Agronomic Spotlight

Seminis grow forward

Lettuce Downy Mildew

- Downy mildew is a major disease of lettuce that causes economic losses worldwide.
- Epidemics of downy mildew can cause significant economic losses when conditions are cool and wet.
- Disease resistant varieties, cultural practices, and fungicides are used to manage lettuce downy mildew.

Downy mildew is one of the most widespread and economically devastating diseases of lettuce.[1] The disease directly affects the marketable portion of the crop, resulting in reductions in yield and quality.[2] Low levels of infection can require the removal of infected wrapper leaves, and severe epidemics can result in a total loss of heads or fields.[3] The disease is most severe in locations and seasons with persistent cool and wet conditions.

Symptoms

All types of lettuce (head, leaf, romaine/cos) are susceptible to downy mildew, and plants are susceptible at all growth stages.[1,2] Seedlings may die from severe infections, but established plants are rarely killed. Localized lesions usually develop on lower, older leaves first. The lesions are initially light green to yellow on the upper leaf surfaces and often have an angular shape because larger veins limit their growth (Figure 1).[1,4,5] With time, the lesions turn brown and become necrotic.

Figure 1. Angular downy mildew lesions on the upper surface of a lettuce leaf. Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org

One to two weeks after infection, mats of white, fluffy, fungal-like growth develop on the undersides of leaves (Figure 2). This white growth includes spores that spread the pathogen from plant to plant.[1,4] On rare occasions, downy mildew infections can become systemic within the plant and cause brown discoloration of internal stem and root tissues.

Figure 2. White, fluffy hyphae and spores of the downy mildew pathogen on the lower surface of an infected lettuce leaf.

Infected leaf tissue can continue to decay during transportation and storage. The necrotic tissues provide a site of infection for secondary pathogens that can result in soft-rotting resulting in further damage.[1]

Cycle and Conditions

The downy mildew pathogen is an obligate parasite, requiring living plant tissue to grow and reproduce. The pathogen is a fungal-like organism related to other pathogens such as *Phytophthora* and *Pythium.* The downy mildew pathogen has been shown to survive on infested seed and plant debris, but it is not clear if either of these sources of inoculum are important in the development of epidemics on lettuce.[1] Lettuce is the main host for this pathogen, but the pathogen can also infect other plant species including artichoke and cornflower.[3]

Lettuce downy mildew requires cool and damp conditions for the production of spores and infection of plants. Spore production is affected by light, temperature, humidity, and wind-speed. Spores are formed at night after a dark and dry period followed by a period of high humidity, and low wind-speed.[1,5] Spores form when temperatures are between 41 and 77 °F, with an optimum temperature of 60 °F. Humidity levels need to be above 90%, and wind-speeds need to be below 1 mph. Spore release starts at dawn, with the peak release between 10 am and noon.

Spores can be spread by splashing water from rain and sprinkler irrigation or carried in wind currents. Spores can

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survive for up to 15 hours once released, but it is not known how far spores can travel and still initiate infections. Once deposited on a susceptible host plant, cool temperatures and a period of leaf wetness are required for the spores to germinate and infect the plant. Spore germination and infection can take place in as little as three hours at temperatures between 50 and 72 °F.[1,5] One study conducted in coastal California showed that infections occurred when lettuce leaves remained wet until at least 10 am, and no infections occurred when leaves were dry by 8 am (2 to 2.5 hours after sunrise).[5] Once infection occurs, symptoms develop and new spores start to form on plants within five to seven days when temperatures are near 60 °F. Symptoms and spores form more slowly at cooler temperatures.[1,2]

Management

Commercial lettuce varieties with high levels of resistance to downy mildew are available, and resistance can be highly effective in managing the disease. One form of resistance to lettuce downy mildew is race specific-resistance conferred by *Dm* genes. At least 27 major *Dm* genes have been identified, but because the pathogen can adapt to this form of resistance, *Dm* genes often do not remain effective for a long time. Eventually, the pathogen can overcome resistance from a particular *Dm* gene, forming a new race of the pathogen. Some of the *Dm* genes are less effective at lower temperatures.[6]

Some commercial lettuce cultivars have resistance to most of the commonly occurring races of the pathogen, but this level of resistance is not available to all known races and in all lettuce types for growing in all areas and seasons.[4,5] Other minor resistance genes provide general, race non-specific resistance against downy mildew. These genes usually provide partial resistance, but they can remain effective for longer periods of time than *Dm* genes. Growers should choose lettuce varieties that are adapted for their needs and growing conditions and that are resistant to the races of downy mildew present in their area.

Fungicides can also be used to help manage downy mildew of lettuce. Fungicide treatments should be initiated when conditions are favorable for the disease but before symptoms develop on the plants. Treatments should continue as long as conditions remain favorable.[2,5] Fungicides should be applied in high volumes of water and at high spray pressures to ensure adequate coverage of all plant surfaces. Because the lettuce downy mildew pathogen develops resistance to some fungicides, fungicides should be applied in combination or in rotation with fungicides belonging to different mode of action groups (FRAC groups). Several fungicides are registered for use against lettuce downy mildew (see references 4, 5, and 7). Transplants can be treated with fungicides before planting to minimize the chances of introducing the pathogen into the field on infected seedlings.[4,5]

Disease forecasting systems have been developed for lettuce downy mildew to help growers know when fungicide applications are needed. These forecast systems are usually based on measurements of temperature and the duration of leaf wetness in the morning. Some systems also factor in the nighttime conditions needed for the formation of spores. Using these forecast systems can reduce the number of fungicide applications per season, as compared to calendar-based spray programs.

Cultural practices can also be used in a program of integrated disease management of lettuce downy mildew. Lettuce should be planted on sites that are less prone to prolonged periods of leaf wetness (sites with good drainage and air circulation).[5] Orienting rows parallel to the direction of prevailing winds, increasing plant to plant spacing, and using drip irrigation can also reduce the duration of leaf wetness and lower disease levels. Sprinkler irrigation results in wet leaves and can splash spores from infected to healthy plants. If sprinkler irrigation is used, apply in the afternoon to limit the duration of leaf wetness in the morning when infection usually occurs.[1,4]

Other cultural practices that can help manage lettuce downy mildew include planting in fields with no history of the disease, crop rotation, using quality seed, removing infected/sporulating plants from the field, controlling weeds, and destroying crop residues promptly after harvest to limit the spread of the disease to nearby fields.[1,3]

Sources:
[1] Subbarao, K., Davis, R., Gilbertson, R., and Raid, R. 2017. Compendium of lettuce diseases and pests, second edition. American Phytopathological Society, St. Paul, MN. [2] Raid, R. and Datnoff, L. 2003. Downy mildew of lettuce. University of Florida, IFAS Extension. HS147. [3] Schefuele, S. 2017. Lettuce, downy mildew. The Center for Agriculture, Food and the Environment, University of Massachusetts. https://ag.umass.edu/vegetable/fact-sheets/lettuce-downy-mildew. [4] Koike, S. and Turini, T. 2017. Lettuce downy mildew. UC Pest Management Guidelines, UC IPM. http://ipm.ucanr.edu/PMG/r441100411.html. [5] Matheron, M. 2015. Biology and management of downy mildew of lettuce. Arizona Cooperative Extension. AZ1682. [6] Michelmore, R. and Wong, J. 2008. Classical and molecular genetics of *Bremia lactucae*, cause of lettuce downy mildew. Eur J Plant Pathol 122:19-30. [7] Reiners, S., Wallace, J., Curtis, P., Helms, M., Landers, A., McGrath, M., Nault, B., and Seaman, A. 2018. Cornell Integrated crop and pest management guidelines for commercial vegetable production. Cornell Cooperative Extension.
Websites verified 7/3/2018

For additional agronomic information, please contact your local seed representative. Developed in collaboration with Technology Development & Agronomy by Monsanto.