

# Managing Disease in Wisconsin Hops

## Management Programming



THE UNIVERSITY  
of  
**WISCONSIN**  
MADISON



Division of Extension  
University of Wisconsin-Madison

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*University of Wisconsin-Madison*

Hop Production for the Wisconsin Craft Brew Industry

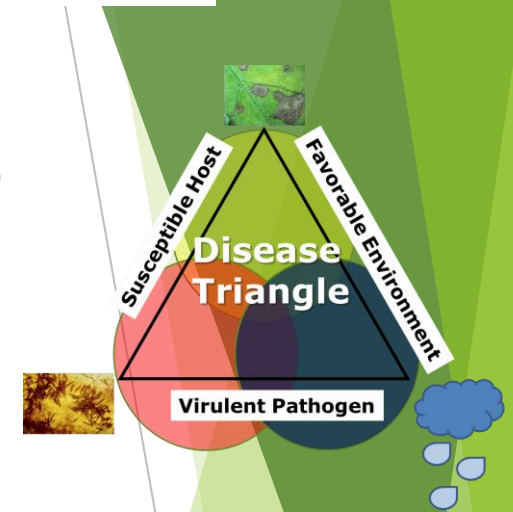
11<sup>th</sup> Annual Seminar - February 29, 2020

New Glarus Brewing Company

New Glarus, WI

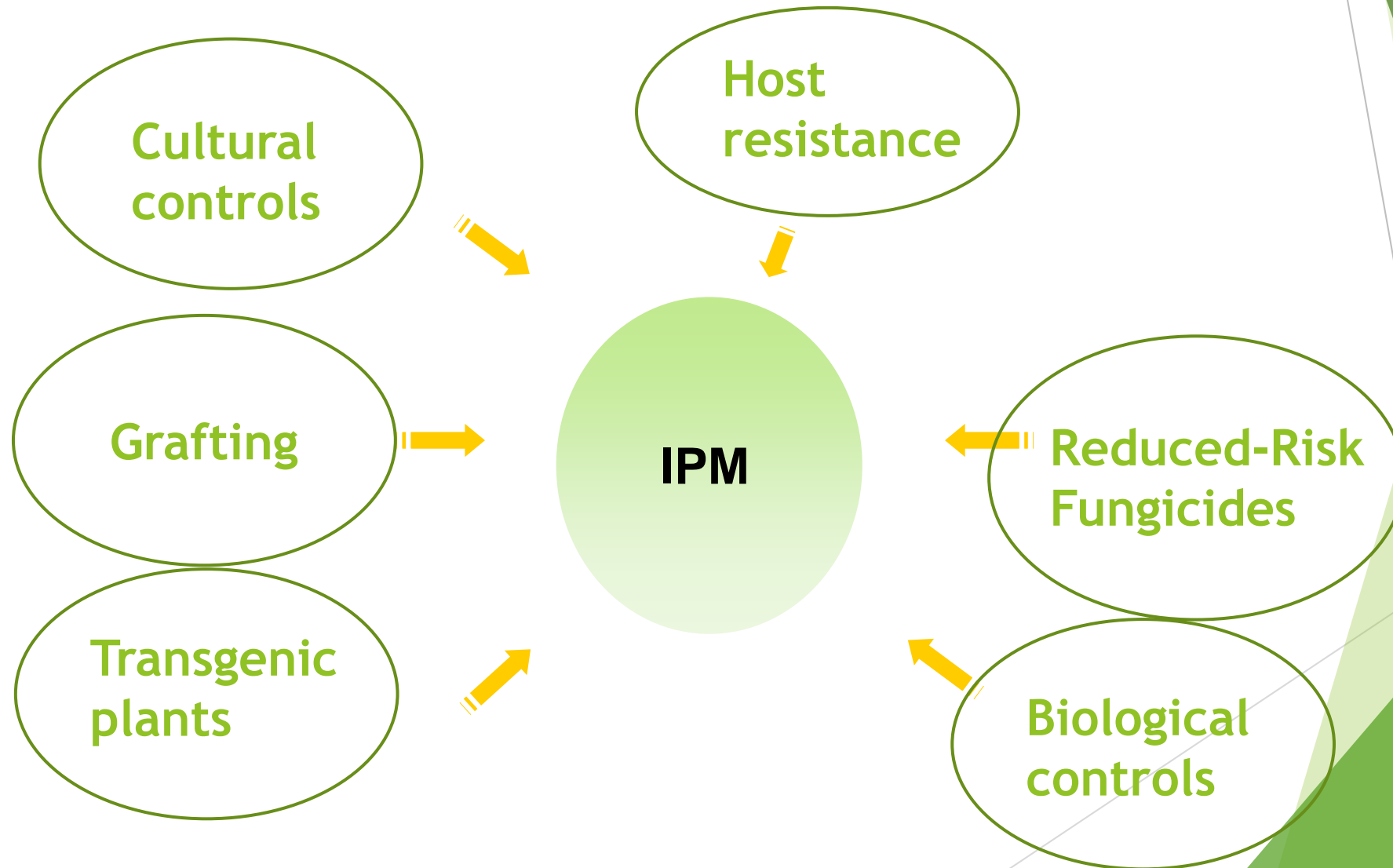
# Components of an Integrated Pest Management Program

- Monitoring and Sampling (inspect)
- Pathogen Identification (what pathogen)
- Decision-making (what action(s))
- Intervention (take action (s))
- Follow-up (re-inspect)
- Record-keeping (write it down, history)
- Education (learn)



# Integrated Disease Management

Options for Disease Management – not all available in hops





# 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 and recent years.

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

# Varietal resistance to downy mildew in hops

- ▶ ‘Centennial’ and ‘Nugget’ are susceptible to downy mildew
- ▶ Most (~75%) of hop varieties grown in U.S. are susceptible to DM
- ▶ Remaining ~25% have some crown tolerance to DM (‘Bullion’, ‘Brewer’s Gold’, ‘Cascade’)
- European hop varieties with DM resistance are ‘extract’ high alpha types (bitters are extracted for flavoring - not directly used from plant product)
- ‘Resistant’ varieties still require ~3 fungicide applications to control DM



# Downy Mildew

## *Management - Initial phase*

Removal of primary basal spikes

Heavily prune and strip leaves in lower 3 ft of bine

Limits downy mildew from moving up the bine and infecting cones

Pruning and thinning also helps reduce moisture in lower canopy which further aids in limiting disease



**Degree-day model to predict emergence of basal spikes - *being validated for WI***

Accumulation of 111 degree-days, base 6°C

# Downy Mildew

## *Management - Initial phase*

Downy mildew can be **systemic**, meaning that the pathogen is inside the below-ground plant parts and can 'awaken' when spikes emerge in the spring.

Spring **pruning** and management of density of hop 'flush' early season can limit disease both in reducing potential for inoculum and in encouraging airflow around base of the plant.

The start of a **preventative fungicide program** should begin at spike emergence.

Fungicides are important for early season control to limit inoculum for the developing crop.



# Downy Mildew *Management*

When to **follow up** with fungicide sprays will vary on the weather. (disease risk index utilized by some Pacific northwestern growers has not yet been validated for WI)

The premise is that the **more rainfall and relative humidity** present under moderate temperatures (46-86F) the **greater the disease pressure**.

Under high pressure times, fungicides should be applied on a 5-7 day spray program.

When rainfall is reduced, relative humidity is low and we experience either temps cooler than 46 or higher than 86F, disease pressure is low and fungicides should be applied on a 10-14 day program.

# Downy Mildew

## *Fungicide Program*

A good fungicide for use in a 14-day calendar program is fosetyl aluminum or Aliette/Linebacker. Phostrol also provides similar extended control as it upregulates resistance in the plant.

Use of an 'Aliette' type product alternated with a tank mix of copper hydroxide plus cymoxanil (Curzate) creates a sound program.

Western states also alternate with copper hydroxide (ie: Kocide) and trifloxystrobin (Flint) in control of powdery mildew. (2016 first official WI report of PM in contemporary times)

If you raise other crops and have familiarity with common base protectant fungicides, remember that you cannot use captan, chlorothalonil, or mancozeb on hops. These fungicides do not have EPA Section 2 or any other special labeling to permit their use on this crop. The only base protectant, broad spectrum fungicide for hops is copper (or copper formulations such as Kocide).

Time of application	Fungicide selection Active ingredient (trade name examples)	Comments
Spray 1: Spike emergence (or GDD 111.3, 6.5°C or 40°F base, Feb 1 start)  <i>For southern WI this often falls within the first week of May</i>	<u>Fosetyl aluminum (Aliette, Linebacker)</u>  Salts of phosphorous acids (Phostrol)	The Aliette program is used in the Pacific northwest with good results. Fosetyl aluminum products cannot be tank mixed with coppers. Phostrol has similar activity as Aliette. Be careful with spray volume and rate – as concentrated Phostrol can potentially be phytotoxic.
Spray 2: 2 weeks after Spray 1  <i>Roughly May 15</i>	<u>Cymoxanil (Curzate)</u>  <u>Copper hydroxide (Kocide)</u>  Dimethomorph (Forum)  Cyazofamid (Ranman)  Pyraclostrobin + Boscalid (Pristine)  Famoxadone + Cymoxanil (Tanos)  Mandipropamid (Revus)  Ametoctradin + Dimethomorph (Zampro)  Mefenoxam (Ridomil Gold SL)	The Curzate + Kocide tank-mix program is used in the Pacific northwest with good results. Curzate and Kocide are good downy mildew fungicides across multiple vegetable crops.  Pre-mixes that have good downy mildew and powdery mildew control are: Pristine and Tanos.  Price point and availability of products in this list may influence selection. All listed have performed well on downy mildews of various crops.  Resistance to Ridomil may exist in downy mildew of WI. Contact UWEX for testing to determine resistance level in your hop yard.

Example fungicide program for Downy mildew control of hops in WI



<p>Spray 3: 2 weeks after Spray 2</p> <p><i>Roughly May 30</i></p>	<p><u>Fosetyl aluminum (Aliette, Linebacker)</u></p> <p>Salts of phosphorous acids (Phostrol)</p>	<p>The Aliette program is used in the Pacific northwest with good results. Fosetyl aluminum products cannot be tank mixed with coppers. Phostrol has similar activity as Aliette. Be careful with spray volume and rate – as concentrated Phostrol can potentially be phytotoxic.</p>
<p>Spray 4: 2 weeks after Spray 3</p> <p><i>Roughly June 15</i></p>	<p><u>Cymoxanil (Curzate)</u></p> <p><u>Copper hydroxide (Kocide)</u></p> <p>Dimethomorph (Forum)</p> <p>Cyazofamid (Ranman)</p> <p>Pyraclostrobin + Boscalid (Pristine)</p> <p>Famoxadone + Cymoxanil (Tanos)</p> <p>Mandipropamid (Revus)</p> <p>Ametoctradin + Dimethomorph (Zampro)</p> <p>Mefenoxam (Ridomil Gold SL)</p>	<p>The Curzate + Kocide tank-mix program is used in the Pacific northwest with good results. Curzate and Kocide are good downy mildew fungicides across multiple vegetable crops.</p> <p>Pre-mixes that have good downy mildew and powdery mildew control are: Pristine and Tanos.</p> <p>Price point and availability of products in this list may influence selection. All listed have performed well on downy mildews of various crops.</p> <p>Resistance to Ridomil may exist in downy mildew of WI. Contact UWEX for testing to determine resistance level in your hop yard.</p>
<p>Spray 5: 2 weeks after Spray 4</p> <p><i>Roughly June 30</i></p>	<p><u>Fosetyl aluminum (Aliette, Linebacker)</u></p> <p>Salts of phosphorous acids (Phostrol)</p>	<p>The Aliette program is used in the Pacific northwest with good results. Fosetyl aluminum products cannot be tank mixed with coppers. Phostrol has similar activity as Aliette. Be careful with spray volume and rate – as concentrated Phostrol can potentially be phytotoxic.</p>

Example fungicide program for Downy mildew control of hops in WI

# Fungicide Resistance Mitigation

<http://www.frac.info/index.htm>

## FRAC Fungicide Resistance Action Committee

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
C. respiration	C1: complex I NADH Oxido-reductase	pyrimidinamines	pyrimidinamines	diflumetorim	Resistance not known.	39
	C2: complex II: succinate-dehydrogenase	SDHI (Succinate dehydrogenase inhibitors)	phenyl-benzamides	benodanil flutolanil mepronil	Resistance known for several fungal species in field populations and lab mutants. Target site mutations in sdh gene, e.g. H/Y (or H/L) at 257, 267, 272 or P225L, dependent on fungal species. Resistance management required.  <b>Medium to high risk.</b>  <b>See FRAC SDHI Guidelines for resistance management.</b>	7
			pyridinyl-ethyl-benzamides	fluopyram		
			furan- carboxamides	fenfuram		
			oxathiin-carboxamides	carboxin oxycarboxin		
			thiazole-carboxamides	thifluzamide		
			pyrazole-carboxamides	benzovindiflupyr bixafen fluxapyroxad furametpyr isopyrazam penflufen pentiopyrad sedaxane		
	C3: complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site ( <i>cyt b gene</i> )	QoI-fungicides (Quinone outside Inhibitors)	methoxy-acrylates	azoxystrobin coumoxystrobin enoxastrobin flufenoxystrobin picoxystrobin pyraoxystrobin	Resistance known in various fungal species. Target site mutations in cyt b gene (G143A, F129L) and additional mechanisms.  Cross resistance shown between all members of the QoI group.  <b>High risk.</b>  <b>See FRAC QoI Guidelines for resistance management.</b>	11
			methoxy-carbamates	pyraclostrobin pyrametostrobin triclopyricarb		
			oximino acetates	kresoxim-methyl trifloxystrobin		
			oximino-acetamides	dimoxystrobin fenaminostrobin metominostrobin oryastrobin		
			oxazolidine-diones	famoxadone		
			dihydro-dioxazines	fluoxastrobin		
			Imidazolinones	fenamidone		
			benzyl-carbamates	pyribencarb		
	C4: complex III: cytochrome bc1(ubiquinone reductase) at Qi site	QiI - fungicides (Quinone inside Inhibitors)	cyano- imidazole	cyazofamid	Resistance risk unknown but assumed to be medium to high (mutations at target site known in model organisms). Resistance management required.	21
			sulfamoyl-triazole	amisulbrom		
	C5: uncouplers of		dinitrophenyl crotonates	binapacryl meptyldinocap dinocap	Resistance not known. Also acaricidal activity.	29
			2,6-dinitro-			

# Fungicides for hop downy mildew control, WI February 7, 2020

## Downy mildew (*Pseudoperonospora humili*)

fosetyl aluminum 33	2.5 lb Aliette  5.0 lb/100 gal spray volume Linebacker	24 Days PHI	Do not tank-mix with coppers. Initiate application when weather conditions favor disease (warm and humid). Avoid mixing with foliar fertilizers or surfactants.
cymoxanil 27	3.2 oz Curzate DF	7	Apply with a protectant fungicide such as copper hydroxide.
dimethomorph 40	6.0 fl oz Forum	7	Do not make more than 3 applications per season. Addition of an adjuvant to spray mix is recommended.
famoxadone and cymoxanil  11,27	8 oz Tanos	7	Use with a tank-mix partner. Apply preventatively and on a 6-8 day spray schedule. Follow resistance management guidelines.
mandipropamid 40	8.0 fl oz Revus	7	A non-ionic surfactant is recommended with use of this product. Follow resistance management guidelines.
cyazofamid 21	2.1-2.75 fl oz Ranman	3	Apply prior to or at first sign of disease. Follow resistance management guidelines.
pyraclostrobin and boscalid  11, 7	14.0 oz/100 gal spray volume Pristine	14	Use preventatively and apply at 14-21 day intervals as needed. Follow resistance management guidelines.
mefenoxam 4	0.5 pt Ridomil Gold SL	45	Label allows drench and foliar applications. Follow resistance management guidelines.
metalaxyl 4	1.0 qt MetaStar 2E	45	Label allows drench and foliar applications. Follow resistance management guidelines.



# Fungicides for hop downy mildew control, WI February 7, 2020

## Downy mildew (*Pseudoperonospora humili*)

ametoctradin + dimethomorph (45+40)	11-14.0 fl oz Zampro	7 DAYS PHI	Use a spreader or penetrating adjuvant. Do not use more than 3X per acre/production season for resistance management. Do not make more than 2 sequential applications before alternating to a different mode of action (different FRAC group).
Extract of <i>Reynoutria sachalinensis</i>	1.0-4.0 qt Regalia	0	Use preventatively and apply at 7 day intervals as needed. Emergence to wire-touch 1.0-2.0 qt recommended/wire-touch through harvest 2.0-4.0 qt. OMRI approved.
potassium bicarbonate	2.5-5.0 lb/100 gal spray volume Armicarb 100	0	Do not exceed mix rate of 5.0 lb/100 gal of water. Do not store unused portion of spray for more than 12 hours prior to use.
copper oxychloride and copper hydroxide	1.8 pts Badge SC 0.75 lb Badge X2	14	Treat after pruning but before training.
copper oxychloride and basic copper sulfate	C-O-C-S WDG 4.0-6.0 lb	14	Apply soon after training vines.
copper hydroxide	1.33 lb Champ Dry Prill 1.33 lb Champ Formula II Flowable 1.06 lb Champ WG 0.75-1.5 lb Kocide 3000 1.5 lb Kocide 2000 2.0 lb Kentan DF 1.33-2.67 pt NuCop 3L	14	Apply after pruning but before training. Apply again as needed on a 10 day basis after training.

# Fungicides for hop downy mildew control, WI February 7, 2020

## Downy mildew (*Pseudoperonospora humili*)

mono and dipotassium salts of phosphorous acid	1-3 qt/100 gal water Fosphite 1.0-2.0 qt/acre in a spray volume of 25 gal water Fungi-phite 2.0-4.0 pt Helena Prophyt 2.5 pt Phostrol	0 DAYS PHI	Apply at 2 to 3 week intervals. Do not apply at an interval less than 3 days.  Apply when conditions favor disease when shoots are 6-12 in high, after training at 5-6 ft tall, about 3 weeks after 2nd application, and during bloom.
mono potassium phosphate and mono potassium phosphite	2.0-4.0 qt Phorcephite 1.0-3.0 qt in 20 gal of water Rampart	0	Apply when conditions favor disease when shoots are 6-12 in high, after training at 5-6 ft tall, about 3 weeks after 2 <sup>nd</sup> application, and during bloom.
<i>Bacillus pumilis</i> QST 2808	2.0-4.0 qt/100 gal spray volume of Sonata	0	Use when conditions favor disease and apply at 7-14 day intervals as needed. OMRI approved.

# 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.

**First contemporary confirmation of powdery mildew on hops in WI in 2016 (as per UW Plant Disease Diagnostic Clinic & UW Vegetable Pathology).**

Photo courtesy: David Gent



# Powdery Mildew Management

While the Pacific Northwestern region has successfully utilized pruning for early season PM control (and reduction in need for early season fungicides, this approach is not validated for WI conditions

Some concern with pruning and impact on timing of maturity when you grow hops in northern latitudes

**Management of powdery mildew in cones is dependent on the success and thoroughness of early season control measures (sanitation, weed control, preventive fungicides).**

# Varietal resistance to powdery mildew in hops

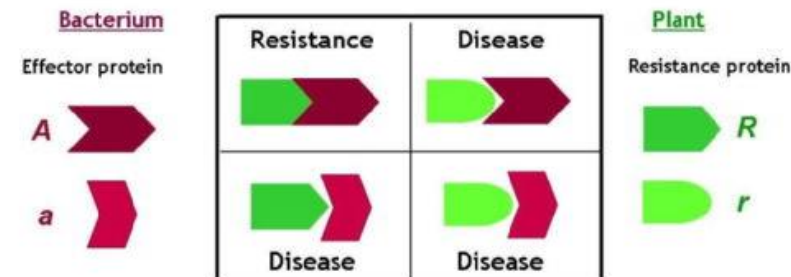
- ▶ A hop variety can carry a gene or genes for resistance to powdery mildew (PM)
- ▶ There are 7 resistance genes to PM in hops

- ▶ Rb
- ▶ R1
- ▶ R2
- ▶ R3
- ▶ R4
- ▶ R5
- ▶ R6

- Gene-for-gene relationship between hops PM races and host resistance

The Gene-for-Gene Model of Plant Immunity

Bacterium	Plant Resistance gene	<i>R</i>	<i>r</i>
	Effector gene		
	<i>A</i>	Resistance	Disease
	<i>a</i>	Disease	Disease



# Varietal resistance to powdery mildew in hops

- ▶ Varieties resistant to Pac NW PM:
  - ▶ ‘Nugget’ (R6)
  - ▶ ‘Cascade’ (R5)
  - ▶ ‘Mt. Hood’
- Varieties moderately resistant to Pac NW PM:
  - ‘Fuggle’
  - ‘Perle’
  - ‘Tettnang’
  - ‘Hallertau’
- Varieties susceptible to Pac NW PM include
  - ‘Horizon’
  - ‘Columbus’
  - ‘Tomahawk’
  - ‘Zeus’
  - ‘Cluster’
  - ‘Chinook’
  - ‘Willamette’
  - ‘Liberty’
  - ‘Chelan’
  - ‘Eroica’
  - ‘Symphony’
  - ‘Galena’
  - Any variety with Rb PM resistance gene



# Fungicides for hop powdery mildew control, WI February 25, 2017

## Powdery mildew (*Podosphaera macularis* and *humili*)

trifloxystrobin 11	1.0 oz with every 15-30 gal spray volume Flint	14 DAYS PHI	Apply preventatively for best results. Apply on a 10 to 14 day interval. Follow resistance management guidelines.
pyraclostrobin and boscalid 11, 7	14.0 oz/100 gal spray volume Pristine	14	Use preventatively and apply at 14-21 day intervals as needed. Follow resistance management guidelines.
myclobutanil 3	2.0-10.0 oz Rally	14	Emergence to training label rate is 2-4 oz/training to wire is 4-6 oz/wire to 14-day prior to harvest is 6-10 oz. Follow resistance management guidelines. (Old product name was Nova)
tebuconazole 3	4.0-8.0 fl oz Monsoon, ONSET 3.6L, Orius 3.6F, Tebustar 3.6L, Tebuzol 3.6F, Toledo 3.6F	14	Apply at 10 to 14 day intervals. Follow resistance management guidelines.
triflumizole 3	12.0 fl oz Procure 480SC	7	Use prior to or at disease onset for best results and reapply on a 14 day schedule.
quinoxyfen 13	4.0-8.2 fl oz Quintec	21	Follow resistance management guidelines, including 'do not apply more than 4X per season.' Minimum spray interval is 7 days.
metrafenone *8	15.4 fl oz Vivando	3	No curative activity. Must be applied early/in advance of infection. Do not make more than 2 applications per year, totaling no more than 30.8 fl oz. Do not mix with oils.

# Fungicides for hop powdery mildew control, WI February 7, 2020

## Powdery mildew (*Podosphaera macularis* and *humili*)

fluopyram and tebuconazole 7, 3	8.0-17.0 fl oz/acre Luna Experience	14 DAYS PHI	Apply preventatively for best results. Apply on a 14 day interval. Follow resistance management guidelines. No more than 34 fl oz per acre per year. Also controls Botrytis.
cyflufenamid U6	6-8 oz Torino	0 DAYS PHI	Do not exceed two applications per year.
fluopyram 7	6.5-6.84 fl oz/acre Velum	7 DAYS PHI	Follow resistance management strategies.
fluopyram and trifloxystrobin 7, 11	3.0-7.6 fl oz/acre Luna Sensation	14 DAYS PHI	Apply preventatively for best results. Apply on a 14 day interval. Follow resistance management guidelines. No more than 27.1 fl oz per acre per year. Also controls Botrytis; and Downy mildew at highest label rate.
flutriafol 3	5.0-7.0 fl oz/acre Rhyme	7 DAYS PHI	Apply preventatively for best results. Apply no more than 28 fl oz/acre per year. Follow resistance management guidelines.

# Fungicides for hop powdery mildew control, WI February 7, 2020

## Powdery mildew (*Podosphaera macularis* and *humili*)

potassium bicarbonate	2.5-5.0 lb/100 gal spray volume Armicarb 100	0 DAYS PHI	Do not exceed mix rate of 5.0 lb/100 gal of water. Do not store unused portion of spray for more than 12 hours prior to use.
sodium bicarbonate	4.0 oz/10 gal water spray volume Milstop	0	Begin application when weather favors disease and apply at 1 to 2 week intervals. Tighten intervals when disease pressure heightens.
copper octanoate	0.5-2.0 gal Cueva in 100 gal water	14	Apply soon after training vines.
potassium bicarbonate	2.5-5.0 lb Kaligreen	1	Apply when weather conditions favor disease and repeat on a 7-10 day basis.
mono and dipotassium salts of phosphorous acid	1-3 qt/100 gal water Phosphite  1.0-3.0 qt in 20 gal of water Rampart	0	Apply at 2 to 3 week intervals. Do not apply at an interval less than 3 days.
Extract of <i>Reynoutria sachalinensis</i>	1.0-4.0 qt Regalia	0	Use preventatively and apply at 7 day intervals as needed. Emergence to wire-touch 1.0-2.0 qt recommended/wire-touch through harvest 2.0-4.0 qt. OMRI approved.

# Fungicides for hop powdery mildew control, WI February 7, 2020

Powdery mildew ( <i>Podosphaera macularis</i> and <i>humili</i> )			
<i>Bacillus subtilis</i> QST 713 strain	4.0-6.0 qt/100 gal spray volume of Serenade ASO	0 DAYS PHI	Use when conditions favor disease and apply at 7 day intervals as needed. OMRI approved.
<i>Bacillus subtilis</i> QST 713 strain	2.0-3.0 lb/100 gal spray volume of Serenade MAX	0	Use when conditions favor disease and apply at 7 day intervals as needed. OMRI approved.
<i>Bacillus pumilis</i> QST 2808	2.0-4.0 qt/100 gal spray volume of Sonata	0	Use when conditions favor disease and apply at 7-14 day intervals as needed. OMRI approved.
neem oil	0.5%-1.0% in 25-100 gal water spray volume of Trilogy	0	Use when conditions favor disease and apply at a 7-14 day interval as needed. OMRI approved. Also a miticide/insecticide.



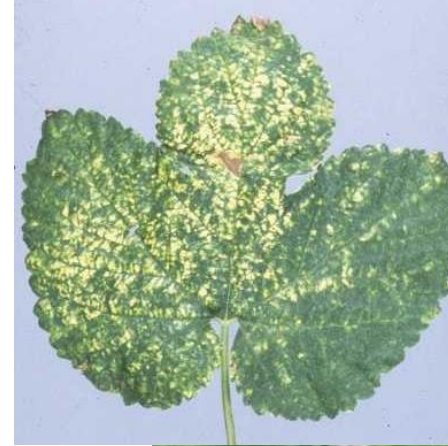
# Updates on the Clean Hops Project Supported by WI-DATCP Specialty Crop Block Grant Program

**Dr. Ruth Genger  
Dr. Amanda Gevens  
&  
Collaborating Growers**



# Diseases carried in hop planting stock (rhizomes or plantlets)

- Carlaviruses
  - Hop Mosaic Virus (HpMV)
  - Hop Latent Virus (HpLV)
  - American Hop Latent Virus (AHLV)
- Apple Mosaic Virus
- Arabis Mosaic Virus
- Hop Stunt Viroid
- Hop Latent Viroid
- Hop Downy Mildew
- Verticillium wilt



Hop Mosaic Virus,  
cultivar Golding  
<http://www.dpvweb.net>



Apple Mosaic Virus  
Picture: David Gent

# Managing diseases spread in planting stock

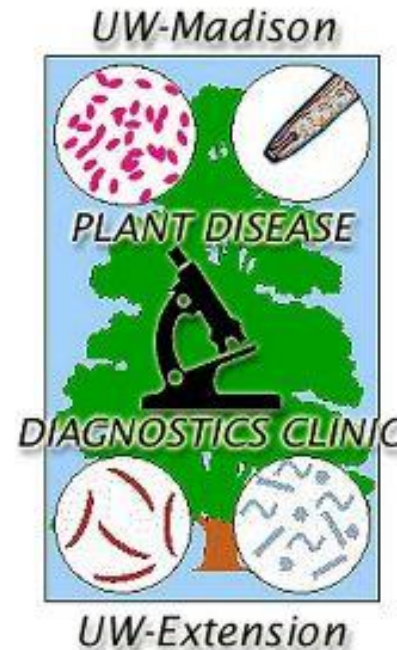
- Plant clean stock
- Sanitation
  - Work in diseased yards last
  - Sterilize tools (soak in 5-10% bleach for several minutes. Rinse with water.)
- Destroy infected plants



Hop stunt viroid in cultivar Glacier.  
Picture: Ken Eastwell.

# Hop testing services

- Plant Disease Diagnostic Clinic at UW-Madison  
<http://labs.russell.wisc.edu/pddc/>
- Brian Hudelson, Clinic Director
- Testing services for
  - Carlaviruses
  - Apple mosaic virus
  - Arabis mosaic virus
  - Downy mildew
  - Powdery mildew
  - Verticillium wilt

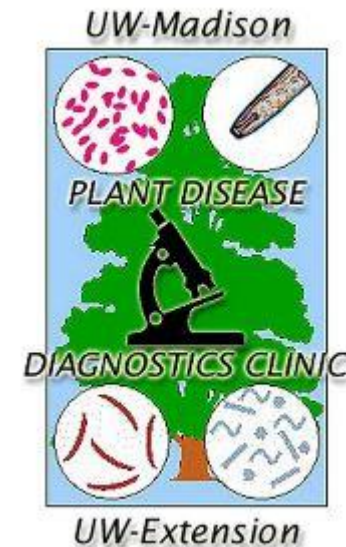


See brochure or website for details on sample submission and pricing.



# University of Wisconsin Clean Hops Program

- Build cultivar collection as local source of clean planting stock
- Develop capacity for pathogen eradication from hop clones
- Offer pathogen testing services for hop samples





# Hop cultivar collection at UW-Madison

Cultivar	Source
Cascade	USDA-NCGR
Hallertauer Tradition	USDA-NCGR
Galena	USDA-NCGR
Mt. Hood	USDA-NCGR
Nugget	USDA-NCGR
Perle	NCPN-Hops
Saazer 38	USDA-NCGR
Tahoma	NCPN-Hops
Willamette	USDA-NCGR
Yakima Gold	NCPN-Hops

- Virus indexed and tested annually
- Source of plants for field trials
- Research into propagation
- Propagation of plants for purchase as requested: contact Ruth Genger [ruth.genger@wisc.edu](mailto:ruth.genger@wisc.edu)

USDA-NCGR: National Clonal Germplasm Repository, Corvallis OR

NCPN-Hops: National Clean Plant Network, Washington State University

# Greenhouse propagation

- Bine cuttings with 1-2 nodes, ~1 inch stem to either side
  - Apply rooting hormone to lower end
  - Insert into moist potting media so that nodes are just covered. Use peat based media, with 50-70% perlite for better drainage.
  - Cover with ventilated plastic dome. Avoid direct sunlight.
  - Water gently. Re-cover nodes with soil if exposed.
- 
- NCPN protocol recommends 1000 ppm indole butyric acid/boric acid (IBA/BA) solution
  - We observed low shoot development and excessive root development at 1000 ppm for 8 varieties tested
  - We recommend using commercial rooting hormone for ease of use, or 10 ppm IBA/BA solution



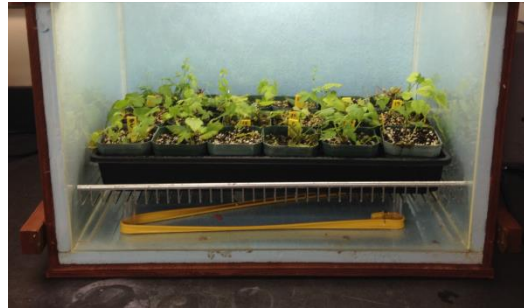
Former student Deena Patterson taking hop cuttings



Successful propagation at 4 weeks

# Virus eradication research

- Approach: heat treatment and apical cuttings on Brewer's Gold and Centennial plants infected with ApMV and carlaviruses



Eileen  
Shea

## Preliminary results:

- ApMV (not carlaviruses) eliminated after 6 day heat treatment
- Higher survival rates for Brewers' Gold than Centennial
- Continuing trials will test longer heat treatments and optimize conditions for different cultivars

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**Ag Research Stations**

**UW Plant Pathology Dept.**

**Plant Pathology**  
at the University of Wisconsin-Madison

**WI Vegetable Production**

**Wisconsin Vegetable Production**  
UW-Madison Extension

**Plant Disease Diagnostic Clinic**

**Plant Disease Diagnostics Clinic**

**UW Vegetable Pathology** University of Wisconsin-Madison  
Department of Plant Pathology

Home Vegetable Crop Updates Weather Data P-Days and Severity Values Field Trial Reports Lab Personnel Slide Sets Fact Sheets Late Blight

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[Information about the North Central Divisional APS meeting \(June 2014 in Madison\)](#)

Resources include:

- **NEW: PROCEEDINGS OF WISCONSIN'S ANNUAL POTATO MEETING, February 4-6, 2014; WISCONSIN MUCK CROPS RESEARCH UPDATE, February 5, 2014, Volume 27** (NOTE: large file/download)
- [Current disease management updates](#)
- [Blitecast & Tomcast estimates \(from remotely sensed weather data\), 2013](#)
- Weather data from four potato growing regions of WI during the growing season (to use in the WISDOM or SureHarvest crop management programs)

# Information Resources

**Web-based disease forecasting  
Information available in 2016-17**

- useful tool to aid in disease control decision making
- requires validation for WI

**W Vegetable Crop Update**  
A newsletter for commercial potato and vegetable growers prepared by the University of Wisconsin-Madison vegetable research and extension specialists

**UW Extension**

No. 8 – June 3, 2011

**UWEX Veg Crop Updates Newsletter**

- weekly updates with disease forecasting information

**Field Guide for Integrated Pest Management in Hops**

Oregon State University  
University of Idaho  
USDA Agricultural Research Service  
and Washington State University

A3422

**Commercial Vegetable Production in Wisconsin**

2017

J.B. Colquhoun E.M. Jensen  
A.J. Gevens G.R.W. Nice  
R.L. Groves M.D. Ruark  
D.J. Holder

**UW Extension**  
University of Wisconsin-Extension

- Asparagus
- Bean
- Carrot
- Celery
- Cole crops
- Cucumber
- Eggplant
- Hops
- Horseradish
- Leafy greens
- Melon
- Mint
- Onion
- Pea
- Pepper
- Potato
- Pumpkin & squash
- Sweet corn
- Table beet
- Tomato

Information current as of October 2016. Pesticide labels change often. This publication is not a substitute for the label. Always read the pesticide label prior to use.



# 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\\_entrant\\_hoppest\\_powderymildew.htm](http://www.cals.uidaho.edu/pses/Research/r_entrant_hoppest_powderymildew.htm)

Plant Pathology  
at the University of Wisconsin - Madison



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