Considerations for disease control in Wisconsin hop production, 2016

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Key diseases of concern include downy mildew and powdery mildew. Downy mildew is likely systemic in most hop yards, meaning that the pathogen is inside the rhizomes and can 'awaken' when spikes emerge in the spring. As such, fungicides are important for early season control of this pathogen so as to limit the amount of initial inoculum that can become available to the developing crop as the season progresses. While we have had some anecdotal reports of powdery mildew in WI, my lab and the UWEX Plant Disease Diagnostic Lab have not yet confirmed the disease.

The start of a preventative fungicide program for downy mildew should begin at spike emergence. This timing can be based on temperature or growing degree days, aligning with growing degree days (GDD) of 111.3. Notes below provide further explanation and directions for determining this number for your location.

> Based on David Gent's work in Oregon, the time to initiate a fungicide program for preventative downy mildew control in hops is at predicted spike emergence (emergence of basal shoots in spring, growing degree day 111.3 air temperature). This is calculated using growing degree days starting from February 1 (base 6.5 degrees C). To get to this emergence date, there is a GDD calculator (link below) that can be used with your specific zip code. Base 6.5C can be defaulted to 40F. With this tool, you select current day's date for 'end'. For example, today April 26, 2013, in Madison, we are at GDD 100.5.
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> http://www.weather.com/outdoors/agriculture/growing-degree-days/53706:4
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> The tool should indicate a crop physiological status (emergence). Emergence can simply be observed, however, emergence is progressive and spans a period of time for 'complete emergence'. In theory, the tool enables you to identify the earliest phase of emergence and as such aids in timing of early/preventative downy mildew control.

When to follow up with fungicide sprays for downy mildew: This will vary depending upon the weather. There is a disease risk index utilized by some Pacific northwestern hop growers that has not yet been validated for WI. The premise is that the more rainfall and relative humidity present under moderate temperatures (46-86°F) 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 86°F, disease pressure is low and fungicides should be applied on a 10-14 day 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.

Below, I have outlined a general foliar fungicide program by calendar for Wisconsin hop yards with additional notes in the right-hand column. 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 containing formulations such as Kocide). Follow the label for appropriate fungicide usage as resistance management guidelines may limit total amount of product per acre and per season, and/or total number of applications per season. The label will also tell you of the REI (re-entry intervals) and PHI (pre-harvest intervals) requirements. Use this table as a reference along with the companion fungicide listing with complete rate, FRAC # (for resistance management mitigation), and mode of action that is available at my website:
http://www.plantpath.wisc.edu/wivegdis/pdf/2015/Hops%20fungicides%20for%20WI%202015_Gevens%20MOA.pdfb

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) *For southern WI this often falls within the first week of May*	Fosetyl aluminum (Aliette, Linebacker) 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 *Roughly May 15*	Cymoxanil (Curzate) Copper hydroxide (Kocide) 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.

Spray 3: 2 weeks after Spray 2 *Roughly May 30*	Fosetyl aluminum (Aliette, Linebacker) 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 4: 2 weeks after Spray 3 *Roughly June 15*	Cymoxanil (Curzate) Copper hydroxide (Kocide) 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.
Spray 5: 2 weeks after Spray 4 *Roughly June 30*	Fosetyl aluminum (Aliette, Linebacker) 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 6: 2 weeks after Spray 5 *Roughly July 15*	*For Powdery and Downy mildew control:* Pyraclostrobin + Boscalid (Pristine) Famoxadone + Cymoxanil (Tanos) *For Powdery mildew control:* Trifloxystrobin (Flint)	Powdery mildew (PM), if present, may be problematic at this time of the year. We often see PM on cucurbits and other crops at this time (earlier in hot years). Pristine and Tanos are good pre-mix selections for both PM and Downy mildew. Products with individual disease activity can be tank-mixed. If you have primarily or just a PM problem, good selections include: Flint, Tebustar, Rally, Quintec, Procure. Neem oil and other horticultural oils

	Tebuconazole (Tebuzol, Orius, Toledo, Monsoon, ONSET, Tebustar) Myclobutanil (Rally, formerly Nova) Quinoxyfen (Quintec) Triflumizole (Procure) Neem oil *For Downy mildew control:* Cymoxanil (Curzate) Dimethomorph (Forum) Cyazofamid (Ranman) Mandipropamid (Revus) Ametoctradin + Dimethomorph (Zampro) Mefenoxam (Ridomil Gold SL)	are good choices for PM control on organic hops. If you have primarily or just a Downy mildew problem, good selections include: Curzate, Forum, Ranman, Revus, or Ridomil Gold SL. As you start to use a reduced risk, single site fungicide multiple times over the production season, keep in mind that some fungicide labels restrict total # of applications per season (ie: Forum, do not apply more than 3X per season).
Spray 7: 2 weeks after Spray 6 *Roughly July 30*	<u>Fosetyl aluminum (Aliette, Linebacker)</u> Salts of phosphorous acids (Phostrol)	See comments above for Spray 5.
Spray 8: 2 weeks after Spray 7 If needed – follow alternation pattern as needed based on status of disease in crop.	<u>Spray 6 program and comments</u>	Pay careful attention to Pre-harvest intervals at this time of the season as you near cone maturity.