

Common Diseases of North Central US Hops & Diagnostic Support Updates



Amanda J. Gevens
Plant Pathology
University of Wisconsin-Madison

North Central Plant Disease Diagnostic Network
Meeting
April 19, 2016 - 10:00-10:30AM
Madison, WI



Photo courtesy (left-right): NC State Coop. Ext.; Oregon Dept. of Ag.; David Gent

Hop Basics

- Scientific name for common hop: *Humulus lupulus* - "little wolf"
- Native to Europe, Western Asia, and North America
- Dioecious flowering plant
- Perennial; dies back to rhizome in the fall, new shoots emerge in spring
- Cones (flowers) used as flavoring agent and preservative in beer
- Roughly 120 acres currently in production (summer 2014 estimate from Hop Growers of America)
- Expansion to roughly 500 acres in the upcoming year in WI



Common Hop Diseases in the U.S.

- Downy Mildew
- Powdery Mildew
- Verticillium Wilt
- Hop Latent Virus
- Hop Mosaic Virus
- American Hop Latent Virus
- Apple Mosaic Virus
- Hop Stunt Viroid
- Hop Latent Viroid



Downy Mildew

Pseudoperonospora humili



Cultivated hop, *Humulus lupulus* is only host
Closely related annual or Japanese hop, *H. japonicus*, is resistant

Fungus-like pathogen overwinters as bud infections or systemically infected crown

In spring, infected shoots, called primary spikes, emerge from the crown and are stunted, pale-green to yellow, upright, and brittle with downward cupped leaves

Few detections of downy mildew in WI in 2013, 2014; severe problem in many hop yards in 2015 and 2016.

Photo courtesy: North Carolina State Univ. Cooperative Extension

Downy Mildew *Pseudoperonospora humili*

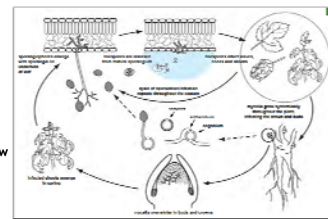


Systemic infection - systemic symptoms of shortened internodes (bunchy new growth), pale green leaves, small leaves

Disease favored by cool, wet conditions - Prediction models aid in proactive management

Photo courtesy: North Carolina State Univ. Cooperative Extension

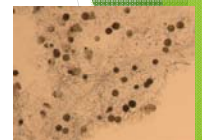
Detection of *Pseudoperonospora humili* oospores in WI



PhD student
Michelle Marks
Hop downy mildew

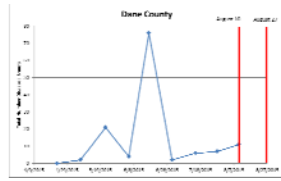


Microscopic view of Pseudoperonospora humili oospores.



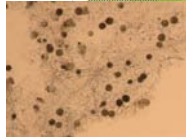
Detection of *Pseudoperonospora humili* oospores in WI

PhD student
Michelle Marks
Hop downy mildew



Oospores detected only in dead/dying foliar tissues in late July and August in 4 WI locations.

- not detected in asymptomatic tissue
- not detected in soil (yet)



Powdery Mildew *Podosphaera macularis*



PM disease develops at 64 to 70°F and reduced when >75°F. Infection can be greatly reduced by short intervals (> 2 h) of temperatures >86°F. Higher temperatures reduce the susceptibility of leaves to infection.

No known detections of powdery mildew on hops in WI in 2013-2015 (as per UW Plant Disease Diagnostic Clinic & UW Vegetable Pathology); recent confirmations in MI and MN

Photo courtesy: David Gent

Common hop viruses and viroids

Carlaviruses

- Hop Latent Virus
- Hop Mosaic Virus
- American Hop Latent Virus

Ilaviruses

- Apple Mosaic Virus

Nepovirus

- Arabis Mosaic Virus

- Hop Stunt Viroid
- Hop Latent Viroid

Factors influencing spread



Photo: thankheavenforbeer.com

Photo: David Gent, USDA ARS



Photo: David Gent, USDA ARS

Hop viruses and viroids

- Many perennial crops have virus and viroid diseases
- Rate of spread in hops is often much higher than in other perennials such as tree fruit
- Why is spread so rapid compared to other perennials?
 - Rapid annual growth - more than 15 feet of main stem growth in 3-4 months
 - Slashing basal growth
 - Close spacing
 - Aphid infestations
- Hop latent viroid was detected in
 - WI in 2013

Apple
mosaic
virus



Hop latent viroid



Photo: www.plantmanagement.com

How are hops affected by disease? (cannot be cured when yards are established with infected plant material)

- Viruses and viroids
 - Yield losses can be severe
 - Reduced acid levels
 - Shift in ratio of α:β-acids
 - Stunting, chlorosis, slower growth
 - Infected plants can produce for years but with reduced vigor/yield (not a good correlation)
- Downy mildew and Verticillium wilt
 - Plant mortality
 - Reduced cone quality



Hop stunt viroid

David Gent, USDA ARS

Downy mildew
effects on
cones

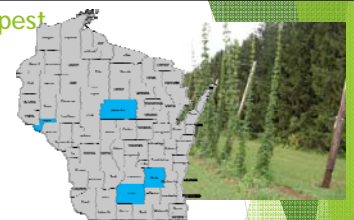


B. Engelhard

Wisconsin hop disease & pest assessment - 2015



PhD student
Michelle Marks
Hop downy mildew



County	March	April	May	June	July	August
Dodge	First buds (30%)	Downy (21%)	Downy	Downy		
Dane		First buds (1%)	Downy (7%)	Downy	Downy	Downy
Pequin		First buds (1%)	Downy (27%)	Downy	Carlavirus Downy	
Marathon		First buds (3%)	Downy (21%)	Leafhoppers	Leafhoppers (early)	Cabbage looper (cones)
				Spider mites	Spider mites	Downy

Diseases transmitted in hop planting stock

- Carlaviruses
- Apple Mosaic Virus
- Arabis Mosaic Virus
- Hop Stunt Viroid
- Hop Latent Viroid
- Hop Downy Mildew
- Verticillium wilt
- Impacts on cone yield and quality, plant survival
- Primary control measure: plant clean stock



Disease diagnostics in hop propagative stock

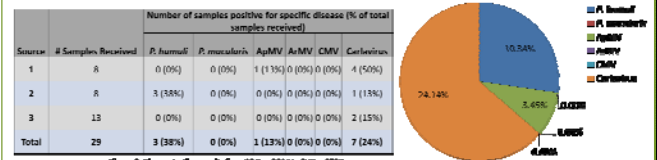
- Growers interested in screening for primary pathogens to improve disease management in new yards
- Multiple testing procedures were used to detect 6 pathogens:
 - Pseudoperonospora humuli* - hop downy mildew
 - Podosphaera macularis* - hop powdery mildew
 - Apple mosaic virus (ApMV)
 - Arabis mosaic virus (ArMV)
 - Cucumber mosaic virus (CMV)
 - Carlaviruses
 - American hop latent virus
 - hop latent virus
- Goals: i) determine feasibility and cost of assays and ii) survey diseases in hop propagative material from multiple WI sources



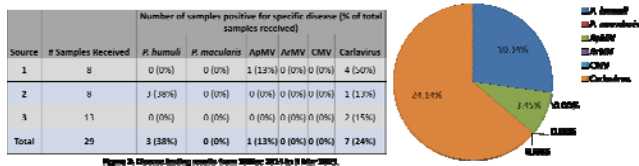
Methods for disease diagnostics in hop propagative stock

- Asymptomatic propagative plantlets
- Agdia ImmunoStrip tests for Arabis mosaic and Cucumber mosaic viruses
- ELISA test for Apple mosaic virus
- Carlaviruses were detected using RT-PCR with Carlavirus-specific primers
- *P. humuli* detected in total genomic DNA from asymptomatic plants with specific primers
- Plant tissues were incubated on water agar amended with antibiotic and examined microscopically for signs of *P. humuli* & *P. macularis*

Total Disease Detections



Total Disease Detections



Conclusion

- *P. humuli*, ApMV, and Carlavirus were detected in asymptomatic plantlets
- reinforced need for continued and more extensive testing of hop propagative material
- Disease panel was repeatable and could be completed within 72 hours
- Future goal: add viroid tests to panel

Sources of clean stock

- Clean Plant Center of the Northwest
 - Distributes material in winter (potted plants) and summer (bine cuttings)
- USDA National Clonal Germplasm Repository
 - Maintains cultivated and wild hop germplasm
 - Material distributed for research and education
- Hop yards and native/feral hops
 - Bine cuttings or rhizomes can be put into culture
 - Challenging to eliminate pathogen infections
- Both the Clean Plant Center of the Northwest & USDA National Clonal Germplasm Repository distribute only small quantities
- No certification system to ensure pathogen-free stock from commercial suppliers



NCR expedition in 2002 to collect native US hops

<http://buffalo.uwex.edu/files/2011/01/Disease-free-hops-planting-stock.pdf>

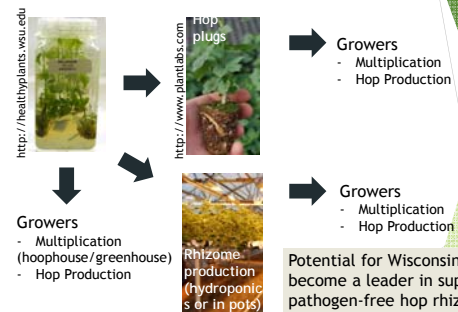
University of Wisconsin 'clean hops' research program update

- ▶ Establish a pathogen-free tissue culture collection of hop varieties, and produce pathogen-free planting material for on-farm variety evaluations.
- ▶ Trial hop rhizome production methods to optimize productivity and economic sustainability.
- ▶ Coordinate participatory variety trials in Wisconsin hop yards, and evaluate disease incidence in existing plantings
- ▶ Work funded by the WI Specialty Crop Block Grant Program for 2013-2015

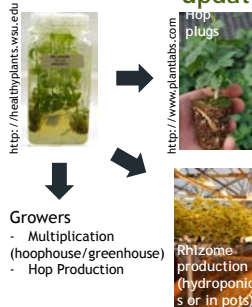


Dr. Ruth Genger
UW-Plant Pathology
WI Seed Potato Certification - Organic Production

Future production possibilities



Future production possibilities - update



- Test material has performed comparably to standard sources of plant material
 - Downy mildew identified within weeks of initial planting in some locations
 - Plants were 'delicate' and needed more frequent watering to thrive
 - Lagged in productivity early in season, but have caught up in growth
- We will continue to monitor plants through harvest
- Potential for Wisconsin to become a leader in supplying pathogen-free hop rhizomes

Start clean - stay clean!

- ▶ Plant disease-free rhizomes and plugs
- ▶ Sanitation for pruners and other tools
- ▶ Prevent movement of soil/infected plants onto your property
- ▶ Plant disease resistant cultivars

Planting stock production & certification programs

- Self-sustaining programs that serve grower needs
- Responsive to grower priorities
- Foster research and education
- Training opportunities

Start clean - stay clean!

- ▶ Diagnostic testing is critical
- ▶ UW-Madison/UWEX Plant Disease Diagnostic Clinic
- ▶ New hop diagnostic offerings include
 - ▶ Carlaviruses
 - ▶ Arabis mosaic virus
 - ▶ Apple mosaic virus
 - ▶ Downy mildew
 - ▶ Powdery mildew
 - ▶ Verticillium wilt

UW-Madison Plant Disease Diagnostic Clinic (PDDC)
Department of Plant Pathology
University of Wisconsin-Madison
1530 Linden Drive
Madison, WI 53706-1598
Phone: (608) 262-2822
Email: pddc@plantpath.wisc.edu
<http://pddc.wisc.edu>
Follow the PDDC on Twitter @UWPPDDC

Fee Schedule
Fees Effective January 1, 2016
Fees subject to change without notice

Standard Diagnostics	Digital Analysis	Virus Analysis	Phytoplasma Analysis	Specific Crop Diagnostics	Turf Diagnostics	Hop Diagnostics
Standard Analysis	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00
Standard Analysis Plus	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$25.00	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00	\$25.00
Digital Analysis	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00
Virus Analysis	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00
Phytoplasma Analysis	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00
Specific Crop Diagnostics	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00
Turf Diagnostics	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00
Hop Diagnostics	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease	Examination of digital photos of disease
\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00	\$20.00

Thank you!

Information Resources

UW Vegetable Extension Team Website
<http://vegetables.wisc.edu/vegetable-team>

University of Wisconsin Vegetable Disease Website (newsletter access)
<http://www.plantpath.wisc.edu/wivegdis/>



http://www.cals.uidaho.edu/pses/Research/r_ent_hoppest_powderymildew.htm

