COLLEGE OF AGRICULTURE & LIFE SCIENCES
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Biology and Management of Downy Mildew of Lettuce

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Characteristics of the plant pathogen and disease development

Downy mildew of lettuce is caused by the fungus-like organism *Bremia lactucae*. This pathogen is an obligate parasite, which means that it can grow and reproduce only on living plant tissue. Downy mildew is a major disease in lettuce production systems worldwide. Downy mildew on vegetable crops other than lettuce grown in Arizona is caused by other fungus-like organisms, but not by *Bremia lactucae*. Disease epidemics can be devastating when environmental conditions are favorable for disease development. In semiarid to arid climates like Arizona, disease intensity and crop loss are highly dependent on weather factors.

When deposited on lettuce plants under favorable environmental conditions, spores of *Bremia lactucae* will germinate, infect leaves, and in due course produce visible symptoms. On young seedlings, symptoms consist of a white fluffy growth on cotyledons and young leaves, resulting in stunting and death of infected plants. Symptoms on older plants, which may first appear on mature leaves, are light green to yellow spots on the upper leaf surface, confined by the veins of the leaf to give lesions an angular appearance (Figure 1). In time, these infected areas become necrotic and turn light tan to brown in color. A white fluffy growth typically develops from these spots on the underside of leaves (Figure 2) and is composed of spore producing structures and spores of the pathogen (Figure 3). Systemic infections can occur infrequently, causing browning of internal stem tissue.

Weather factors play a critical role in the development and severity of downy mildew of lettuce. The following points highlight the effect of environmental factors on the biology of *Bremia lactucae* and disease development.

- Spores of the pathogen are produced at night after a dry dark period followed by a few hours of near absolute humidity and low wind speed.
- The optimum temperature for spore production is 68°F, but it will occur between 41 to 75°F.

Figure 1. Downy mildew infection sites confined by the veins of the lettuce leaf give these lesions an angular appearance. Light green to yellow spots on the upper leaf surface become necrotic and turn light tan to brown in color as they age. .

Figure 2. A white fluffy growth containing the spore producing structures and spores of *Bremia lactucae* typically develops from downy mildew infection sites on the underside of leaves.

Figure 3. Microscopic view of the spore producing structures and spores of *Bremia lactucae*. For reference, the yellow line is 0.1 mm in length (Photo courtesy of Bruce Watt, University of Maine).

- Spore release and dispersal begin around sunrise and peak from 10 a.m. to noon.
- At temperatures between 50 to 72°F, infection can occur in as little as 3 hours when leaves are wet, so new infections can begin as early as 3 hours after sunrise.
- In coastal California lettuce fields, research has shown that downy mildew infections occur when lettuce leaves do not dry until 10 a.m. or later. On the other hand, no infection occurs when leaves are dry by 8 a.m. When leaf wetness persists until 10 a.m. or longer, spore dispersal and infection can occur simultaneously.
- Spores of *Bremia lactucae* may infect, colonize, and produce a second generation of spores on lettuce in as few as 10 days.
- Increasing number and duration of wet leaf days increases epidemic development.

Disease management considerations

Resistant varieties. Over the years, plant breeders have incorporated genetic resistance to downy mildew in some lettuce varieties to combat this disease. Genetic resistance to downy mildew can be a highly effective disease management tool, as it is active for the life of the plant. However, the use of genetic resistance against downy mildew does have limitations. Firstly, lettuce varieties resistant to all known races of the pathogen and suitable for all planting windows within an Arizona production season may not be available. Also, *Bremia lactucae* is a very adaptable pathogen, having the ability to develop new races which in time can overcome the genetic resistance within lettuce varieties. Finally, the races of the pathogen present in fields may differ from year to year, making decisions on lettuce variety selection difficult.

Fungicides. Fungicides can be very effective management tools. Table 1 lists some fungicides with demonstrated activity against downy mildew on lettuce. To achieve the highest level of disease control from fungicide products, the following points should be considered.

- A fungicide application program should rotate among or use mixtures of products with different modes of action to delay development of resistance to these active ingredients within the pathogen population.
- Read each fungicide label carefully. The label provides important information concerning the particular characteristics of the product and appropriate application instructions. Use the suggested rate, application interval, recommendation for rotation with other fungicides, and other pertinent advice for each product within a fungicide application program.
- Initiate a fungicide application program as a disease prevention measure, when environmental conditions favor disease but before the appearance of downy mildew symptoms. Continued fungicide applications will be necessary as long as the threat of downy mildew development exists.
- For optimal performance, fungicides should be applied with sufficient water volume to thoroughly cover lettuce foliage.

Integrated Disease Management. The overall success in managing downy mildew on lettuce can be optimized by employing an integrated disease management approach. Simply put, this involves using all disease management tools that can reduce the incidence and severity of downy mildew. The primary management tools, planting resistant varieties when available and applying fungicides with different modes of action as needed, when used together can 1) provide a level of disease control superior to that achievable with either tool alone, 2) delay development of new races of the pathogen, and 3) slow down development of resistance to fungicides within the pathogen population. Also, since moisture on leaves is essential for downy mildew development, minimizing the incidence and duration of leaf wetness can help reduce disease intensity. To the extent possible, choosing a growing period when leaf wetness is less likely to occur, selecting a planting location that is less prone to frequent and prolonged periods of dew formation, and using drip or furrow rather than sprinkler irrigation are all decisions that can lower the final severity of downy mildew on a lettuce crop.

References

van Bruggen, A. H. C., and Sherm, H. 1997. Downy mildew. In Compendium of Lettuce Diseases; Davis, R. M., Subbarao, K. V., Raid, R. N., Kurtz, E. A. eds. 1997. APS Press, St. Paul, MN

Table 1. Fungicides with activity against downy mildew.

Product[1]	Active Ingredient	Active Ingredient[2]	
		Name	Number
Ridomil Gold	Mefenoxam	Phenylamide	4
Cabrio	Pyraclostrobin	Quinone outside Inhibitor	11
Quadris	Azoxystrobin	Quinone outside Inhibitor	11
Reason	Fenamidone	Quinone outside Inhibitor	11
Previcur Flex	Propamocarb	Carbamate	28
Aliette	Fosetyl-Al	Phosphonate	33
Oxiphos, Phostrol	Phosphorous acid salts	Phosphonate	33
Forum	Dimethomorph	Carboxylic Acid Amide	40
Revus	Mandipropamid	Carboxylic Acid Amide	40
Presidio	Fluopicolide	Benzamide	43
Zampro	Ametoctradin	QoI stigmatellin binding site	45
	+ Dimethomorph	+ Carboxylic Acid Amide	40
Orondis[3]	Oxathiapiprolin	Piperidinylthiazoleisoxazolines	U15
Actigard	Acibenzolar-S-methyl	Benzothiadiazole	P1
Dithane, Manzate	Mancozeb	Dithiocarbamate	M3

[1] This is not intended to be a complete list of products registered for use on lettuce in Arizona for management of downy mildew. However, the products in this list have been evaluated in Arizona field fungicide efficacy trials and significantly reduce downy mildew severity on lettuce when applied preventatively, compared to nontreated plants. Always consult product labels before using these or any other fungicides for up-to-date information on registration status and application instructions, as product labels may change over time. It is the applicator's responsibility to insure that the products are registered and used in accordance with label instructions.

[2] Mode of Action names and numbers are from the Fungicide Resistance Action Committee (FRAC) (www.frac.info/). Applying fungicides with different group numbers as mixtures or in rotation within a fungicide application program can be an effective resistance management strategy.

[3] At the time of publication, registration of Orondis was pending.

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