WHAT HAPPENED WITH CUCURBIT DOWNY MILDEW AND POTATO AND TOMATO LATE BLIGHT IN 2011?

Stephen A. Jordan[1] and Amanda J. Gevens[2]
{With contributions from Anna Seidl[3] & Amilcar Sanchez Perez[3]}

Introduction

On vegetable and potato crops, the water molds, or fungus-like, oomycetous plant pathogens, which threaten the greatest crop losses include *Pseudoperonospora cubensis* (causal agent of downy mildew on cucumbers), and *Phytophthora infestans* (causal agent of late blight on potatoes and tomatoes). Downy mildew and late blight can both be aerially dispersed over long distances and genotypes identified in the region are not known to be soilborne at this time (1, 3). Initial inoculum and infection occurs as the result of movement of spores in the air from diseased fields to healthy, infected seed or transplants, or by overwintering plant tissues harboring the pathogen from the previous year (e.g. volunteers, cull piles, compost piles). In Wisconsin in 2011, both diseases made minor appearance on vegetable crops.

Results and Discussion

Cucurbit downy mildew caused by the fungus-like pathogen *Pseudoperonospora cubensis* has become more prevalent in the Midwestern & Great Lakes states and throughout the U.S. over the past 5 years. Growers of cucurbits (cucumber, squash, melon, pumpkin) in the Midwestern U.S. states, may recall rare occurrences of late season downy mildew on squash or watermelon crops over the last four decades. Why, since the mid-2000's, has downy mildew become problematic on cucumbers mid-production season? Why has this disease revisited some Midwestern states with greater regularity and aggressiveness?

Since 2005, the Midwestern U.S. has seen cucumber as the first cucurbit crop infected with downy mildew with symptoms detected as early as mid-June. In 2011, pumpkin, butternut squash, cantaloupe, watermelon, and yellow summer squash were also infected in several states, but symptoms were not detected until late-July. It is not known if our region has had two different strains of cucurbit downy mildew, an early-arriving strain aggressive on cucumber and a late-arriving strain aggressive on pumpkin, squash, and melon or if we have one strain that gets established on cucumber and spreads to other less susceptible cucurbits after inoculum has increased locally. We do know that once downy mildew is in a region, it can be a continual challenge until harvest or frost.

Cucurbit crops in the Midwest have typically not needed routine application of fungicides for downy mildew control. For ~40 years, varietal resistance in commercial cucumber and some melon varieties, conferred by the recessive *dm1* downy mildew resistance gene, was effective in controlling disease. Pumpkin, squash, and watermelon crops were without this resistance and would sporadically become infected with downy mildew late in the production season. It had

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[1]Associate Researcher, Plant Pathology Department, University of Wisconsin-Madison

[2]Assistant Professor and Extension Plant Pathology, University of Wisconsin-Madison

[3]Graduate Research Assistant, Plant Pathology Department, University of Wisconin-Madison.

been standard recommendation that pumpkins in northern states were to be planted and harvested early to avoid risk of downy mildew because the pathogen could make its way north on late season air currents. The strain(s) of the downy mildew pathogen that have recently made their way to our region are not adequately controlled by *dm1* resistance that held up for decades.

Whether there has been a change in the pathogen population by way of a genetic mutation or introduction of an invasive and aggressive cucumber strain, or if changes in environmental conditions have promoted increased virulence is unknown. North Carolina State University researchers determined that recent eastern U.S. populations of cucurbit downy mildew were much more diverse in host range and pathogenicity than was previously known, with *Cucumis* species (cucumber, melon) having greater susceptibility to most pathogen isolates than *Cucurbita* species (squash, pumpkin).

Downy mildew, like other members of the water molds, is favored by warm temperatures (65-85°F) and wet field conditions. In 2010, areas of Wisconsin received over 30 inches of rainfall from May to October, the highest quantity of precipitation recorded over the production season since 1895. Conducive weather coupled with presence of the pathogen resulted in downy mildew in multiple cucumber producing areas of the state.

While downy mildew does not cause fruit infection on cucurbits, the pathogen can defoliate plants leaving fruit at risk for sunscald and secondary infection. Foliar symptoms include pale green-yellow angular (squared off within veins) lesions on leaf surfaces with corresponding and distinctive fuzzy brown growth on leaf undersides. The fuzzy growth is the pathogen producing thousands of new sporangia (spores) which can become airborne and further spread the pathogen within field and beyond at a rate of approximately 6 miles/day. Early infections can be tricky to identify, as they may mimic a nitrogen deficiency, angular leaf spot, or even virus symptoms. The pathogen is an obligate parasite, requiring living plants to remain viable. The pathogen cannot overwinter in the soil on its own, as production of persistent soilborne spores (oospores) have not been found here in Wisconsin.

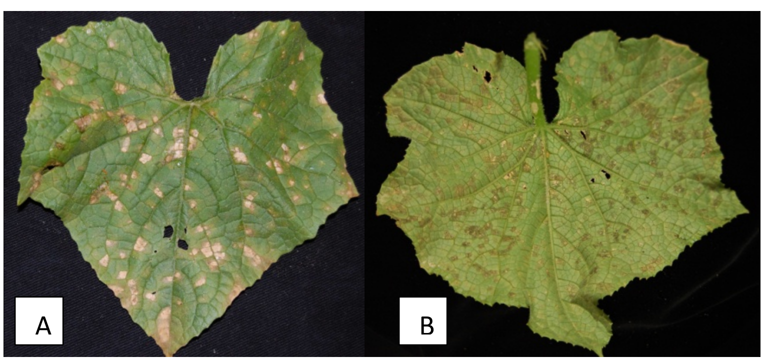
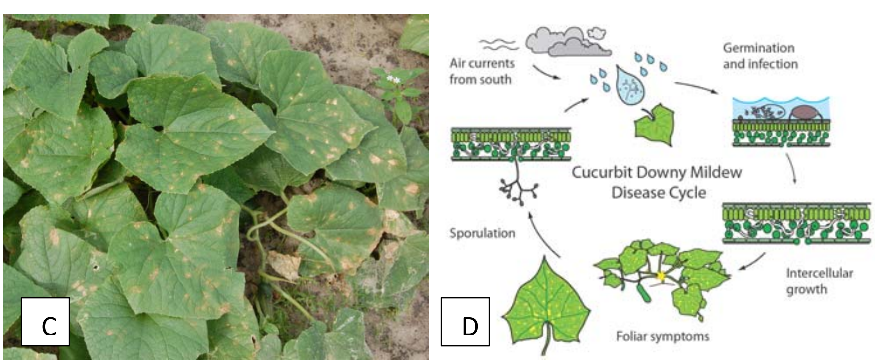


Figure 1. Symptoms of downy mildew on cucumber. A) Mature, angular, necrotic downy mildew lesions on cucumber leaf surface. B) Fuzzy, brown, pathogen sporulation on leaf underside. C) Cucumber downy mildew in the field. D) Cucurbit downy mildew diseaes cycle. Created by Rosemary Clark, formerly of UW-Vegetable Pathology.



Management

Currently, with mid-season risk of spore movement and lack of commercially available and durable varietal resistance in cucurbits, fungicide applications are essential for protection of yield and quality. The selection of fungicides, timing of application, and thoroughness of application are critical for effective disease control. Fungicides should be applied prior to or at first sign of infection to best control cucurbit downy mildew. Based on field research in multiple states including Michigan and North Carolina, effective fungicides for downy mildew control include zoxamide+mancozeb, fluopicolide, propamocarb hydrochloride, cyazofamid, and famoxadone+cymoxanil. The effective control program for cucumber established at Michigan State University by Dr. Mary Hausbeck, which I recommend to producers in Wisconsin, specifies a 7-day spray interval of the previously listed materials tank-mixed with either mancozeb or chlorothalonil when initiated **before** downy mildew is found in the field. Fungicides should be alternated so as to manage the potential development of fungicide resistance. Sprays are tightened up to a 5-day interval when initiated **after** disease is found in the field. For cucurbits other than cucumber, the program above is modified to expand the spray intervals from 7 to 10-day **before** disease, and 7-day **after** disease is found in the field. Downy mildew can be well controlled in cucurbit crops with use of effective fungicides, however, this adds a significant increase to the cost of production and success is contingent upon careful attention to regional extension vegetable disease reports and careful field scouting to appropriately time fungicide application.

To aid in tracking cucurbit downy mildew in your county and beyond, the website: http://cdm.ipmpipe.org/ offers forecasting of the disease based on confirmed reports across the U.S. The ipmPIPE (or **i**ntegrated **p**est **m**anagement **P**est **I**nformation **P**latform for **E**xtension and Education) cucurbit downy mildew website provides a publicly accessible site for sharing of cucurbit downy mildew detections, as well as symptom descriptions and management recommendations by region. The site is maintained by researchers at North Carolina State University with collaboration from researchers across the U.S., including Wisconsin. With the multitude of tasks that growers have to manage in the field, office, and marketplace, I recommend use of the CDM ipmPIPE Alert System (link on left side bar of website) which sends you an email or text message when downy mildew is reported within a selected geographic radius around your farm. Also, consider e-mail list serve membership to the University of Wisconsin Extension Vegetable Crop Update newsletter each week through the growing season for downy mildew status reports. Newsletters may be sent out by your grower association or can be directly accessed each week at our UW-Vegetable Pathology website: http://www.plantpath.wisc.edu/wivegdis/.

Research is ongoing in the U.S. and worldwide to better understand the pathogenicity, host resistance, and spread of cucurbit downy mildew. Advances in resistance breeding will greatly aid in improved disease control and sustainability of cucurbit production in Midwestern states and worldwide.

Late blight, is the most limiting disease to potato production worldwide and has been recognized as a significant agricultural concern since the Irish potato famine in the late 1840s. Two mating types are needed to produce sexual, persistent soil-borne oospores. The population is largely clonal outside its center of origin in the Toluca Valley of Mexico, relying on production of asexual sporangia for persistence. Nationally, US-1 (A1) was the predominant clonal lineage until the late 1980s-early 1990s, when US-8 appeared. US-8 was the opposite mating type (A2) and was insensitive to mefenoxam, a fungicide with exceptional activity against oomycetes, but with a specific mode of action that effectively selects for insensitivity.

After 2002, Wisconsin growers enjoyed a 6-year respite from this disease, until it appeared in 2009, with follow up performances in 2010 and 2011. In these years, isolates were collected from potato and tomato from across the state. Allozyme genotype was resolved using cellulose acetate electrophoresis. This revealed 3 banding patterns which profiled US-22, US-23, and US-24. All isolates of US-22 and US-23 were sensitive to mefenoxam, while isolates of US-24 showed partial insensitivity. US-22 isolates were of the A2 mating type, and US-23 and US-24 isolates were of the A1 mating type. Isolates of opposite mating types were geographically separated in the state in 2010.

The late blight in WI in 2009 was part of a nationwide epidemic likely initiated by tomato transplants, thus one clonal lineage, US-22, predominated. In 2010, the sources of late blight are unknown, but US-22 may have overwintered on plant material protected under the early heavy snowfall. US-24 was found only on potato in central WI, and US-23 was found only on tomato, primarily in areas of WI with concentrated suburban tomato gardens. This year, WI had an early (7 July) and isolated detection of late blight on tomato in Waukesha Co. caused by US-23. Late blight did not again reappear until confirmed on 26 and 27 August in Waushara and Adams Cos. (US-23 and US-24).

In the laboratory, we demonstrated that by pairing US-22 (A2) with US-23 or US-24 (both A1), oospores can be formed at 12, 16, and 20°C on detached leaves of 3 varieties of tomato and a single variety of potato ('Katahdin'). The greatest concentration of oospores was seen at 16°C, an optimum temperature for promotion of late blight epidemics in production fields. To date, opposite mating types have not been identified in the same field or county within the same production year in Wisconsin. Further studies are designed to better understand the overwintering and germination potential of oospore. Constant monitoring and managing of late blight through use of varietal resistance and well-timed and –selected fungicides is essential in order to efficiently and effectively control late blight and maintain geographical separation of mating types.

Management

With the late season presence of the late blight pathogen in WI, it is critical that growers remain on alert and prepared for late blight control from field to storage.

Late-season potato late blight disease management practices should include the following:

1) Continue to scout fields regularly. Scouting should be concentrated in low-lying areas, field edges along creeks or ponds, near the center of center-pivot irrigation structures, and in areas that are shaded and protected from wind. Any areas where it is difficult to apply fungicides should be carefully scouted.
2) Avoid excess irrigation and nitrogen. If foliage is infected with late blight, spores can be washed down through the soil and infect tubers. Green vines can continue to be infected and produce spores even at harvest. Additionally, green and vigorous vines are hard to kill and skin may not be well-set at digging resulting in higher risk of post-harvest infection by late blight and other diseases.
3) Allow 2-3 weeks between complete vine kill and harvest. Fungicide applications should be continued until vines are dead. When foliage dies, spores of the late blight pathogen that remain on the foliage also die. This practice will prevent infection of tubers during harvest and development of late blight in storage.
4) Do not produce cull piles of late blight infected tubers. Such piles are a significant source of spores and centers of large piles may not experience freezing/killing winter temperatures which serve to kill tuber tissue and the pathogen. Culls should be spread on fields not intended for potato production the following year in time that they will freeze

completely and be destroyed during the winter. Potato culls can also be destroyed in some other way such as chopping, burial, burning or feeding to livestock.

5) Keep tubers dry in storage. Air temperature and humidity should be managed so as to avoid producing condensation on tubers. Condensation can promote spore production of the late blight pathogen in storage. Application of fungicidal materials on tubers entering storage. Avoid or limit long term storage of tubers from fields in which late blight was detected.

Wisconsin fungicide recommendations for late blight can be found in the University of Wisconsin Extension Publication entitled “Commercial Vegetable Production in Wisconsin,” publication number A3422 (http://learningstore.uwex.edu/assets/pdfs/A3422.PDF) and additional information is provided in weekly newsletters during the growing season (provided at the vegetable pathology website: http://www.plantpath.wisc.edu/wivegdis/).

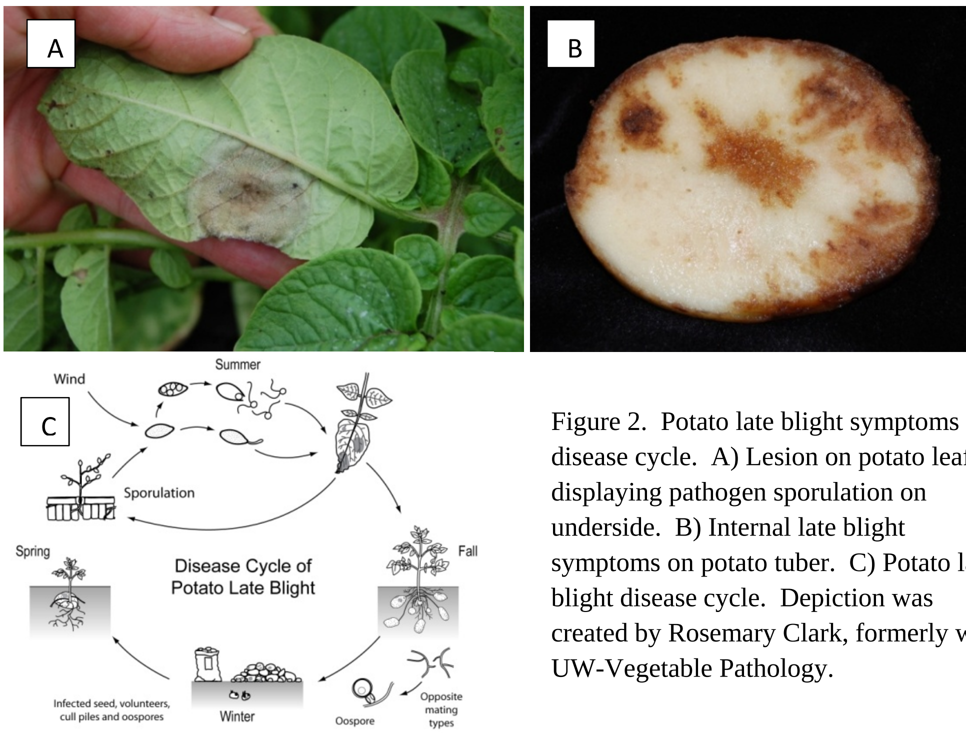


Figure 2. Potato late blight symptoms and disease cycle. A) Lesion on potato leaf displaying pathogen sporulation on underside. B) Internal late blight symptoms on potato tuber. C) Potato late blight disease cycle. Depiction was created by Rosemary Clark, formerly with UW-Vegetable Pathology.

References

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