PNW 643

Powdery Mildew on Sugar Beet

Importance, identification, and control

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Introduction

Powdery mildew is a recurring disease problem on sugar beet in many production areas throughout Europe, the United Kingdom, and the western United States, causing sugar yield losses of up to 30–35%. Losses are primarily determined by the age of the plant at the time of infection. In the U.S., powdery mildew was first observed in California in 1937 followed by Washington and Oregon in 1947 and 14 additional western states in the 1970s. Today, powdery mildew can be found in all sugar beet growing areas. It is well adapted to environmental conditions in semi-arid regions with warm, dry climates and large diurnal temperature fluctuations. The disease can be especially severe in arid climates.

Symptoms

The first symptoms of the disease are small, scattered, circular, white mycelium mats on older leaves, often on their undersides (figure 1). As the disease progresses, all the leaves become infected, and the plant takes on a dusty white appearance (figure 2).

The disease can spread rapidly when conditions are conducive for pathogen growth and may cover entire leaves in a short period of time (figure 3). Severely infected leaves may yellow and then turn purplish-brown. Later in the growing season, when the disease is more severe and environmental conditions are favorable, dark brown to black, globular, sexual reproductive structures (chasmothecia = cleistothecia in older literature) may appear, mostly on the upper surface of older leaves (figures 4 and 5).

Causal Organism

Powdery mildew is caused by the fungus *Erysiphe betae* (synonym = *Erysiphe polygoni*), which is an obligate parasite, requiring a living host to develop and reproduce. The fungus attacks only plant species in the genus *Beta*, such as sugar beet, fodder beet, Swiss chard, and wild *Beta* species. *Erysiphe betae* grows on leaf surfaces as a superficial mycelium (figure 1). The pathogen directly penetrates epidermal cells of the host and forms haustoria (specialized feeding structures) within the host cells.

Conidiophores—asexual, spore-bearing structures extending from the mycelium mats—produce single-

Figure 1. The first symptoms of powdery mildew are small, scattered, circular, white mycelium mats, about half the diameter of a penny. Photo by Oliver T. Neher

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celled, colorless, elliptical conidia, which are carried by wind to new infection sites (figure 6).

Sexual reproductive structures called chasmothecia may appear as dark brown to black, globular structures primarily on the surfaces of older leaves that are heavily covered by mycelium (figures 4 and 5). A chasmothecium holds multiple asci (singular = ascus), sac-like structures containing ascospores (figure 7).

Figure 2. Infected leaves take on a dusty white appearance as the powdery mildew progresses. Photo by Oliver T. Neher

Sexual reproduction presents the opportunity for genetic recombination—the exchange of genetic information between two members of a population. Genetic recombination allows for faster adaptation to new environmental conditions, the development of pesticide resistance, and new pathogenic races.

Disease Cycle and Epidemiology

The life and disease cycle of *E. betae* is closely linked to the life cycle of the host and the predominant environmental conditions. *Erysiphe betae* does not overwinter in Idaho or the eastern parts of Oregon and Washington since its conidia are short-lived and cannot survive cold winters.

The fungus is introduced annually to Idaho as airborne conidia, which are blown into the southwestern growing regions around the end of June through the middle of July. These conidia originate from areas in southern California where *E. betae* overwinters on fall-planted crops or on volunteer sugar beets. From the southwestern parts of Idaho, *E. betae* spreads to the Magic Valley in southcentral Idaho approximately 2–3 weeks later, then to the eastern growing regions.

Germinating conidia produce infection hyphae (vegetative, threadlike structures), which directly penetrate epidermal plant cells. The continuous growth of these hyphae leads to an ever-expanding superficial mycelium covering leaf surfaces (figure 1).

Originating from the mycelium mats, conidiophores (spore-bearing structures) produce new conidia that spread by wind to nearby beets (figure 6). Conidial pro-

Figure 3. Powdery mildew can infect an entire field when environmental conditions favor pathogen growth. Photo by Oliver T. Neher

Figure 4. Sexual reproductive structures (chasmothecia [cleistothecia in older literature]) as seen with the naked eye on the surface of an older leaf. Photo by Oliver T. Neher

duction continues until environmental conditions or host tissues are no longer suitable for reproduction.

Powdery mildew can develop only if conidia settle on a suitable host (*Beta* spp.) and specific moisture and temperature conditions are fulfilled. Conidial germination occurs at very low relative humidity (30–40%). The germination rate increases as relative humidity increases up to 100%. Free moisture, on the other hand, inhibits conidial germination and colony development. The optimal temperature range for conidial germination, infection, and colony development is 59°–86°F (15°–30°C) with an optimum of 77°F (25°C).

Enhanced production and viability of conidia are observed when daily temperatures fluctuate by up to 27°F (15°C) between daytime and nighttime and under conditions of low relative humidity (30–40%). A high relative humidity (60–100%), while favoring conidial germination and infection, inhibits conidial production and viability. Disease development is therefore usually slower under sprinkler irrigation than under surface irrigation because the microclimate under sprinkler irrigation favors higher relative humidity (up to 100%) and free moisture on the leaf surface.

Figure 5. Close-up of chasmothecia. Photo by Oliver T. Neher

Chasmothecia—the sexual reproductive structures—can form later in the season. Temperatures ranging from 54°F to 72°F (12–22°C) and 30% relative humidity play an important role at their formation. The sexual stage was observed only once in the U.S. until 2001 when it was observed in Idaho, Colorado, and Nebraska. The sexual stage was observed in Montana in 2003, North Dakota in 2006, and Michigan in 2010. The function of chasmothecia is not well understood, but it is thought that they provide a means of winter survival and a way for new pathogenic races and fungicide-resistant strains to develop.

Control

Powdery mildew is an insidious disease because its damage is not as obvious as the damage caused by

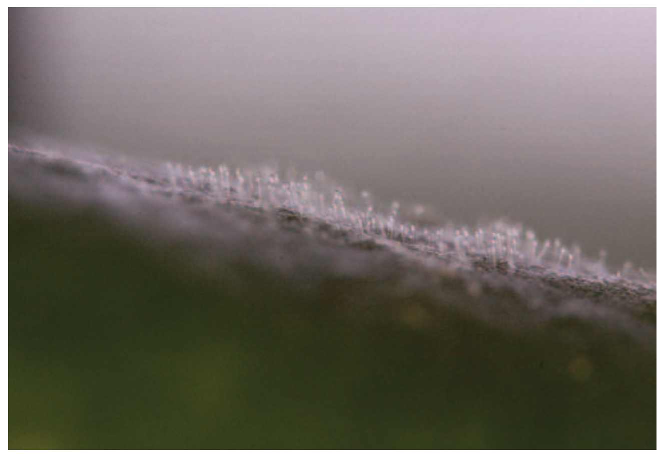

Figure 6. Conidiophores (asexual, spore-bearing structures) under magnification. Photo by Oliver T. Neher

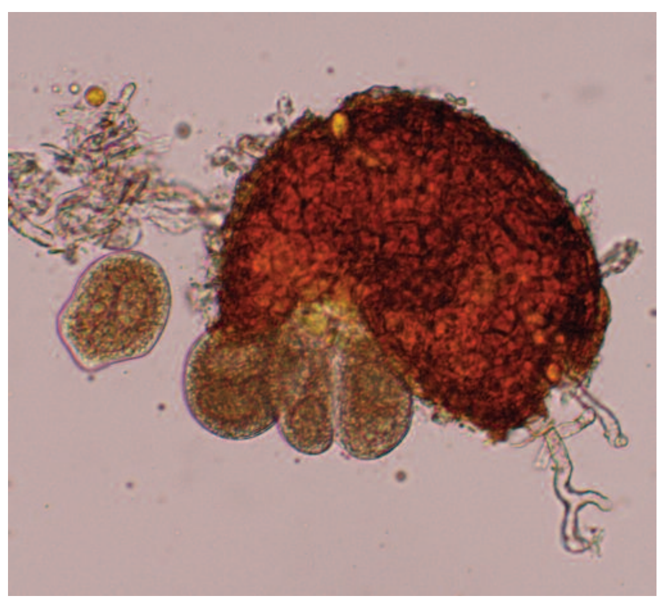

Figure 7. Crushed chasmothecium releasing asci, which contain ascospores. Photo by Oliver T. Neher

other diseases or conditions. A grower can have significant infection and sugar loss, yet still harvest a crop with high root yield.

Timing of control measures

When the disease is treated is far more important than which fungicide is used. In many instances, the crop is not being treated when it should be.

Because powdery mildew can increase rapidly, the concept of reaching a disease threshold before treatment is of little practical value. It is far more effective to treat at first disease onset, or, preferably, just prior to its historical appearance, than to wait until the disease is widespread.

If powdery mildew has been found in a nearby field, the recommendation is to treat knowing that it is coming. A delay of 2 weeks in implementing control measures can result in serious losses because inoculum levels can become too high for adequate control.

The earlier the disease appears, the more severe it will be. In cases where the disease begins to appear late in the season, the general rule based on field experiments is to treat if the disease first appears 5 weeks or more before harvest. Later treatment will be of no economic benefit.

Where multiple treatments are required, applications should be repeated every 2 to 3 weeks or as the disease reappears, but no closer to harvest than 5 weeks.

Disease monitoring

Early detection is essential for good control. In southwestern Idaho, the date of powdery mildew appearance is rather predictable. It first appears about the first to second week in July, but in some years it can appear as early as the last week of June or as late as the first week in August. Experienced growers and crop consultants are usually prepared and know when to look for it. Traditionally the disease occurs about 2 to 3 weeks later in the western portion of Twin Falls County. Travelling to the east, the first appearance is later in the growing season.

Figure 8. To detect powdery mildew early, hold the leaf against the sky. Photo by Oliver T. Neher

Disease monitoring should start in the middle to the end of June. In order to detect powdery mildew in its early stage (figure 1), examine lower leaves in the canopy. Monitoring surface-irrigated fields, fields that were water stressed, or fields that suffer from poor fertility can increase the chance for early detection of powdery mildew. In addition, plants at the border of a field, in areas with standing water, or exposed to physiological stress are more likely to show early infection with powdery mildew and can be used as sentinel plants.

To detect developing colonies, the angle of the light and the visual angle should be as low as possible in relation to the leaf surface. A good method is to roll the leaf over your finger with the questionable spot on top and hold it against the sky (figure 8). Young colonies will likely be missed if you look directly at the face of the leaf at a perpendicular angle.

Growers and crop consultants can use a simple, consistent method for monitoring disease progress and determining when to treat. First, randomly select the most recently fully expanded mature leaf from a representative number of plants in the field and estimate the percentage of each leaf surface covered by powdery mildew. Next, calculate an average of the percentages to determine the percentage mature leaf area diseased (% MLAD).

Any appearance of powdery mildew should trigger the first treatment, and an increase % MLAD in subsequent readings indicates a need for additional treatment. Research shows that there is negligible economic loss when the average, season-long % MLAD is maintained below 10%.

Cultural practices

Powdery mildew can be especially severe under surface irrigation. Surface irrigation leaves the soil well supplied with water, which increases humidity in the lower beet canopy. Increased humidity (up to about 60%), in turn, favors the development of the disease and increases its severity. Sprinkler irrigation, in contrast, tends to slow disease spread by washing conidia off the leaf surfaces and because free moisture inhibits germination of conidia and colony development. Nevertheless, drought-stressed plants sustain greater damage because infected leaves die more rapidly and therefore, photosynthesis will be reduced. Balanced irrigation can minimize the effects of excessive soil moisture and avoid drought stress.

Chemical and biological control

Timely application and good crop coverage is essential for effective control of powdery mildew. Fungicides should be applied with enough water to ensure good coverage. Fungicides belonging to the following groups provide acceptable control of powdery mildew:

- Demethylation inhibitors (DMI) (triazoles, Group 3)
- Cell-respiration inhibitors (QoI) (strobilurins, Group 11)
- Mitosis and cell division inhibitors (MBC) (thiophanates, Group 1)
- Amino acid and protein synthesis inhibitors (AP) (anilino-pyrimidines, Group 9)

Consider using resistance-management practices when applying products with a high (MBC, thiophanates) or medium (DMI, AP) potential for the development of fungicide resistance. For current availability of fungicides and proper rates, check with local crop consultants, chemical company representatives, Cooperative Extension Service representatives, or the annually revised *Pacific Northwest Plant Disease Management Handbook* (http://pnwhandbooks.org/plantdisease/). Be sure to read and follow all label information.

Sulfur provides an alternative to the above-mentioned chemicals and provides good control of powdery mildew. If possible, use sulfur dust, providing better coverage than liquid formulations. Tank mixtures with sulfur or the application of sulfur dust are recommended to reduce the development of fungicide-resistant *E. betae* strains.

Tolerant varieties

Most moderately or in some cases highly tolerant varieties (figure 9) appear to express quantitative resistance against powdery mildew. Quantitative resistance refers to resistance controlled by multiple genes. These genes are less effective by themselves, but by together controlling numerous physiological processes they can render a plant tolerant to powdery mildew. This form of resistance is not able to protect the plant completely and strongly depends on initial disease pressure. It is able to slow the infection ("slow-mildewing" phenotypes).

Disease development in a tolerant variety is usually slower than in susceptible varieties and will not reach the same level of severity. But the level of tolerance may vary, depending on environmental conditions, fertilization and water management, and overall plant health.

Figure 9. Tolerant (right) and susceptible (left) varieties grow side-by-side in trials conducted in 2010 near Parma, ID. Photo by Oliver T. Neher

Unfortunately, resistance is often incorrectly equated with immunity, and growers may incur unnecessary losses when the tolerant variety is not treated when it should be. The number of treatments required for disease management can usually be reduced when growing tolerant varieties, and in situations where only one treatment would normally be required, it may be eliminated during some seasons. Specific data for treating a powdery mildew-tolerant variety have not yet been developed.

Further reading

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Glossary

Chasmothecium (plural = chasmothecia). In older literature referred to as cleistothecium, plural = cleistothecia. An almost-round structure (figure 5) that ruptures at maturity to release multiple asci (figure 7).

Ascus (plural = asci). Sac-like structure, born inside of a chasmothecium, containing multiple ascospores.

Ascospore. A sexual spore born in an ascus.

Conidiophore. Asexual spore-bearing structures consisting of simple or branched hyphae (figure 7).

Conidium (plural = conidia). An asexual spore produced on a conidiophore.

Hypha (plural = hyphae). Tubular filaments that form the body of a fungus.

Mycelium (plural = mycelia). Mass of interwoven hyphae forming the body/colony of a fungus.

Obligate parasite. A parasite requiring living plant tissue on which to grow and multiply.

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