

Common Diseases of North Central US Hops & Diagnostic Support Updates



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



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

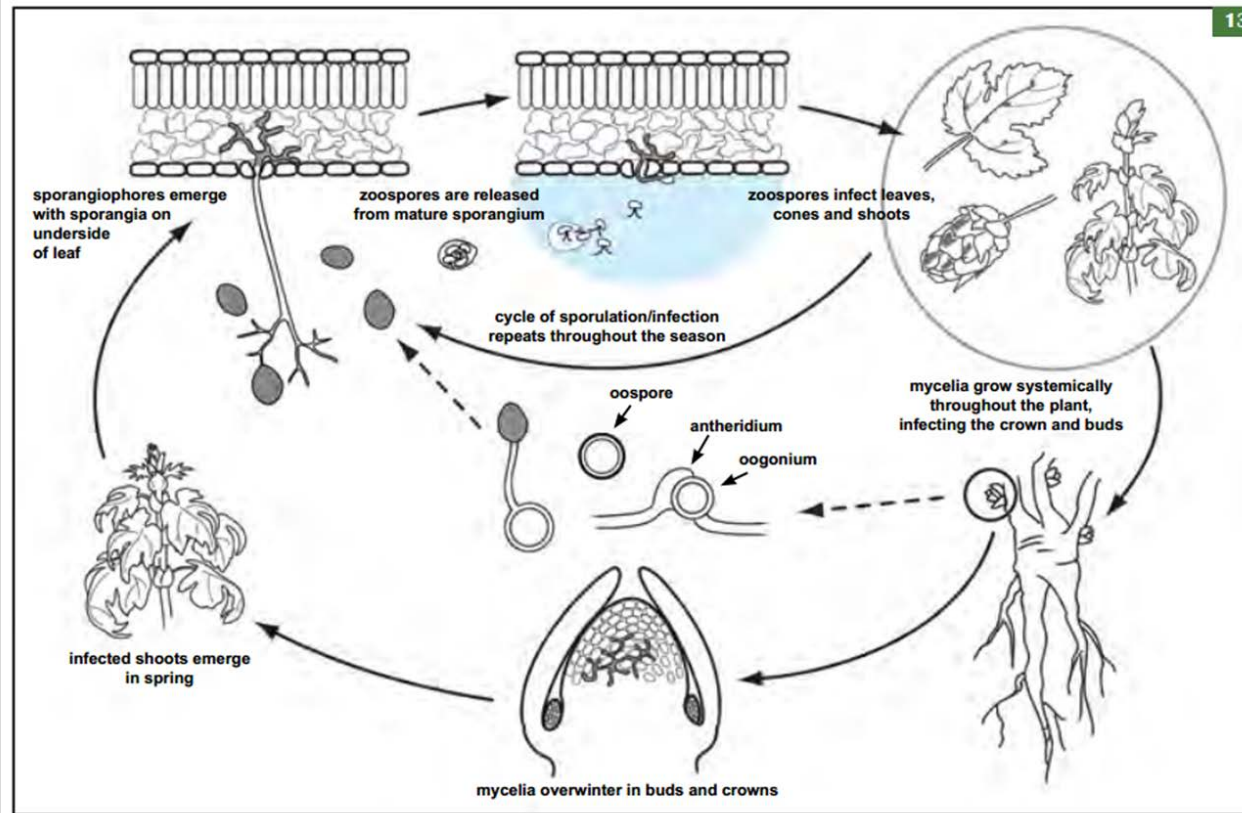
Pseudoperonospora humili



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

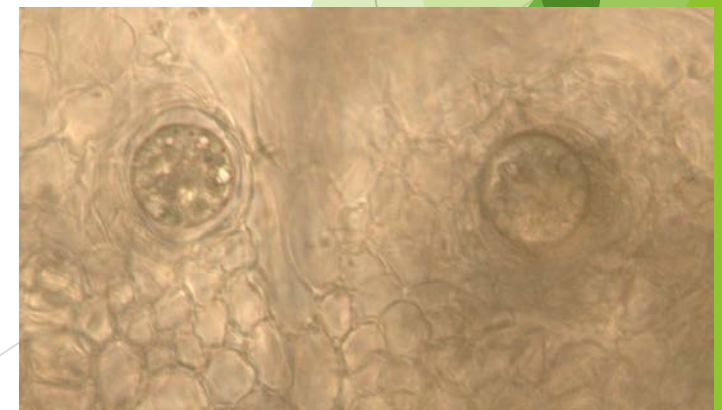
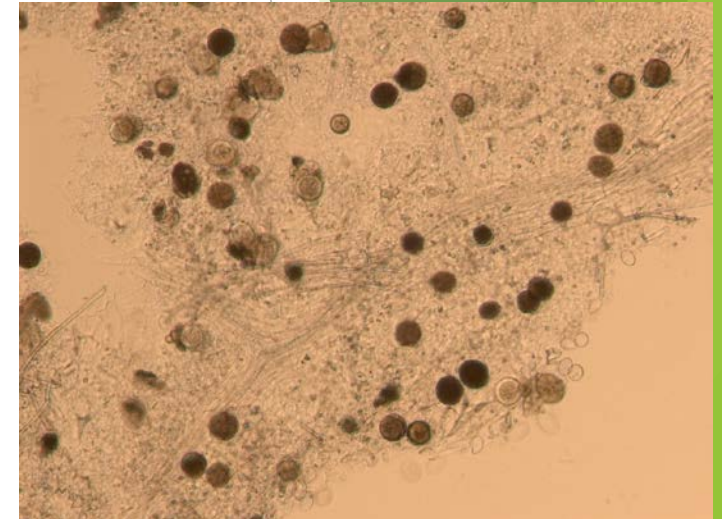
Detection of *Pseudoperonospora humili* oospores in WI



PhD student
Michelle Marks
Hop downy mildew

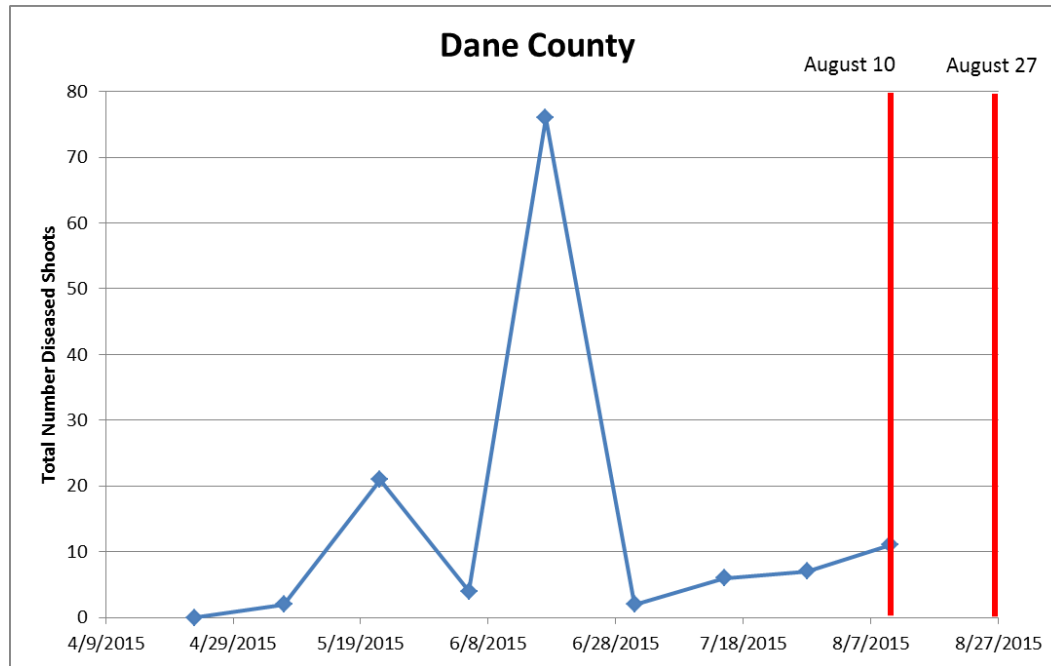


Photo credit: V. Brewster, Compendium of Hop Diseases and Pests.



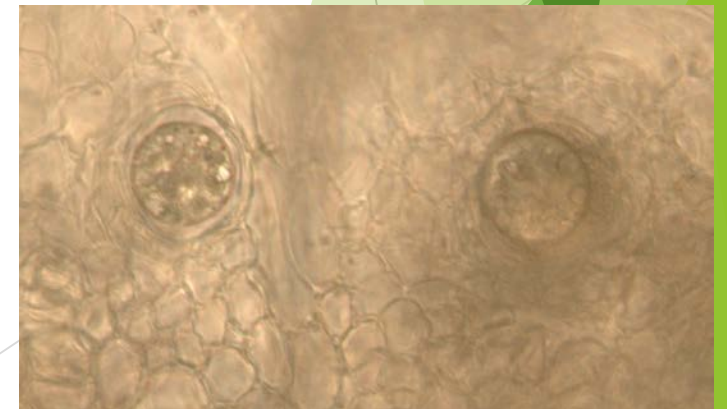
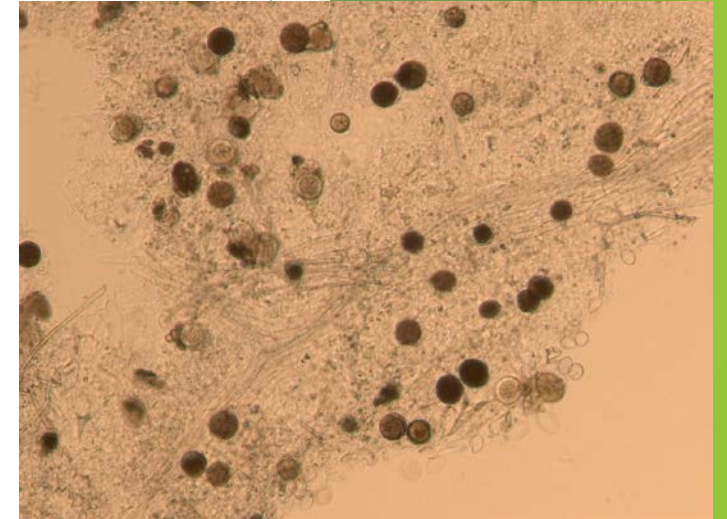
Detection of *Pseudoperonospora humili* oospores in WI

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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

Ilavirus

- Apple Mosaic Virus

Nepovirus

- Arabis Mosaic Virus
- Hop Stunt Viroid
- Hop Latent Viroid

Factors influencing spread

Photo: David Gent, USDA ARS



Photo: thankheavenforbeer.com



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



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



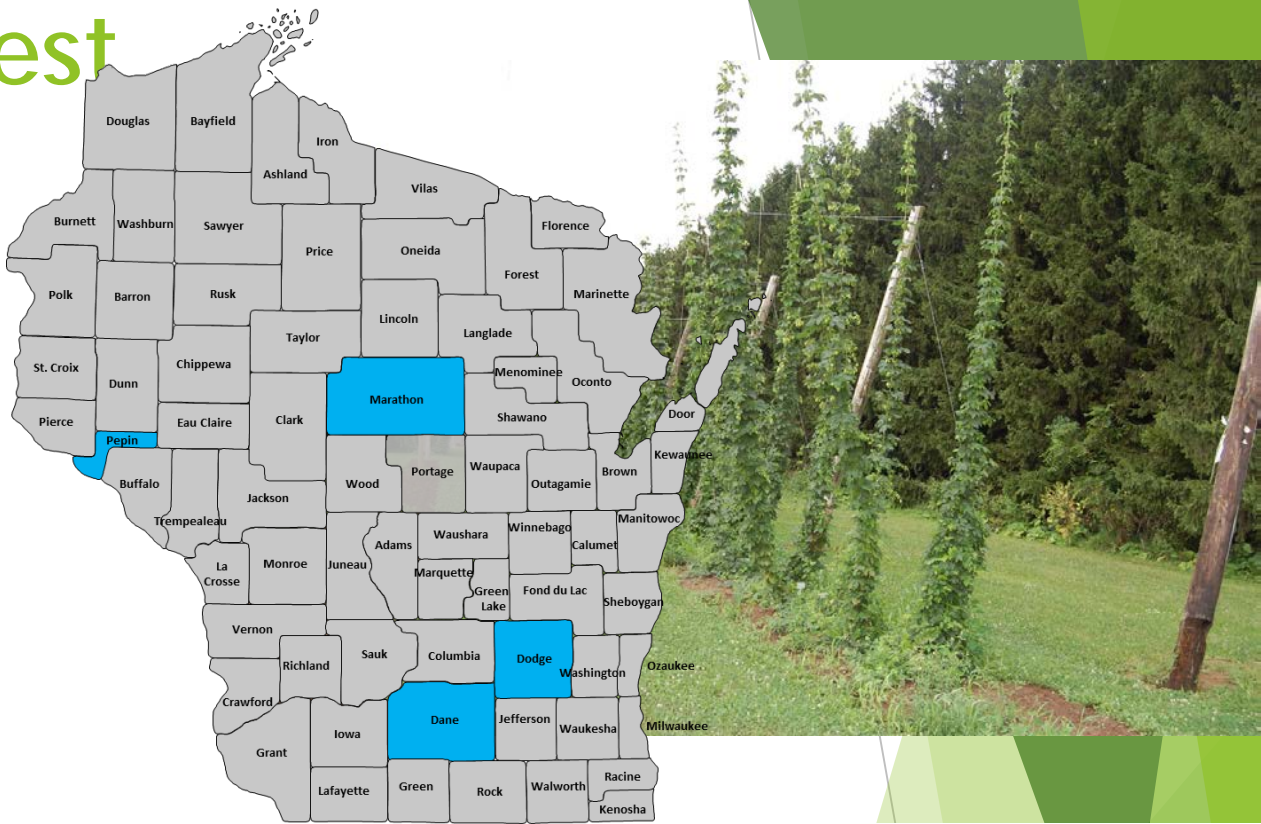
Downy mildew
effects on
cones

B. Engelehard

Wisconsin hop disease & pest assessment - 2015



PhD student
Michelle Marks
Hop downy mildew



<u>County</u>	<u>March</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
Dodge	First buds (30 th)	Downy (21 st)	Downy	Downy		
Dane		First buds (1 st)	Downy (7 th)	Downy	Downy	Downy
Pepin		First buds (1 st)	Downy (27 th)	Downy	Carlavirus Downy	
Marathon		First buds (3 rd)	Downy (21 st)	Leafhoppers Downy	Leafhoppers (early) European corn borer Spider mites	Cabbage loopers (cones) 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



Apple Mosaic Virus
Picture: David Gent

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 humili* - 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
 - hop mosaic virus
- Goals: i) determine feasibility and cost of assays and ii) survey diseases in hop propagative material from multiple WI sources



April 30 - Pepin County



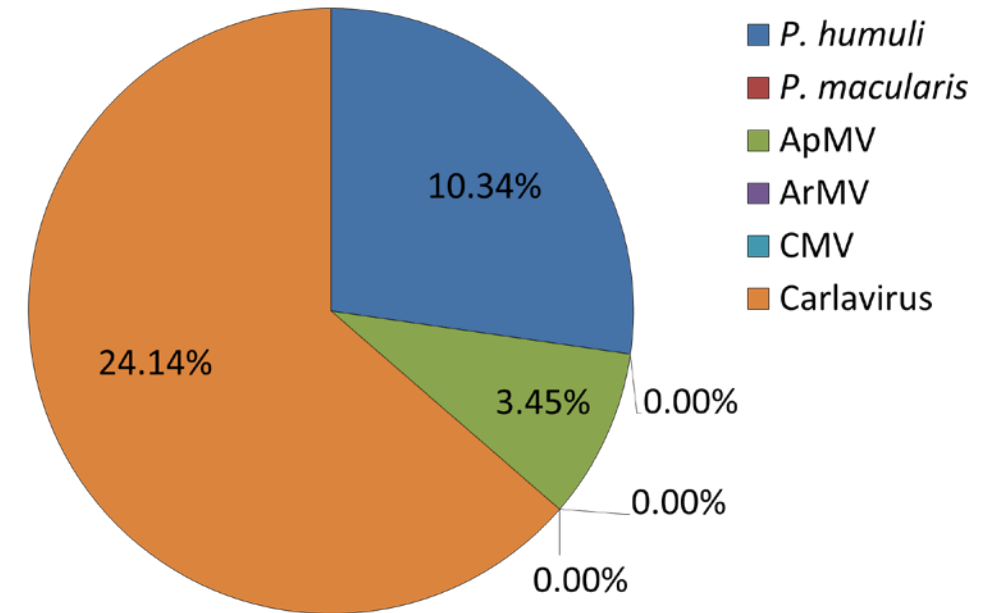
Methods for disease diagnostics in hop propagative stock

- 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. humili* 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. humili* & *P. macularis*

Total Disease Detections

Source	# Samples Received	Number of samples positive for specific disease (% of total samples received)					
		<i>P. humuli</i>	<i>P. macularis</i>	ApMV	ArMV	CMV	Carlavirus
1	8	0 (0%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	4 (50%)
2	8	3 (38%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (13%)
3	13	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (15%)
Total	29	3 (38%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	7 (24%)

Figure 2. Disease testing results from 10 Dec 2014 to 9 Mar 2015.

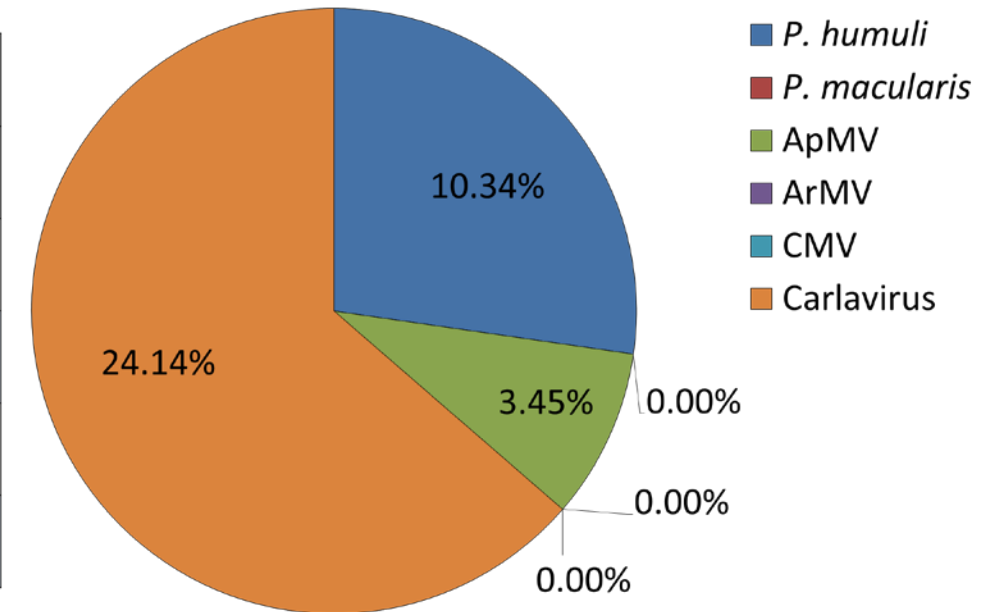


July 16 - Dodge County

Total Disease Detections

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Figure 2. Disease testing results from 10 Dec 2014 to 9 Mar 2015.



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



NCGR expedition
in 2002 to collect
native US hops

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

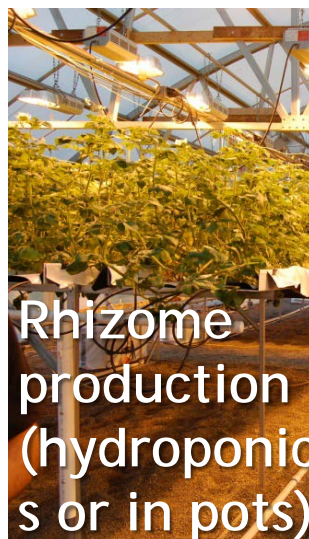
Future production possibilities

<http://healthyplants.wsu.edu>



Growers

- Multiplication
- Hop Production



Growers

- Multiplication
- Hop Production

Growers

- Multiplication (hoophouse/greenhouse)
- Hop Production

Potential for Wisconsin to become a leader in supplying pathogen-free hop rhizomes

Future production possibilities - update

<http://healthyplants.wsu.edu>



<http://www.plantlabs.com>



Growers

- Multiplication (hoophouse/greenhouse)
- Hop Production



- 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!

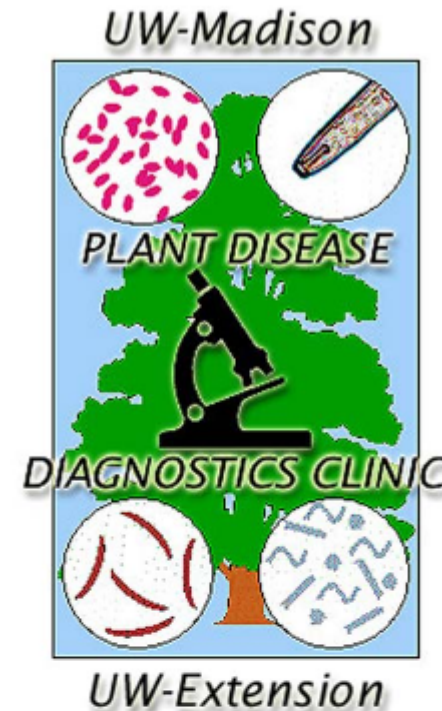
- ▶ Plant disease-free rhizomes and plugs
- ▶ Sanitation for pruners and other tools
- ▶ Prevent movement of soil/infected plants onto your property
- ▶ Plant disease resistant cultivars

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



*Providing plant disease identification
and control recommendations
to homeowners, businesses and
agricultural producers*

Plant Disease Diagnostics Clinic (PDDC)
Department of Plant Pathology
University of Wisconsin-Madison
1630 Linden Drive
Madison, WI 53706-1598

Phone: (608) 262-2863

E-mail: pddc@plantpath.wisc.edu

Web: pddc.wisc.edu

Follow the PDDC on Twitter @UWPDDC



Fee Schedule

Fees Effective January 1, 2016

Fees subject to change without notice

Standard Diagnostics

Standard Analysis

\$20.00

Includes visual and microscopic examination, and incubation in a moist chamber where needed.

Standard Analysis Plus

\$25.00

Includes "Standard Analysis" plus use of standard techniques for isolation of fungal or bacterial pathogens.

Digital Analysis

\$20.00

Examination of digital photos of diseased plants submitted via email.

Virus Analysis

**Variable cost
starting
at \$25.00**

Includes "Standard Analysis" plus additional tests for specific viruses. Exact cost will depend on the number and type of viruses assayed. Available virus tests (at \$5 per test) include Tobacco mosaic virus (TMV), Cucumber mosaic virus (CMV), Impatiens necrotic spot virus (INSV), Tomato spotted wilt virus (TSWV), Arabis mosaic virus (ArMV), and potyvirus (POTV). Other virus testing is available upon request. Call for details.

Phytoplasma Analysis

\$35.00

Includes "Standard Analysis" plus testing for phytoplasmas using PCR

Specific Crop Diagnostics

Turf Diagnostics

Homeowner \$20.00
Commercial with phone report \$100.00
Commercial with written report and phone consultation \$150.00
Site visit and written report \$250.00

(site visit only made following a sample submission)

Hop Diagnostics

**Variable cost
up to
\$135.00**

Select from one or more of the following tests: carlaviruses, Apple mosaic virus (ApMV), Arabis mosaic virus (ArMV), downy mildew, powdery mildew and Verticillium wilt. Call for pricing details.

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

Plant Pathology
at the University of Wisconsin - Madison

