LATE BLIGHT AND DOWNY MILDEW UPDATES IN VEGETABLE CROPS

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Introduction

Late blight is a potentially destructive disease of potatoes and tomatoes caused by the fungal-like organism, *Phytophthora infestans*. This pathogen is referred to as a 'water mold' since it thrives under wet conditions. Symptoms include leaf lesions beginning as pale green or olive green areas that quickly enlarge to become brown-black, water-soaked, and oily in appearance. Lesions on leaves can also produce pathogen sporulation which looks like white-gray fuzzy growth. Stems can also exhibit dark brown to black lesions with sporulation. Tuber infections are dark brown to purple in color and internal tissues are often reddish brown in color and firm to corky in texture. The time from first infection to lesion development and sporulation can be as fast as 7 days, depending upon the weather.

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. In the U.S., clonal lineage (also referred to as genotype or strain) US-1 (A1 mating type) 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. New clonal lineages have predominated epidemics in recent years with varying levels of mefenoxam resistance. Late blight pathogen populations in the U.S. have and continue to experience major genetic changes or evolution. The end result is the production of pathogen isolates with unique genotypes and epidemiological characteristics. As such, continued investigation of this pathogen is necessary to maintain best management strategies in susceptible crops.

Our objective was to monitor for late blight on a state-wide basis and characterize *P. infestans* in a timely manner to inform appropriate management recommendations and enhance understanding of the pathogens introduction and persistence in Wisconsin.

RESULTS & DISCUSSION

To date here in Wisconsin, our late blight diagnostics and management approaches address clonal or **asexual** populations of the pathogen. In this scenario, we can genotype the pathogen and receive a result which is tightly associated with mating type, mefenoxam/metalaxyl resistance, and often host preference. This scenario also includes an end to the late blight disease cycle when the affected plant tissues are dead. A **sexually** recombining population creates a different scenario, one in which we can no longer get a fast-response genotype with correlates with pathogen character or phenotype. And, the disease cycle in this latter scenario does not end when plant tissues are dead. Rather, the pathogen remains in the soil in absence of plant tissues, providing an ongoing source of inoculum for the long-term. This article provides some key biological concepts and management of each of these potential scenarios, and offers a review of late blight in 2014.

Volunteer survival 2013-2014: When soil temperatures do not get low enough to kill unharvested potato tubers, they can remain alive through the winter and emerge as unwanted volunteer plants in the spring. While the volunteers can create stubborn weeds in the following season, they can also harbor pathogens such as *Phytophthora infestans* in its **asexual** forms (sporangia, zoospores, and mycelia) and initiate the disease in the next year. A model for categorizing risk of survival of potato volunteers developed by researchers at Michigan State University categorizes risk based on accumulation of cold soil temperatures at 2 and 4 inch depths occurring between November 1 and March 31. This past winter in Wisconsin, we had accumulated hours of cold temperatures below -3◦C (27◦F) at 2 and 4" depths at Hancock (204 hrs below at 2"/120 hrs below at 4") and Arlington (984 hrs below at 2"/563 hrs below at 4") indicating low risk for volunteer survival. And, low risk for overwintering of the late blight pathogen in its current (non-oospore) form. Indeed, risk will vary by location, soil type, vegetative ground cover, as well as snow cover, but the risk assessment provides helpful information in considering weed and disease management.

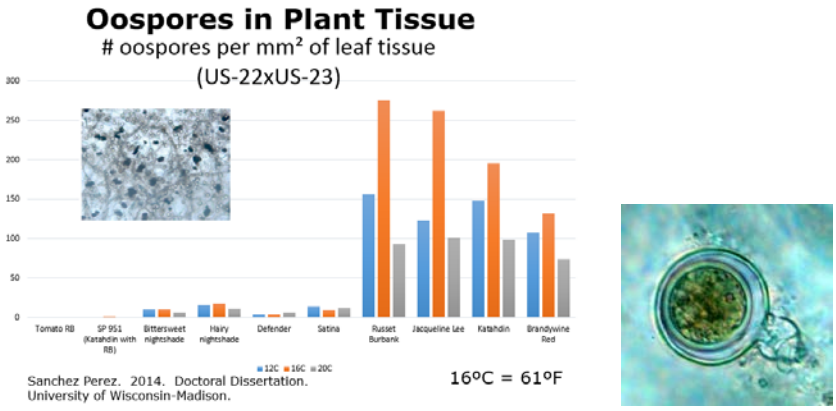
Results of Blitecasting and late blight character in 2014: Spring was slow to warm in 2014, but by the first week in June, the earliest planted potatoes in the Grand Marsh area of WI had accumulated environmental conditions favorable to late blight – as determined by Blitecast Disease Severity Values (DSVs) of ≥18 or risk threshold for early planted potatoes. By late June, Bitecasts for all early and mid-season plantings of potato plantings across Wisconsin had reached or surpassed the 18 DSV threshold. Late blight was first detected in the state in mid-July in Portage County, with subsequent reports from six additional counties (Adams, Marinette, Milwaukee, Oconto, Racine, Waushara). As in previous years, our UWEX Vegetable Pathology Blitecast tool provided timely information to aid in preventative disease management. Late blight of the US-23 (A1) clonal lineage was determined in all of the seven counties, with US-8 (A2) also identified in three of the counties (Adams, Portage, Waushara) – posing additional risk for sexual recombination and oospore production. The table below shows the pathogen clonal lineages from this and previous 5 years here in Wisconsin. Recall the predominance of US-8 during the late blight of the 1990s. Continued monitoring of genotypic and phenotypic characteristics of the *P. infestans* population will contribute to both short-term and long-term management of late blight in Wisconsin and surrounding states.

Year	Clonal Lineage (Mating Type, and Mefenoxam Sensitivity) of the Late Blight Pathogen (*Phytophthora infestans*) Detected in Wiscsonsin
2014	US-8 (A2, Resistant), US-23 (A1, Sensitive)
2013	US-8 (A2, Resistant), US-23 (A1, Sensitive)
2012	US-23 (A1, Sensitive)
2011	US-23 (A1, Sensitive), US-24 (A1, Intermediately Sensitive)
2010	US-22 (A2, Sensitive), US-23 (A1, Sensitive), US-24 (A1, Intermediately Sensitive)
2009	US-22 (A2, Sensitive)

Impact of mating types and sex on pathogen character and management: Knowledge of the mating types in a *P. infestans* population is important for immediate and long-term

management of late blight. By knowing the distribution of mating types, future changes in the population due to sexual recombination can be anticipated and potential problem fields closely managed and monitored. The mating types (A1 and A2) can be thought of as male and female components of a population. Under close proximity and specific environmental conditions, the mating types can sexually recombine and produce oospores ("Kids"). Of which, some will be genetically similar to A1 ("Dad") and some similar to A2 ("Mom"), while others will be genetically brand new with unknown clonal lineages and phenotypic characters such as mating type, fungicide resistance, aggressiveness, and host preference. A soil persistent oospore phase of *P. infestans* would drastically change current management practices.

Recent oospore research from UW-Potato Pathology helps us understand risk: In our recent laboratory research, we have documented the potential for oospore production between US-22 (A2) and US-23 (A1) clonal lineages. We started our work on oospores in 2011 when US-22 seemed to be the most likely A2 type to cause mating risk. Since that time, US-8 has reappeared and would be the more immediate A2 risk. On late blight susceptible tomato and potato foliage, roughly 100-275 oospores formed within 1 mm² of plant tissue when inoculated with both US-22 and US-23. 'Russet Burbank' resulted in the highest number of oospores per mm² at 16ºC (61ºF) among the plant types we tested. The graphic below shows the number of oospores produced in 1 mm² leaf tissue of multiple tomato and potato varieties including tomato transformed with *RB* late blight resistance gene, 'Katahdin' potato transformed with *RB*, bittersweet nightshade, hairy nightshade, 'Defender' potato, 'Satina' potato, 'Russet Burbank' potato, 'Jacqueline Lee' potato, 'Katahdin' potato, and 'Brandywine Red' tomato. Further studies have shown that roughly 85% of the oospores formed in green leaf tissues are alive and of those, nearly 40% can germinate with potential to cause disease. In our simulated overwintering experiments, less than 35% of oospores remained viable in the soil with very low potential (<7% incidence) of causing infection on susceptible tomato leaves under flooded conditions.



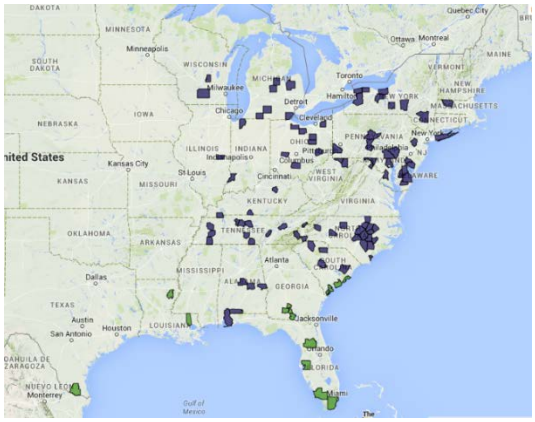
How long do oospores remain in the soil and can they travel?
Oospores are the largest of the spore types that the late blight pathogen can potentially make and they are designed to be persistent in soil outside of plant tissues for many years. While oospores can be associated with soil and be moved with soil – they are not known to

move aerially or long distances through irrigation or precipitation splashing. Equipment and any implement or plant part that may have soil associated with it could potentially move oospores.

Where to find information on late blight types in the U.S.?: Since 2011, many national late blight confirmations and characterizations have been made publicly available in an online format (www.usablight.org) through the efforts of research and extension scientists funded by the United States Department of Agriculture, National Institute of Food and Agriculture (AFRI). The coordinated project, entitled "Reducing losses to potato and tomato late blight by monitoring pathogen populations, improved resistant plants, education, and extension" conducts basic and applied research with the team goal of learning more about the pathogen and disease to further reduce losses in crop yield and quality. As per the national database, the US-23 lineage has again predominated epidemics on tomato and potato in 2014.

Cucurbit Downy Mildew Updates for Wisconsin 2014

In Wisconsin, there were few confirmed reports of curcurbit downy mildew in Dane, Green Lake, and Calumet Counties primarily on cucumber. In recent years, WI has had mid- and late-season downy mildew on primarily cucumber. There is risk of downy mildew to WI cucurbits in 2015 likely through spores moving in air from southerly growing regions. Incidence and severity is dependent upon temperature and moisture. Nationally, reports came from over 20 states, primarily along the eastern seaboard and the Midwestern states (see Figures below). Cucumber remains the primary crop affected by cucurbit downy mildew, followed by squash of various types (summer, winter) (see Figures below). Further information and disease forecasting can be found at http://cdm.ipmpipe.org/.



Crop Type	# of Reports in 2014	% of Total Reports
Cucumber	96	**45**
Squash	59	**28**
Cantaloupe	25	**12**
Pumpkin	22	**10**
Watermelon	11	**5**
TOTAL	**213**	**100**

Further information on late blight and disease management recommendations can be found at the University of Wisconsin Potato & Vegetable Pathology website: http://www.plantpath.wisc.edu/wivegdis/

and, in the University of Wisconsin Extension Publication entitled “Commercial Vegetable Production in Wisconsin,” publication number A3422 (http://learningstore.uwex.edu/assets/pdfs/A3422.PDF).

1. Fry, William E. and Niklaus J. Grünwald. 2010. Introduction to Oomycetes. *The Plant Health Instructor*. DOI:10.1094/PHI-I-2010-1207-01

2. Legard, Daniel E. and William E. Fry. 1996. Evaluation of field experiments by direct allozyme analysis of late blight lesions caused by *Phytophthora infestans*. Mycologia 88(4) 608-612.

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