org/wiki/Oospore)) and asexual spores (called [sporangia](https://en.wikipedia.org/wiki/Sporangia)) in a many-stage (polycyclic) disease cycle.

White rust can overwinters in midwestern soils as thick-walled, weather-resistant spores. The overwintering spores germinate in the spring and infect young seedlings. As disease development progresses, the pathogen produces other spores in pustules on the under surface of leaves. The spores may become airborne and spread to other plants and fields. Overwintering spores are produced in decaying crop debris and released into the soil.

The thick-walled oospores are the main overwintering structures, but the [mycelium](https://en.wikipedia.org/wiki/Mycelium) can also survive in conditions where all the plant material is not destroyed during the winter. In the spring the oospores germinate and produce sporangia on short stalks called [sporangiophores](https://en.wikipedia.org/wiki/Sporangiophore) that become so tightly packed within the leaf that they rupture the [epidermis](https://en.wikipedia.org/wiki/Epidermis) and are consequently spread by the wind. The liberated sporangia in turn can either germinate directly with a [germ tube](https://en.wikipedia.org/wiki/Germ_tube) or begin to produce [biflagellate](https://en.wikipedia.org/wiki/Biflagellate) motile [zoospores](https://en.wikipedia.org/wiki/Zoospore). These zoospores then swim in a film of water to a suitable site and each one produces a germ tube - like that of the sporangium - that penetrates the [stoma](https://en.wikipedia.org/wiki/Stoma). When the oomycete has successfully invaded the host plant, it grows and continues to reproduce.

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CONTROL MEASURE

Controlling white rust is very difficult due to the nature of the 'Albugo' pathogen. The method of control is tailored to specific crops and production systems. This is why identification of specific hosts (crops and possible weeds) is necessary to determine range and location of control methods.

*Albugo* proliferates in wet and moist conditions so movement through infected fields should be limited after spore maturation in these conditions to limit spread. Minimizing irrigation in cool and moist seasons as well as eliminating [windbreaks](https://en.wikipedia.org/wiki/Windbreak) to allow faster leaf drying can be beneficial. When infection is recognized, systemically infected plant material (including culled crops) should be completely removed and destroyed. Fields should be inspected every 7–14 days to remove additional material and monitor spread. On root crops, infected leaf removal prior to harvest will limit the spread of the pathogen during harvest. Any susceptible plants or weeds should be mowed or eliminated to reduce spread.

Both conventional and organic [fungicides](https://en.wikipedia.org/wiki/Fungicide) are available and could be used to limit spread and yield losses during the spring, early summer and fall on crops and susceptible neighboring plants. Each of the 17 specific [races](https://en.wikipedia.org/wiki/Race_(biology)) of the white rust pathogen affects different plants so monitoring is essential as much as possible to limit overuse and cost of fungicide treatments. Common OMRI fungicides include [sulphur](https://en.wikipedia.org/wiki/Sulphur), [copper oxide](https://en.wikipedia.org/wiki/Copper_oxide), [rosemary oil](https://en.wikipedia.org/w/index.php?title=Rosemary_oil&action=edit&redlink=1), and [azadirachtin](https://en.wikipedia.org/wiki/Azadirachtin) products. Common conventional fungicides include [mefenoxam](https://en.wikipedia.org/wiki/Mefenoxam) and [fosetyl](https://en.wikipedia.org/wiki/Fosetyl)-aluminum products.

There are some resistant and partially resistant varieties which are necessary in landscapes where white rust is present. Long-term white rust persistence in fields is not an issue with all crops or in all states; however, non-susceptible crop rotation in infected fields for at least three years is widely recommended to limit establishment and wider dispersal of this pathogen from plant debris, soil, and perennial root material. This pathogen can eliminate viable production of susceptible crops in specific fields indefinitely if infection is widespread over many years.

The strategy for white rust control involves reducing the pathogen population in the field. This may be accomplished through procedures such as rotation out of cruciferous crops, fall plowing, and good weed control. Protective fungicides are available for use on only a few crops. White rust-resistant varieties are not available.