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DOWNY MILDEW AND ITS OCCURRENCE ACROSS THE USA

Margaret Tuttle McGrath
Plant Pathology & Plant-Microbe Biology Section, SIPS, Cornell University
Long Island Horticultural Research & Extension Center
3059 Sound Avenue
Riverhead, NY 11901

Symptoms of downy mildew in basil.
Affected leaf tissue turns yellow and then brown. A characteristic symptom is the yellow tissue being in bands across the leaf blade delimitated by the leaf veins. This occurs because the pathogen cannot grow through or around large veins. Other affected leaves are more generally yellow because there were multiple infection sites. Affected leaves die after they turn brown and drop off the plant. Key to confirming the yellowing is due to downy mildew is to look for signs of the pathogen (brown sporulation) on the underside of leaves. The best time to look is in the morning because spores are produced during night and will be dispersed during the day. The structures that hold the spores are white and thus not as readily visible as the brown spores. The pathogen begins producing spores before leaves turn yellow, so sometimes spores can be seen on a green leaf. Very rarely spores develop on the top side of leaves and on leaf petioles. Spores also develop on the leafy parts of flowers.

Biology of the pathogen causing downy mildew in basil.
It is important to understand the biology of a pathogen as this knowledge enables selecting cultural practices to manage the disease. The pathogen that causes downy mildew in basil (*Peronospora belbahrii*) has no other known host plants; thus there is no need to be selective about other crops grown nearby.

Peronospora belbahrii can be seed-borne, which is the main source of the pathogen for greenhouse crops grown between outdoor growing seasons (late fall through spring in the northeastern USA). Unfortunately gelatinous exudate from seed when soaking in water precludes treating seed in hot water. Steam is being used instead to manage seed-borne inoculum.

Peronospora belbahrii is an obligate pathogen, which means it cannot survive long in the absence of living plant tissue (leaves or seed), unless it produces oospores, which are its resting, survival spore. Most Oomycete pathogens produce oospores through sexual reproduction that occurs when pathogen strains of opposite mating type grow together. Oospores have only been observed recently in Israel. There have been no indications from patterns of downy mildew occurrence to suggest that the pathogen could be surviving over winter in the USA as oospores; therefore crop rotation is not considered a necessary management practice.

The pathogen makes an abundance of asexually-produced spores (sporangia, the brown spores on the underside of leaves) that can be dispersed long distances by wind. These spores are considered to be the main initial inoculum for field-grown crops and for basil grown in greenhouses during the outdoor growing season. The spores can be moved easily between rooms in a greenhouse complex and can survive at least a few days after their production; therefore good sanitation is needed to prevent spread between greenhouse rooms and before starting another crop following a greenhouse outbreak.

The pathogen does not need leaves to be wet in order to infect; relative humidity above about 85% is adequately favorable. Therefore in a greenhouse it is not sufficient for managing this disease to avoid wetting the leaves when watering plants. Humidity needs to be managed by using fans, lights, and/or bottom heat.

The pathogen needs a period of darkness to produce spores. When plants were grown with lights on during at least the first six hours of night, spores did not form on leaves directly exposed to the light.

Occurrence of basil downy mildew in USA.

Basil downy mildew has been reported in 42 states plus the District of Columbia (see table) since it was first observed in Florida in fall 2007. States where this disease has not yet been reported and/or confirmed are Alaska, Idaho, Nevada, New Mexico, Oklahoma, South Dakota, Utah, and Wyoming. Unknowingly distributing contaminated seed is a plausible way that the pathogen was first introduced into the USA and how it has been spread long distances between geographically-separated areas.

These reports were almost all made to a web-based monitoring page in a Google spreadsheet. It was started in 2009. Links to the pages are at:
http://vegetablemdonline.ppath.cornell.edu/NewsArticles/BasilDowny.html
A total of 49 reports of basil downy mildew were logged in 2009, 63 reports in 2010, 63 reports in 2011, 75 reports in 2012, 64 reports in 2013, and 284 reports in 2014. These came from 20, 26, 22, 26, 20, and 35 states, respectively, plus the District of Columbus. More reports of downy mildew in 2014 than previous years was associated with affected plants for sale at garden centers in several states and cooler temperatures in the North Carolina to Maryland area where typical high summer temperatures might have limited downy mildew development in other years. Some reports were from outside the USA: Argentina, Australia, Mexico, Baja California, Grand Cayman, Costa Rico, Puerto Rico, Jamaica, Quebec, Ontario, British Columbia, South Africa, and South Korea. Most reports were made by home gardeners, growers and extension specialists of sightings on outdoor plants. Affected plants were also seen in greenhouses. Some reports were not confirmed.

For more information about downy mildew of basil plus photographs, go to:
http://vegetablemdonline.ppath.cornell.edu/NewsArticles/BasilDowny.html

Years that reports of downy mildew in basil were made from each state and the District of Columbia to the monitoring page.

State	2008	2009	2010	2011	2012	2013	2014
Alaska			? *				
Alabama			X		X		X
Arkansas	X		X		X		
Arizona				?			
California		X	X	X	X	X	X
Colorado			X	X	X		
Connecticut				X	X	X	X
Washington D.C.						X	X
Delaware		X	X	X	X		X
Florida	X	X	X	X	X	X	X
Georgia		X			X		X
Hawaii				X	X		X
Iowa							X
Idaho							
Illinois		X	X	X		X	X
Indiana		X		X	X		X
Kansas	X			X			X
Kentucky			X				X
Louisiana			X	X		X	X
Massachusetts	X	X	X	X	X	X	X
Maryland		X	X	X	X	X	X
Maine				X	X	X	X
Michigan			?		X		X
Minnesota				X	X		X
Missouri					X		X
Mississippi		X					
Montana			?				X
North Carolina	X	X	X		X		X
North Dakota	?	X	X				
Nebraska							X
New Hampshire			X		X	X	X
New Jersey	X	X	X	X	X	X	X
New Mexico							
Nevada							
New York	X	X	X	X	X	X	X
Ohio		X	X			X	X
Oklahoma							
Oregon					X		
Pennsylvania		X	X	X	X	X	X
Rhode Island				X		X	
South Carolina		X	X		X	X	X
South Dakota							
Tennessee		X				X	X
Texas			X	X	X		X
Utah							
Virginia		X	X			X	X
Vermont		X	X	X	X	X	X
Washington				X	X		X
Wisconsin		X	X			X	X
West Virginia					X	X	X
Wyoming							

* Question mark indicates the only report(s) from the state did not have sufficient information to confirm the report. Other reporters either were known to be capable of identifying the disease or provided pictures and/or adequate description to confirm that it was basil downy mildew.