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DISEASES OF LANDSCAPE PLANTS

# Downy Mildew

Downy mildews are a group of closely related pathogenic 'water molds' that can cause major damage in the nursery, greenhouse, and landscape in the form of leaf spots, blights, and distortions (Fig. 1). A number of annuals, perennials, and woody plants are host for downy mildew pathogens (Table 1). Most downy mildews that infect ornamentals belong to either the genus *Peronospora* or *Plasmopara*. These pathogens can have a very wide or a very narrow range of hosts. For example, the downy mildew that infects impatiens (*Plasmopara obducens*) only infects impatiens, while the downy mildew that infects sunflowers (*Plasmopara halstedii*) is a different species of downy mildew pathogen that infects members of the daisy family, including black-eyed Susan (Figure 2).

***Figure 1.*** *The different strains of downy mildew can be very host specific, or it can infect many members of the daisy family, including this* Rudbeckia.


***Figure 2.*** *The large lesions caused by downy mildew can easily be mistaken for other kinds of damage.*

## Symptoms and Signs

On the foliage, downy mildew symptoms begin as small, water-soaked spots. Lesions first appear slightly chlorotic, with a yellow-green appearance and progress to a bright yellow on the upper leaf surface. As lesions progress, they become angular, brown (necrotic) and distorted, and plants may defoliate (Fig. 2).


***Figure 3.*** *Downy mildew symptoms can vary widely on different plants, as seen on sunflower (left), Lewisia (center) and stock (right).*

***Figure 4.*** *Downy mildew causes whitish to grayish downy fungal growth on the undersides of leaf lesions.*

Due to the wide host range of these pathogens, symptoms vary significantly from host to host (and even between cultivars), making it difficult to make generalizations about downy mildew symptoms. This variability of lesion color and size, and the severity of infection often makes the disease difficult to diagnose (Fig. 3).

Upon favorable environmental conditions, sporulation develops on the underside of lesions, with a gray, 'downy'-like appearance that can vary from a light to almost black color (Fig. 4,5). This 'down' may be sparse or thick, and appear white to grey or brown, and consists of sporangiophores and sporangia (Fig. 5).

## Biology and Disease Cycle

The disease triangle is a useful tool to understand downy mildew. Symptom severity depends upon how virulent the pathogen is coupled with the susceptibility of the host plant (Fig. 6). Plant age, health, and vigor (due to too much or too little fertilizer) also impacts disease severity. Finally, environmental conditions affect both the plant and the fungus, with cool, wet weather providing optimal conditions for downy mildews to infect.

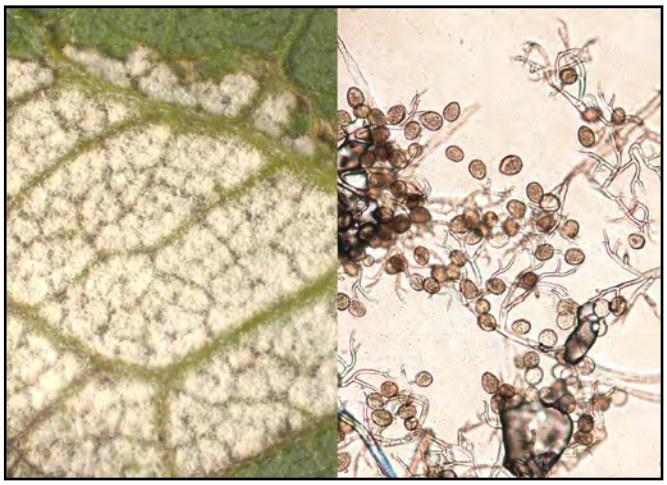

***Figure 5.*** *Close-up of downy mildew sporulation and micrograph of the downy mildew pathogen (Photo by John Bonkowski).*

The fungus overwinters in or on plant parts as mycelium or oospores (thick-walled, gumball-like structures that form the resting stage of the pathogen). Temperature and humidity play key roles in the pathogen's development.

Table 1. Midwest landscape plants that can be infected by downy mildew.

| **Annuals and Perennials** | | | |
|---|---|---|---|
| Alyssum | dead nettles (*Lamium*) | lupine | Scabiosa |
| aster (*Aster*, *Stokesia*, others) | Delphinium | pansy (*viola*) | snapdragron |
| Bachelors' button (*Centaurea*) | Dianthus | Phlox* | statice |
| bee balm (*Monarda*) | Geum | Portulaca (moss rose) | stock |
| black-eyed Susan (*Rudbeckia*) | Impatiens* | primrose | sunflower (annual and perennial) |
| Cineraria (and other daisies) | kale | Prunella | sweet pea |
| Coreopsis (tickseed) | Geranium, perennial | Osteospermum (daisy) | Veronica |
| coleus | Lewisia | sage (Salvia) | Viola |
| **Trees and Shrubs** | | | |
| Butterfly-bush (Buddleja spp.) | hops | rose* | Viburnum |
| cinquefoil (*Potentilla*) | redbud | rosemary | |

* resistant varieties available.

During cool (50-75 °F), wet conditions with high relative humidity (85 percent or higher), downy mildew outbreaks develop when germinating oospores form sporangiophores, which resemble a bunch of grapes emerging from the plant stomate (Fig. 5). Each "grape" is a sporangium. And each sporangium is filled with dozens of zoospores that swim to susceptible plants and infect them even when just a film of free water is available. High relative humidity and free water favor pathogen development and spread, with prolonged periods of leaf wetness promoting spore germination; keeping plants dry minimizes the spread of this disease. The disease cycle (Fig. 7), from the initial infection to the production of additional spores and secondary infection, is usually seven to ten days, but can be as short as four days under humid conditions — again, this varies depending on the species of downy mildew, and the host's susceptibility to infection. Finally, some species of downy mildew (e.g., rose downy mildew, impatiens downy mildew) may infect the plant systemically, meaning that the downy mildew spreads within the plant and can persist even in dormant plants.

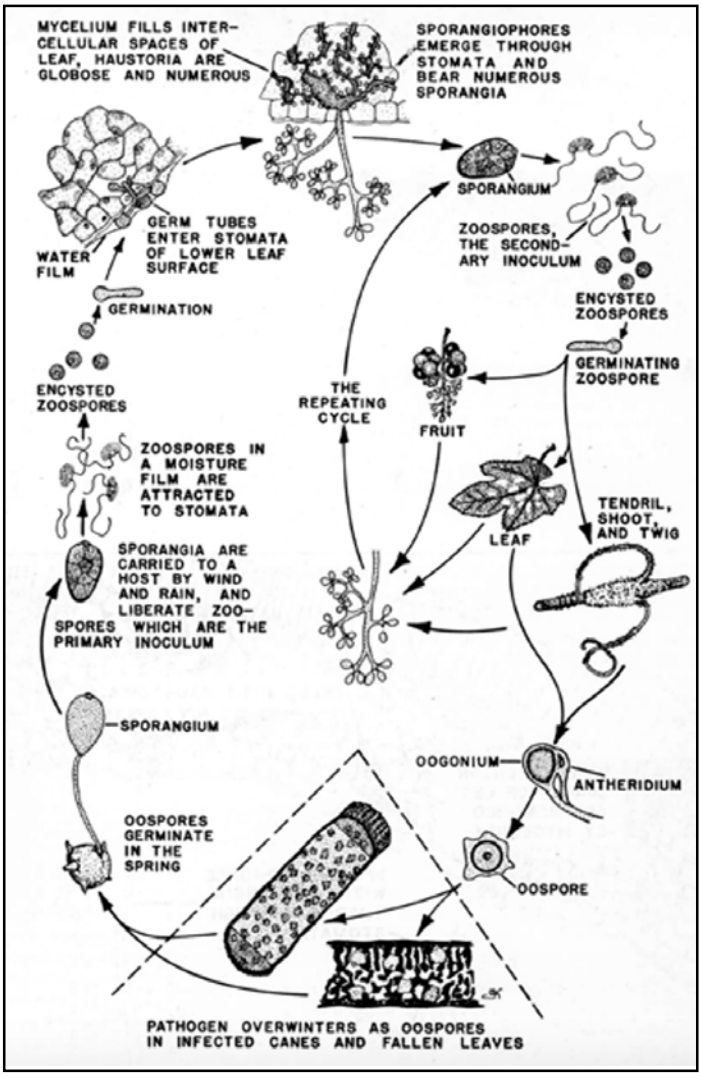


***Figure 6.*** *The downy mildew disease cycle. Life cycle drawing provided by C.B. Kenaga, E.B. Williams, and R. J. Green; Plant Disease Syllabus.*

***Figure 7.*** *Downy mildew can cause a diversity of symptoms on roses and may even be mistaken for rose black spot or phytotoxicity,.*

## Management

Understanding the disease cycle is critical to managing downy mildew and minimizing reliance on chemicals (Fig. 6). Cultural practices aimed at alleviating high humidity can help prevent the disease or decrease its severity. Such practices involve increasing air circulation and light penetration by pruning and thinning plants to reduce overcrowding in the landscape. Plant spacing can influence the relative humidity around plants, with wider spacing between plants reducing relative humidity in the plant canopy. Pruning plants to open-up a dense canopy promotes rapid drying of leaves. Leaf wetness early in the day is critical to downy mildew development. Any action that reduces the amount of leaf moisture early in the day (such as watering in the late afternoon or changing from overhead irrigation to a drip lines) will reduce the spread of this disease.

Sanitary practices should be followed to reduce movement of the pathogen, whether the site is a greenhouse, nursery, or landscape. Starting with clean plant stock is critical to reduce the occurrence of downy mildew, especially if plants can harbor asymptomatic, systemic infections. Downy mildew pathogens can also overwinter on plant debris, move via wind from southern locations, or be introduced by asymptomatic but infected plants. Sanitation, however difficult, is essential for properly managing the disease. Removing infected plants as they are identified is important to reduce the amount of inoculum available to create additional disease. Sanitation minimizes the amount of inoculum that overwinters as mycelium or oospores in or on plant parts, reducing the risk of infection to nearby plants.

For a few plant species, the use of downy mildew resistant or tolerant varieties is an option for disease management (Fig. 8). With impatiens, cultivars resistant or tolerant to downy mildew have been identified in recent years, and include the Imara and Beacon series, in addition to the use of New Guinea impatiens. However, host resistance does not protect against all races of this pathogen. Sustainable stewardship of these resistant varieties includes crop rotation in planting beds, sanitation, plant spacing, and the judicious use of fungicides, to protect plants from infection. See 'Disease Resistant Annuals and Perennials in the Landscape' for more information.

## Use Fungicides for Prevention

The role of water and this disease is obvious, and downy mildew epidemics generally cease when the weather is hot and dry. However, keeping plants dry may prove impossible, or nearly so. When that's the case, proper fungicide use comes into play to prevent additional infection from occurring. Table 1 lists fungicides labeled for managing downy mildews. Most of these fungicides are not available to homeowners —so professional applicators will need to apply these products.

Remember, successful downy mildew management relies on preventative fungicide applications — do not wait to see downy mildew symptoms before you begin spraying, as that will be too late! The key to successfully managing downy mildews is to maintain a protective program of fungicides, and recognize that fungicides do not 'cure' plants. Apply products with differing modes of action (FRAC Codes) in rotation (or as a tank-mix, when indicated). This is important in preventing resistance to any one fungicide by the downy mildew pathogen. Be sure to read the label: Make sure the fungicide you choose is appropriate for the type of application you are making and where this application will occur.

Make fungicide applications every seven to ten days, being sure to rotate or tank mix fungicides with different FRAC codes to prevent fungicide resistance from developing. This disease is much easier to prevent than to eradicate, so begin any spray program early and keep to a regular schedule.

***Figure 8.*** *Different responses to impatiens downy mildew by impatiens. Note the very susceptible I. walleriana in the foreground, the less susceptible I. balsamina and more resistant 'Sunpatiens' and wild touch-me-nots (I. capensis).*

## References

Farr, D.F., & Rossman, A.Y. Fungal Databases, U.S. National Fungus Collections, ARS, USDA. Retrieved February 22, 2022, from https://nt.ars-grin.gov/fungaldatabases/

Palmer, C. and Vey,E. 2017. IR-4 Ornamental Horticulture Program Downy Mildew Efficacy. Available on line at https://ir4.cals.ncsu.edu/ornamental/SummaryReports/DownyMildewDataSummary2017.pdf

Table 2. Fungicides labeled for downy mildew control of ornamentals.

| Fungicides (active ingredients) | FRAC Code | Sites* | REI | Spray or Drench |
|---|---|---|---|---|
| **Adorn (fluopicolide)** | 43 | G, N, L, S | 12 h | S,D |
| **Aliette (fosetyl Al)** | 33 | G, N | 12 h | S |
| **Alude, Magellan, Vital, etc. (phosphorus acid salts)** Monterey Garden Phos Systemic Fungicide | 33 | G, N | 4 h | S |
| **Broadform (trifloxystrobin+fluopyram)** | 7+11 | G, N, I, L, S | 12 h | S |
| **Compass** | 11 | G, N, I, L, S | 12 h | S,D |
| **Fenstop (fenamidone)** | 11 | G | 12 h | S |
| **Heritage (azoxystrobin)** | 11 | G, N, L, S | 4 h | S,D |
| **Micora (mandipropamid)** | 40 | G, N, S | 4 h | S,D |
| **Orvego (ametoctradin+dimethomorph)** | 40+45 | G, N, I, S | 12 h | S,D |
| **Protect (mancozeb)** | M | G, N, L, S | 24 h | S |
| **Segovis (oxathiapiprolin)** | U15 | G, N, L, S | 4 h | D |
| **Segway (cyazofamid)** | 21 | G, N, L | 12 h | S |
| **Stature DM (dimethomorph)** | 40 | G, N, S | 12 h | S |
| **Subdue Maxx (mefenoxam)*** | 4 | G, N, L, S | 0 h | D |

* G = Greenhouse; N = Nursery; I = Interiorscape; L = Landscape; S = Shadehouse

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