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

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

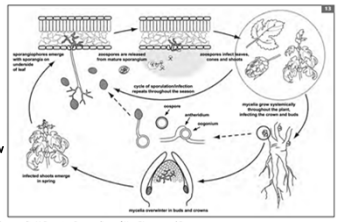
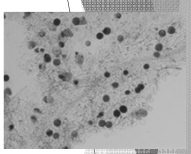
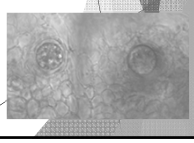


Photo credit: V. Brewster, Compendium of Hop Diseases and Pests.

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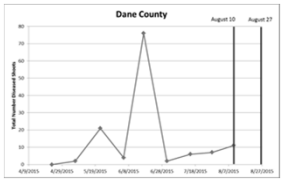
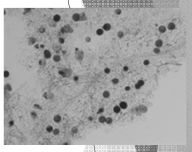
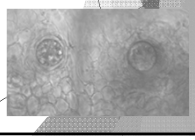


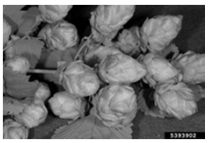
Oospores detected only in dead/dying foliar tissues in late July and August in 4 WI locations.

- *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


Photo: David Gent, USDA ARS

Hop latent viroid

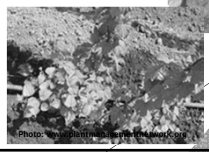


Photo: [illegible]

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

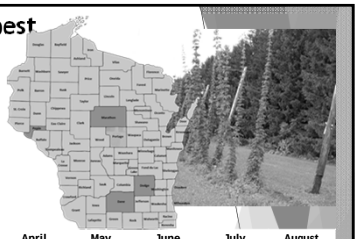
Downy mildew effects on cones


B. Engelehard

Wisconsin hop disease & pest assessment - 2015

SARE Sustainable Agriculture Research & Education

PhD student
Michelle Marks
Hop downy mildew



County	March	April	May	June	July	August
Dodge	First buds (30th)	Downy (21st)	Downy	Downy		
Dane		First buds (1st)	Downy (7th)	Downy	Downy	Downy
Pepin		First buds (1st)	Downy (27th)	Downy	Carlavirus Downy	
Marathon		First buds (3rd)	Downy (21st)	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

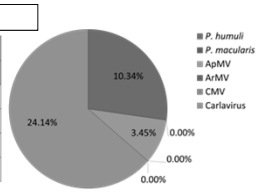
Methods for disease diagnostics in hop propagative stock

- 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)					
		P. humuli	*P. macularis*	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

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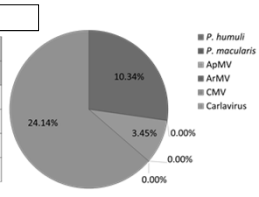


Conclusion

- *P. humili*, 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

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

University of Wisconsin 'clean hops' research program update

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

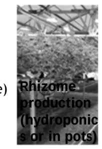
- Establish a pathogen-free tissue culture collection of hop varieties, and produce pathogen-free planting material for on-farm variety evaluations.
- Trial hop rhizome production methods to optimize productivity and economic sustainability.
- Coordinate participatory variety trials in Wisconsin hop yards, and evaluate disease incidence in existing plantings

- **Work funded by the WI Specialty Crop Block Grant Program for 2013-2015**

Future production possibilities

Growers
- Multiplication
- Hop Production

Growers
- Multiplication (hoophouse/greenhouse)
- Hop Production



Growers
- Multiplication
- Hop Production

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

Future production possibilities - update

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!

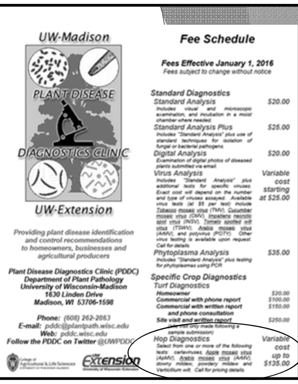
- Plant disease-free rhizomes and plugs
- Sanitation for pruners and other tools
- Prevent movement of soil/infected plants onto your property
- Plant disease resistant cultivars

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



UW-Madison
PLANT DISEASE DIAGNOSTICS CLINIC
UW-Extension

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 — Includes visual and microscopic examination, and incubation in a moist chamber where needed.	$20.00
Standard Analysis Plus — Includes "Standard Analysis" plus use of standard techniques for isolation of fungal or bacterial pathogens.	$25.00
Digital Analysis — Examination of digital photos of diseased plants submitted via email.	$20.00
Virus Analysis — 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 (POTY). Other virus testing is available upon request. Call for details.	Variable cost starting at $25.00
Phytoplasma Analysis — Includes "Standard Analysis" plus testing for phytoplasmas using PCR	$35.00
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 (site visit only made following a sample submission)	$250.00
Hop Diagnostics — 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.	Variable cost up to $135.00

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/

Vegetable Crop Update

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

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