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Hop Integrated Pest Management

Erin Lizotte
Michigan State University Extension

Overview

- Scouting protocol
- Pest ecology and management
- Beneficials
- Considerations
- Resources

Scouting

- Scouting involves monitoring the crop and cropping area for problems
- Begin as soon as plants begin to grow or pests become active
- Continue until the crop is dormant or the risk of the pest has passed

Scouting

- A critical step in quantifying the potential pest damage
- Aids in determining if intervention to control the pest is warranted
- Helps determine the lifestage of the pest which is critical to optimize management
- Assists in determining management efficacy

Scouting

- Scouting for diseases includes monitoring the crop for signs and symptoms of disease and quantifying incidence and severity

Scouting

- Scouting for insects includes looking for all life stages and attempting to quantify the population
- May also include inspecting for crop damage and setting traps to collect them

Abiotic issues

- Unexplained by pests
  - Lack of water
  - Lack of nutrient
  - pH
  - Mechanical damage
  - Excessive water

Vertebrate damage

Scouting records

- Maps, a record of sampling, pest pressure, as well as the control measures utilized

Scouting protocol

- Section your farm off into manageable portions based on acreage, variety, and age
- Review the list of known pests and beneficials
- If biological information is available, use it to gauge when you might scout more intensively

Wait-- What am I looking for?

- One of the hardest things to learn about scouting is how to pick up on the visual cues that something is wrong with the plant
- Consider the following as a starting point:
  - Cupped, chlorotic, spotted or malformed foliage
  - Discolored, damaged, swollen or sunken areas of bark
  - A large number of insects—identify them!
  - Pockets of less vigorous or dying plants
  - **Anything out of the ordinary**

General Protocol

- Gently shake strings or ruffle foliage as you walk looking for a flush of activity
- Remove leaves as you move through the yard—turn them over and give a close inspection using a hand lens
- Check leaves from all reachable heights, but favor the lower, denser portion of the canopy
- The more you look, the more you see…..

Hop Pest Scouting Calendar

	Dormancy	Sprouting	Leaf expansion	Bine elongation and sidearm formation	Flowering	Cone develoment	Cone maturity	Senescence
Insects								
Two spotted spider mite	+	+	+	+	+	+	+	+
Potato leafhopper			+	+	+	+	+	+
Japanese beetle				+	+	+	+	
Rose chafer				+	+			
Damson hop aphid		+	+	+	+	+	+	
European corn borer				+	+	+	+	+

High risk, monitoring and control usually required
Less risk, monitoring or control may be required
+ Potential pest activity, monitoring should occur

Hop Pest Scouting Calendar

	Dormancy	Sprouting	Leaf expansion	Bine elongation and sidearm formation	Flowering	Cone develoment	Cone maturity	Senescence
Diseases								
Downy mildew	+	+	+	+	+	+	+	+
Fusarium canker	+	+	+	+	+	+	+	+
Fusarium cone tip blight					+	+	+	+
Alternaria cone disorder					+	+	+	+
Gray mold					+	+	+	+
Verticillium wilt	+	+	+	+	+	+	+	+
Varios viruses	+	+	+	+	+	+	+	+
Powdery mildew	+	+	+	+	+	+	+	+

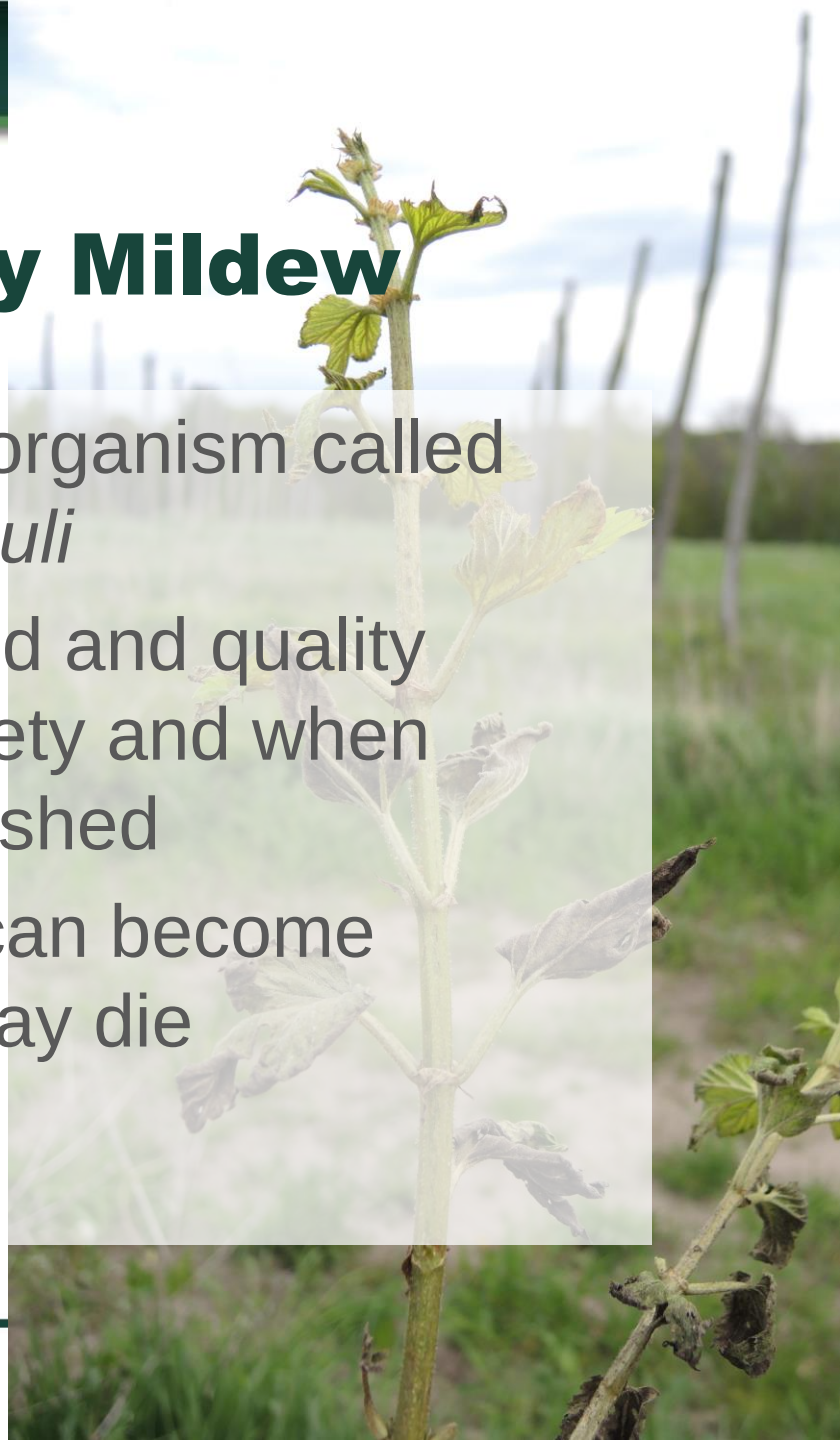
High risk, monitoring and control usually required
Less risk, monitoring or control may be required
+ Potential pest activity, monitoring should occur

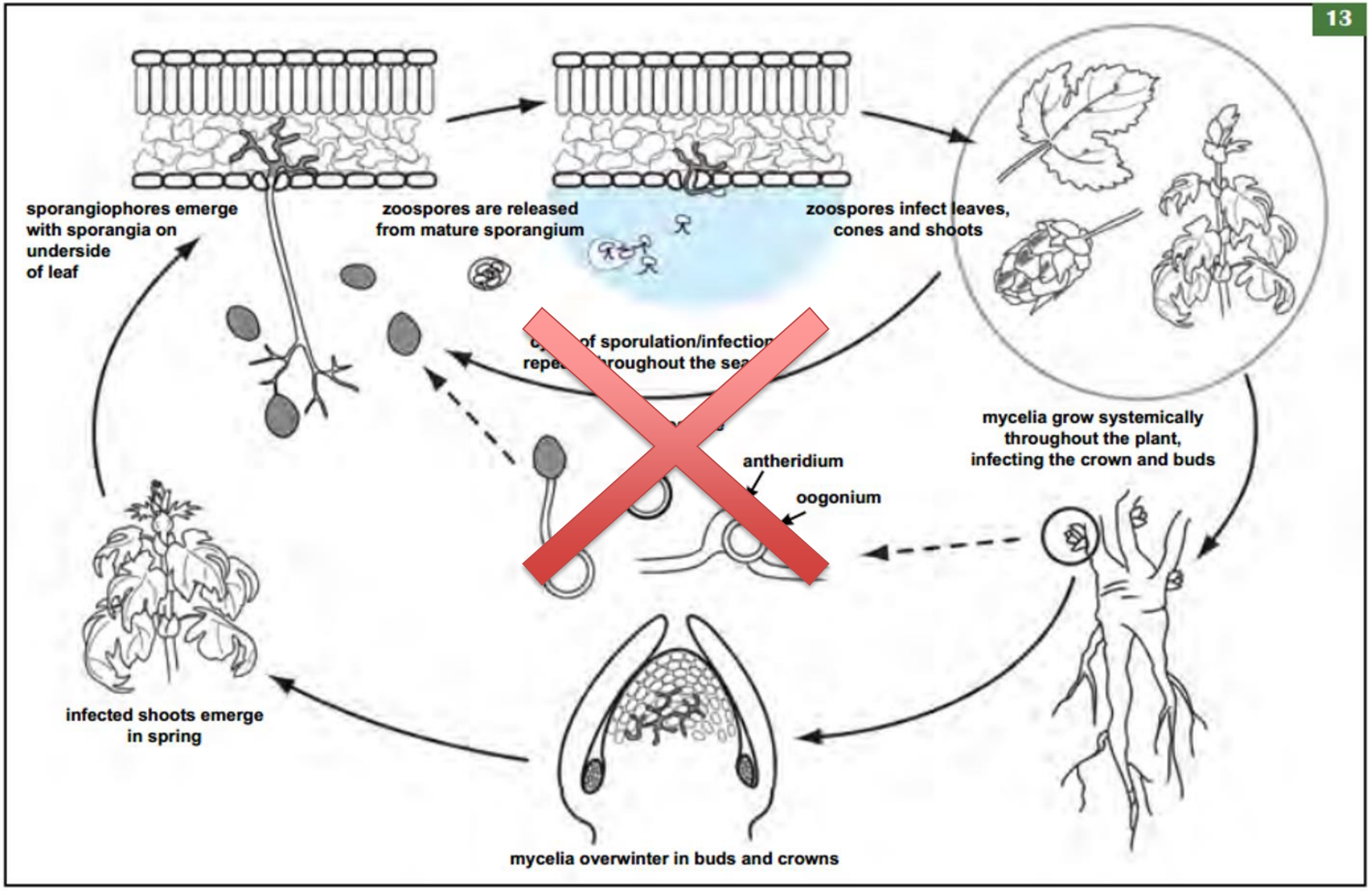
Primary pests of hop

- Downy Mildew
- Powdery mildew
- Potato leafhopper
- Mites
- Beetles
- Viruses

Primary pests – Downy Mildew

- Caused by a fungus-like organism called *Pseudoperonospora humuli*
- Can cause significant yield and quality losses depending on variety and when infection becomes established
- In extreme cases cones can become infected and the crown may die





Disease cycle of *Pseudoperonospora humuli*, the causal agent of downy mildew in hop. (Cred. V. Brewster, Compendium of Hop Diseases and Pests)

Downy mildew

- Infection is favored by mild to warm temperatures (60 to 70F) when free moisture is present for at least 1.5 hours
- Leaf infection can occur at temperatures as low as 41F when wetness persists for 24 hours or longer
- Initially, downy mildew appears early in the season on the emerging basal spikes
- Spikes then appear stunted, brittle and distorted

Downy mildew

- Spore masses appear fuzzy and black on the underside of infected leaves
- As bines expand new tissue becomes infected and fails to climb the string
- Can retrain new shoots but often incur yield loss as a result
- Appearance may vary based on variety and timing

Downy mildew “spike”

Downy or glyphosate?

Downy mildew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Downy mildew management

- Varietal susceptibility is important
- Utilize a protectant fungicide management strategy SEASON LONG
- Clean planting materials should be selected
- All plant materials removed in pruning should be removed from the hopyard and covered up or burned

Table 2. Disease Susceptibility and Chemical Characteristics of the Primary Public Hop Varieties Grown in the U.S.

Variety	Usage	Disease Susceptibility[a]		
		Powdery Mildew	Downy Mildew	Verticillium Wilt
Brewers Gold	Bittering	S	MR	MR
Bullion	Bittering	S	MR	R
Cascade	Aroma	MR	MR	MR
Centennial	Bittering	MR	S	U
Chinook	Bittering	MS	MR	R
Columbia	Aroma	MS	MR	S
Comet	Bittering	R	S	R
Crystal	Aroma	R	S	R
East Kent Golding	Aroma	S	S	MR
First Gold	Bittering	R	S	MR
Fuggle	Aroma	MS	R	S
Galena	Bittering	S	S	R
Glacier	Aroma	S	S	U
Hall. Gold	Aroma	MS	R	S
Hall. Magnum	Bittering	S	R	MR
Hall. Mittelfrüh	Aroma	MS	S	S
Hall. Tradition	Aroma	MR	R	MR
Horizon	Bittering	MS	S	MR
Late Cluster	Aroma	S	S	R
Liberty	Aroma	MR	MR	U
Mt. Hood	Aroma	MS	S	S
Newport	Bittering	R	R	U
Northern Brewer	Bittering	S	S	R
Nugget	Bittering	R	S	S
Olympic	Bittering	S	MS	R
Perle	Aroma	S	R	MR
Pioneer	Bittering	MR	MR	U
Saazer	Aroma	S	MS	S
Saazer 36	Aroma	S	MS	S
Spalter	Aroma	S	R	MR

Hop IPM Field Guide

Downy mildew management

- Apply fungicide treatments on a protectant basis as soon as bines emerge in the spring regardless of the presence or absence of visible symptoms
- Applications should continue season long on a 7-10 day reapplication interval until harvest
- Several periods in the season are particularly critical for disease control:
  - Before and after training; lateral branch development; bloom; and cone development
  - Covering young, developing bracts before cones close up is critical to protecting against downy mildew when conditions for disease are favorable

Downy mildew protectants

- Available fungicides include: **Revus** (mandipropamid), **Forum** (dimethomorph), **Ridomil Gold SL** (mefenoxam), **copper-based products** (copper hydroxide, octanoate, sulfate, oxychloride), **Curzate 60DF** (cymoxanil), **Tanos** (cymoxanil+famoxadone), **Ranman** (cyazofamid), **phosphonate fungicides** (Agri-Fos, Aliette, Fosphite, etc.)
- Copper is the only organically available fungicide that has shown any efficacy

Downy mildew management, post infection

- Weather conditions may necessitate “curative” applications in addition to preventative sprays
- Research from the Pacific Northwest indicate that:
  - Cymoxanil (e.g. Curzate), Tanos (cymoxanil and famoxadone) have post infection activity (2d) and 3-7d protectant activity
  - Dimethomorph (e.g., Forum) and mandipropamid (e.g., Revus) have the same mode of action and offer 7 days of protectant activity and 1-2 days of post-infection activity on actively growing shoots
  - Phosphorous acid fungicides (e.g., Phostrol) have been shown to provide about 4-5 days protection and post-infection activity of up to 5-7 days

Powdery mildew

- Caused by *Podosphaera macularis*
- Associated with secondary pathogens
- Can cause complete crop loss
- Affects postharvest quality

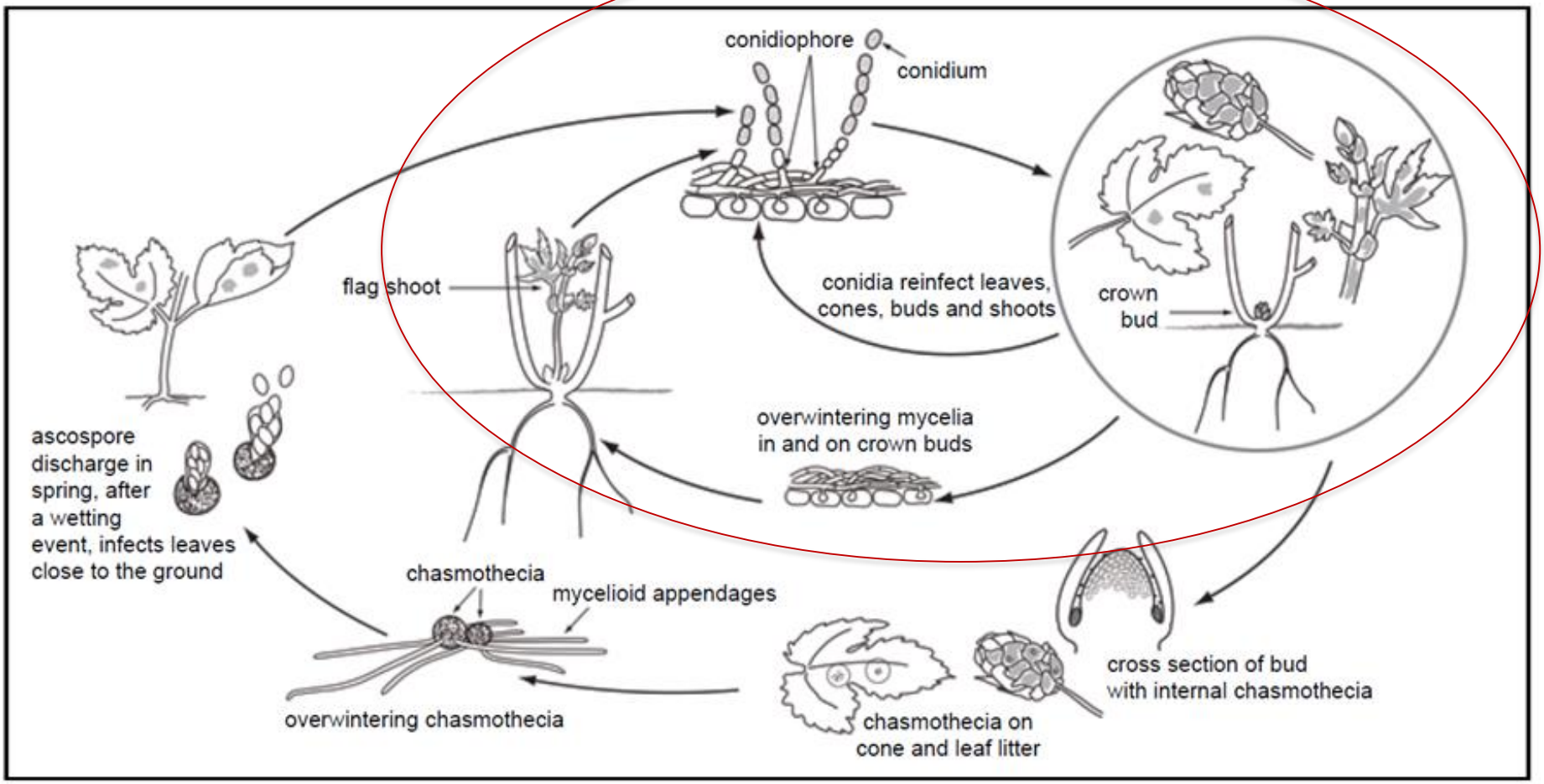
Disease Cycle

- Powdery mildew overwinters as mycelia (fungal threads) inside buds and in soil and plant debris.
- Shoots emerging from infected buds form flag shoots which become covered with spore masses, appearing white, stunted and distorted.
- Flag shoots are rare and healthy shoots quickly outgrow infected shoots, making detection difficult.
- The spore masses on flag shoots spread to adjacent healthy tissue causing new infections.

Disease cycle

- Sexual spores (ascospores) may also be present in spring.
- Ascospores are discharged and land on newly emerged shoots where they germinate, infect the plant, and eventually produce a new spore mass of asexual spores (conidia).
- Conidia are produced in large numbers over multiple cycles and are dispersed via wind, rain splash, insects, tractors, equipment, and humans.

Powdery disease cycle



Prepared by V. Brewster, Hop IPM Field Guide, 3rd edition.

No Resting Spore

- Powdery mildew does not appear to producing resting spores in Michigan.
- *P. macularis* is a obligate parasite in the asexual form and can't survive outside of plant…..
- *P. macularis* only affects hop…..
- Infections in 2017 did not
  - "blow in on the wind"
  - "come from cucumbers"
- Infections likely came from baby hop plants with existing infections.

Appears in the spring on white, stunted shoots (<1% of shoots).

As leaf tissue expands, powdery mildew lesions first appear as raised blisters on leaves which then develop white, round colonies.

Infected burrs and cones can also support white fungus or may exhibit a reddish discoloration.

Powdery Mildew

- Several weak pathogens and secondary organisms can be found on cones infected by powdery mildew; limiting powdery mildew reduces these secondary organisms.

  e.g. Alternaria, gray mold, fusarium

Powdery Mildew Management

- Integrate resistant varieties, crop sanitation practices, optimizing fertilization and irrigation.
- Regular fungicide applications.
- Source quality baby hops.
- Spring pruning can limit disease under high pressure.
  - Mechanical most effective.
  - No pruning on babies.

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Saazer 36	Aroma	S	MS	S
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Hop IPM Field Guide

Powdery Mildew Management

- Fungicide treatments should begin immediately after shoot emergence.
- Regrowth should be pruned in high-risk situations (not babies), or when the disease is first detected in a region.
- Different fungicides are utilized for powdery mildew control during three distinct periods of the season: emergence to mid-June; mid-June to bloom; and bloom to preharvest.

Powdery Mildew Management Emergence-June

- Consider a combination of applications of **sulfur**, **oils, trifloxystrobin** (Flint), **tebuconazole** (e.g. Orius 3.6F, Monsoon, Tubuzole 3.6F), **flutriafol** (Rhyme), **triflumizole** (Procure 480 SC), or Unicorn DF (tebuconazole + sulfur).
- Under high pressure, growers should tank mix with oils and integrate copper into their downy mildew programs when possible.

Powdery Mildew Management Mid June-Bloom

- **Tebuconazole** (e.g. Orius 3.6F, Monsoon, Tubuzole 3.6F), **flutriafol** (Rhyme), **triflumizole** (Procure 480 SC), fluopyram + tebuconazole (Luna Experience), and **metrafenone** (Vivando).
- Under high pressure, growers should tank mix with oils and integrate copper into their downy mildew programs when possible.

Powdery Mildew Management Bloom-Preharvest

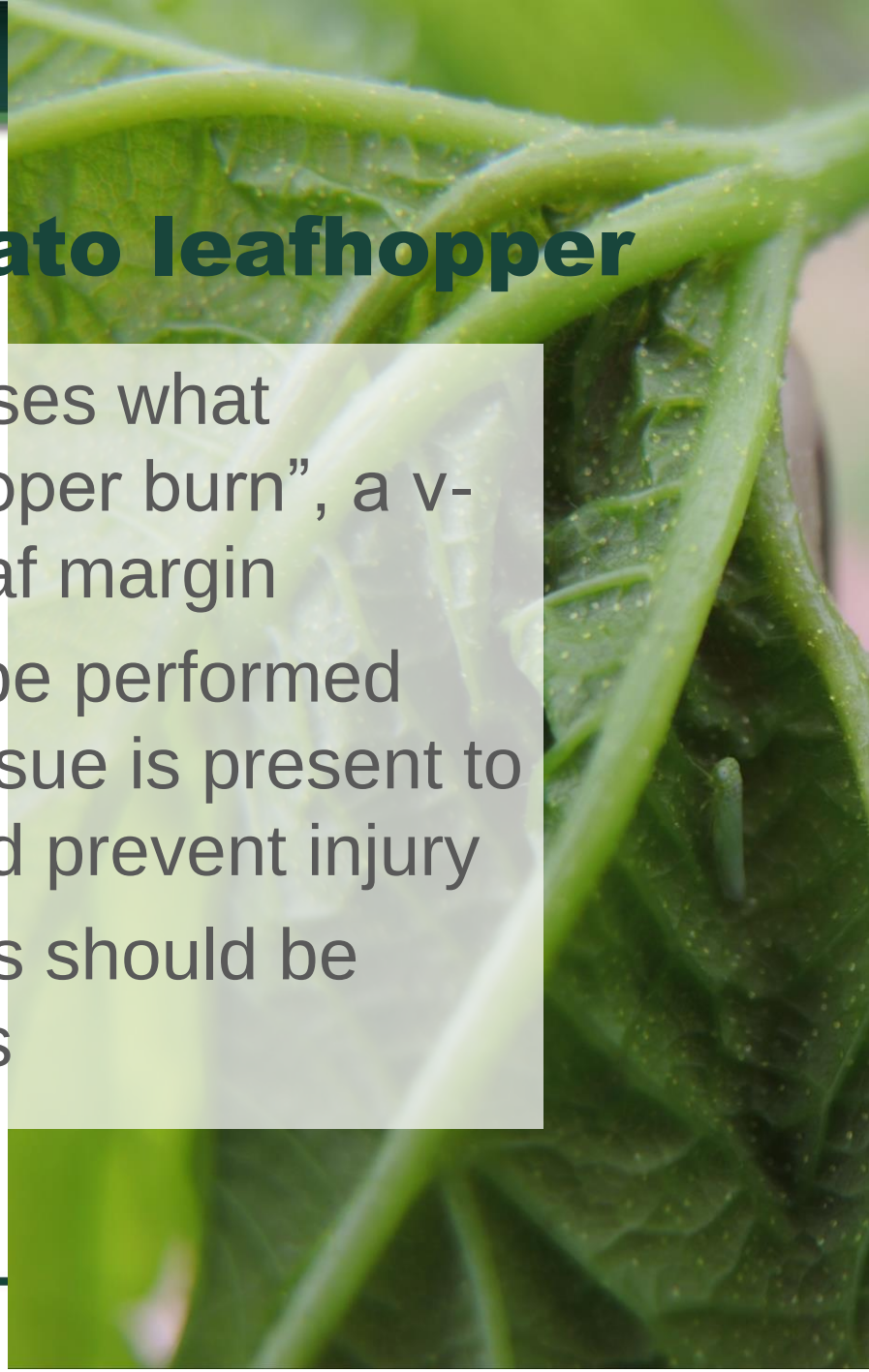
- Growers may use a combination of **quinoxyfen** (Quintec, 21 day preharvest interval), **pyraclostrobin + boscalid** (Pristine, 14 day preharvest interval) and **Fluopyram + trifloxystrobin** (Luna Sensation, 14 day preharvest interval).
- Mind the preharvest interval.

Management Considerations

- Mid-July through early August (burr to cone) is an essential disease management period.
  - The fungicide quinoxyfen (Quintec) is especially effective during this time.
- The powdery mildew pathogen has an extremely high risk of developing fungicide resistance, therefore careful attention to resistance management is critical.

Primary pests – Potato leafhopper

- PLH feeding on hops causes what growers have termed “hopper burn”, a v-shaped necrosis of the leaf margin
- Scouting for PLH should be performed weekly as soon as leaf tissue is present to ensure detection early and prevent injury
- More frequent spot checks should be done following rain storms



PLH

PLH

Scouting for PLH

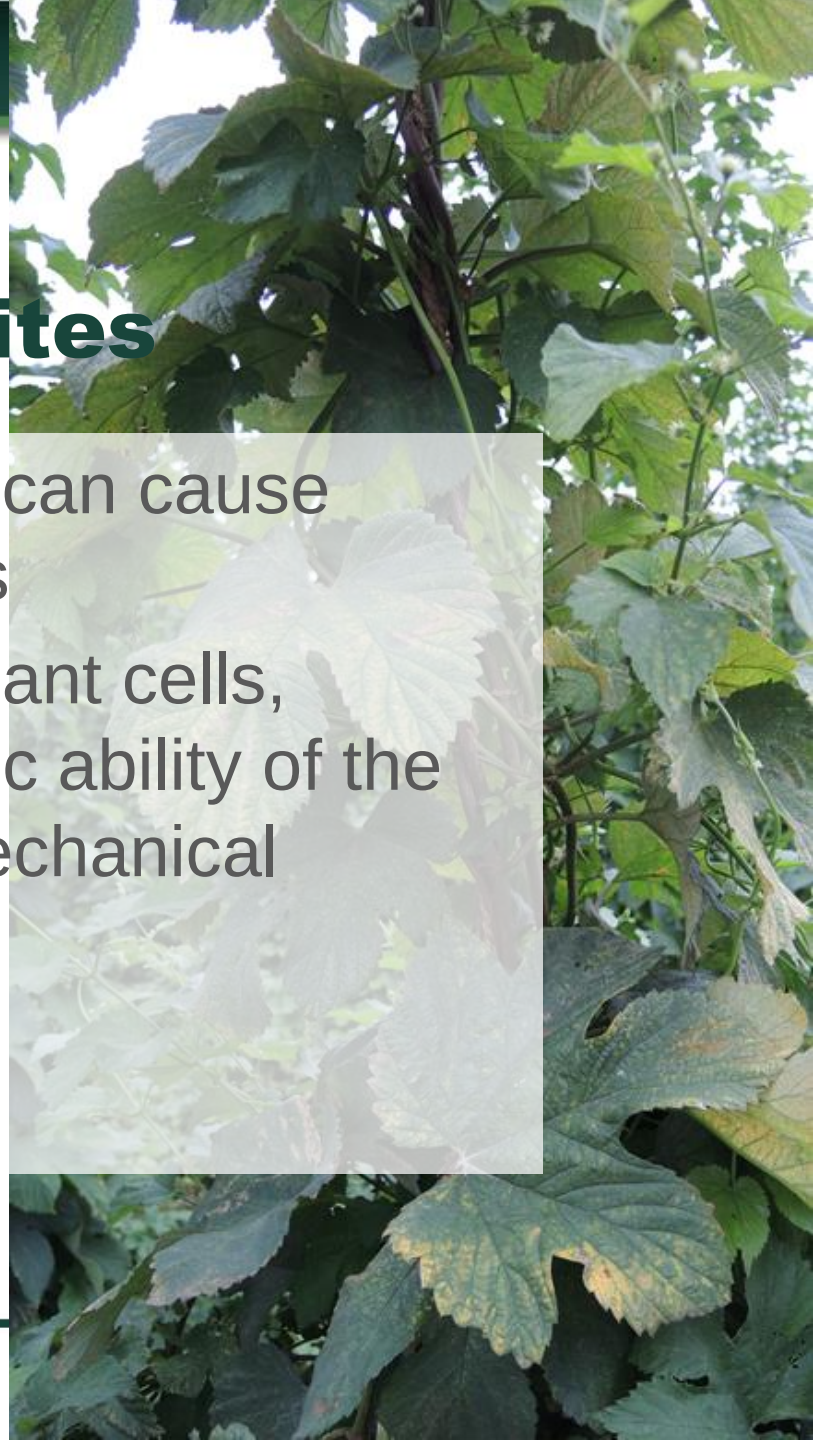
- Shake the bine
- Flip leaves and shoots over
- PLH move in all directions when disturbed
- Hop plants can tolerate some level of feeding and growers should be conservative in the application of insecticides
- At this time there is no set economic threshold for PLH in hops

PLH Management

- PLH can be managed with neonicitinoids (e.g. Provado, Platinum), pyrethroids (e.g. Baythroid XL, Brigade 2EC), organophosphates (e.g. Malathion 57EC) or spinosyns (e.g. Entrust)
- Consider that pyrethroids have been shown to cause increases in mite populations
- Neonicitinoids are longer lasting and narrow spectrum but may also contribute to increased pest mites
- Pyganic, Entrust and Trilogy are OMRI approved insecticides organic growers might consider for PLH management

Two-spotted spider mites

- A significant pest of hop and can cause complete economic crop loss
- TSSM feed on the liquid in plant cells, decreasing the photosynthetic ability of the leaves and causing direct mechanical damage to the hop cones
- Also a contaminate pest



Two spotted spider mite

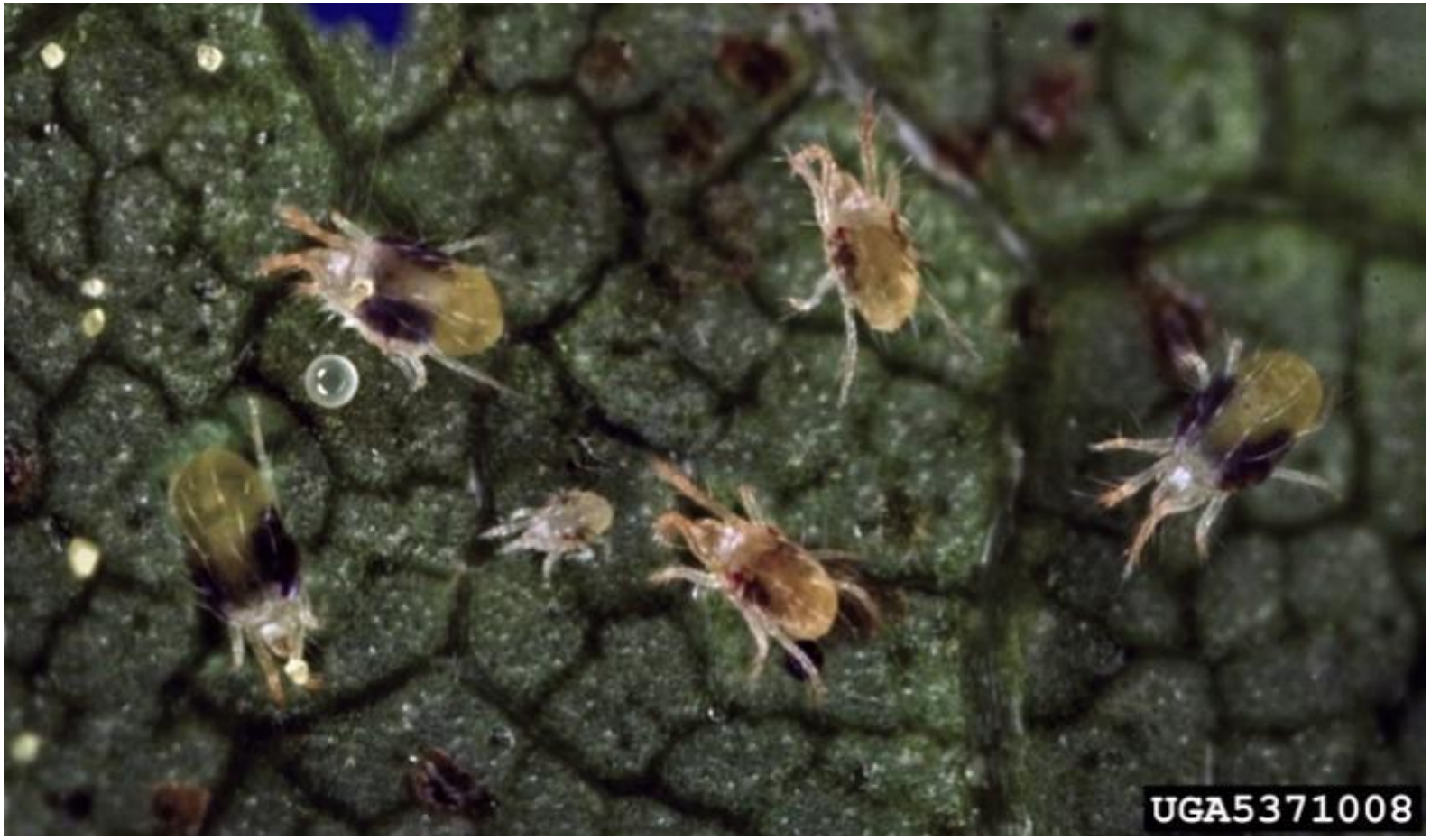
- Leaves take on a white appearance and will eventually defoliate under high pressure conditions
- Intense infestations weaken the plant and reduce yield and quality
- Infested cones develop a reddish discoloration, do not hold up to the drying process, and commonly have lower alpha levels and shorter storage potential

TSSM

TSSM

- In the spring, only mated females are present, they have overwintered in a dormant stage from the previous season and are ready to lay fertilized eggs
- She appears particularly orange in color this time of the year and has overwintered on debris and trellis structures in the hopyard
- As temperature warm the females feed and begin laying eggs
- Larvae emerge from the eggs in 2-5 days (depending on temperatures) and develop into adults in 1-3 weeks (again depending on temperature)

TSSM



TSSM

TSSM

- TSSM like it hot, with the pace of development increasing until an upper threshold around 100F is reached, conversely, cold and wet weather is not conducive to development
- TSSM are very small but can be observed on the underside of leaves using a hand lens
- As the season progresses cast skins and old webbing give infested leaves a dusty and dirty appearance
- The eggs look like tiny clear spheres and are most commonly found in close proximity to adults and larvae
- The larvae themselves are small, translucent versions of the adults
- Adults and larvae also have two dark spots

Scouting for TSSM

- Focus sampling on the lower, dense canopy
- As the season progresses samples should be taken from reachable heights
- Use a hand lens to evaluate 2 leaves from 20 plants per yard
- Thresholds developed in the Pacific Northwest
  - Do no apply in Michigan
- The goal is to prevent cone infestation, not 100% control

TSSM Management

- Only manage for mites when absolutely necessary—management can disturb beneficial populations that help keep numbers in check
  - NO CALENDAR SPRAYS--SCOUT
- Consider using a true miticide to minimize the impact on predatory mites
- OMRI-approved products containing oils, bifenazate, and azadirachtin are labeled for mites

Rose chafer and Japanese beetle

- Both beetles are generalists
- Prevalent near grassy areas, particularly irrigated turf
- Grubs feed on grass roots in early spring and again in the fall
- Larvae prefer moist soil conditions and do not survive prolonged periods of drought

Rose chafer and Japanese beetle

- RC emerge in June, JB emerge in early July, each are active for around 6 weeks
- They feed on leaves skeletonizing the tissue
- If populations are high, they can remove all of the green leaf material from a plant
- Visual observation of adults or feeding damage is an effective scouting technique
- Because of their aggregating behavior, they tend to be found in larger groups and are typically relatively easy to spot

European rose chafer

European rose chafer

Japanese beetle

Japanese beetle

Rose chafer and Japanese beetle

- No established treatment thresholds
- Malathion is effective, but can take up to 3 days to take effect and provides 10-14 days of residual control
- Pyrethroids (bifenthrin or beta-cyfluthrin) have good knockdown activity, and 7-10 days of residual control, but can be problematic in hopyards where mites are a concern
- Neonicitonoids (imidacloprid or thiamethoxam) have contact toxicity for 2-5 days, and residual anti-feedant activity
- Consider spot treatments with knock-down materials

Rose chafer and Japanese beetle

- OMRI approved options include neem-based products (azadirachtin) which have a 1-2 day residual and good knockdown activity as well as Surround (kaolin clay) which has had good results in blueberry and grape and acts as a physical barrier and irritant
- Surround should not be used after burrs/cones are present

Viruses in MI

- Caralavirus complex:
  - *Hop latent virus*
  - *American hop latent virus*
  - *Hop mosaic virus*
- ***Apple mosaic virus***
- *Hop stunt viroid*

David Gent, USDA

Scouting for virus

- Viral symptoms can appear similar to damage caused by potato leafhopper, two-spotted spider mites, downy mildew and even nutrient deficiencies
- The similarity between symptoms makes field diagnosis of viruses very difficult
- Growers can submit samples for testing to the Washington State University Virus Testing Lab

Hop mosaic virus

Apple mosaic virus

Hop stunt viroid

In general…

- Infected plants establish poorly, have weak growth and production and may be more susceptible to stressors
- Propagation and distribution of virus-infected plants is the primary mode through which they are spread between yards
- Within the hopyard, transmitted largely through mechanical means and root grafting within a field, some aphid vectoring
- Purchase from reputable propagators who are using certified virus-free planting stock—ask around
- Limit mechanical damage

Natural enemies
Don't forget about the good guys!

- As research continues, our understanding of the importance of these partners continues to grow


D. Landis, MSU

Insect predators and parasites, known as natural enemies, can help control pest populations in agricultural crops and landscapes

Common Natural Enemies

Green Lacewing-Predator

- Adults of many species are not predaceous
- Predaceous larvae have long, curved mandibles that they use to pierce and suck the fluids out of their prey
- The larvae are about 1/8 inch long, look like tiny alligators, and prey on most small soft bodied insects, often pale with dark markings
- Eggs are laid on individual silken stalks

Common Natural Enemies

Lady Beetles-Predator

- Most adults and larvae feed on soft-bodied insects
- These may be important in aphid population control
- Adults are rounded, and range in size from tiny to medium-sized (about ¼ inch long), color ranges from black to brightly colored
- Larvae are active and elongate with long legs, and look like tiny alligators

Common Natural Enemies

Crab spiders-Predator

- Crab spiders stalk and capture insects resting on surfaces or walking, they do not spin webs
- The front two pairs of legs are enlarged and extend to the side of their body, giving them a crablike appearance
- Over 200 species in North America

Common Natural Enemies

Predatory mites

- Predatory mites are often translucent, larger than pest mites and move at a much faster speed across the leaf surface
- Play an important role in balancing the two-spotted spider mite populations and should be protected when possible

Supporting Natural Enemies

- Natural enemies are more likely to thrive in undisturbed areas that provide overwintering habitat, flowers to support their survival and reproduction, and refuge from pesticide applications in crops
- Natural enemies may be conserved with the same plantings that support pollinators

Continued from page 19- Signal Words and Relative Impact of Pesticides Registered for Use on Hop on Representative Non-target Beneficial Arthropods

Insecticides/Miticides		Beneficial arthropod	IOBC	rankings[1]
Active Ingredient	Signal word	Trade Name	Predatory mites	Lady beetles	Lacewing larvae
abamectin	Warning	Agri-Mek & other formulations	3	3	ND
B. thuringiensis subsp. aizawal	Caution	Xentari & other formulations	1	2	ND
B. thuringiensis subsp. kurstaki	Caution	Dipel & other formulations	1	2	ND
beta-cyfluthrin	Warning	Baythroid XL	4	4	4
bifenazate	Caution	Acramite-50WS	1	2	ND
bifenthrin	Warning	Brigade & other formulations	4	4	4
cyfluthrin	Danger	Baythroid 2E	4	4	4
dicofol	Caution	Dicofol	1	1	ND
etoxazole	Caution	Zeal	OK[2]	OK[2]	ND
fenpyroximate	Warning	Fujimite	1	3	ND
hexythiazox	Caution	Savey 50DF	1	1	ND
imidacloprid	Caution	Various formulations	1	3	3
malathion	Warning	Various formulations	2	4	3
naled	Danger	Dibrom	2	4	3
pymetrozine	Caution	Fulfill	1	1	1
pyrethrin	Caution	Pyganic & other formulations	2	2	2
spinosad	Caution	Success & other formulations	2	2	1
spirodiclofen	Caution	Envidor	2	2	1
spirotetramat	Caution	Movento	1	1	1
thiamethoxam	Caution	Platinum Insecticide	1	1	ND

[1]International Organization for Biological Control (IOBC) has categorized pesticides using a ranking of 1 to 4. Rankings represent relative toxicity based on data from studies conducted with tree fruit, hop, mint and grape. 1= less than 30% mortality following direct exposure to the pesticide; 2 = 30 to 79% mortality; 3 = 79 to 99% mortality; and 4 = greater than 99%. ND = not determined.

[2]IOBC rankings not available for this newly registered product. Tests in 2009/2010 determined these compounds safe on predatory mites and *Stethorus*.

Source: Pacific Northwest Hop Handbook 2010

Successful IPM Practitioners

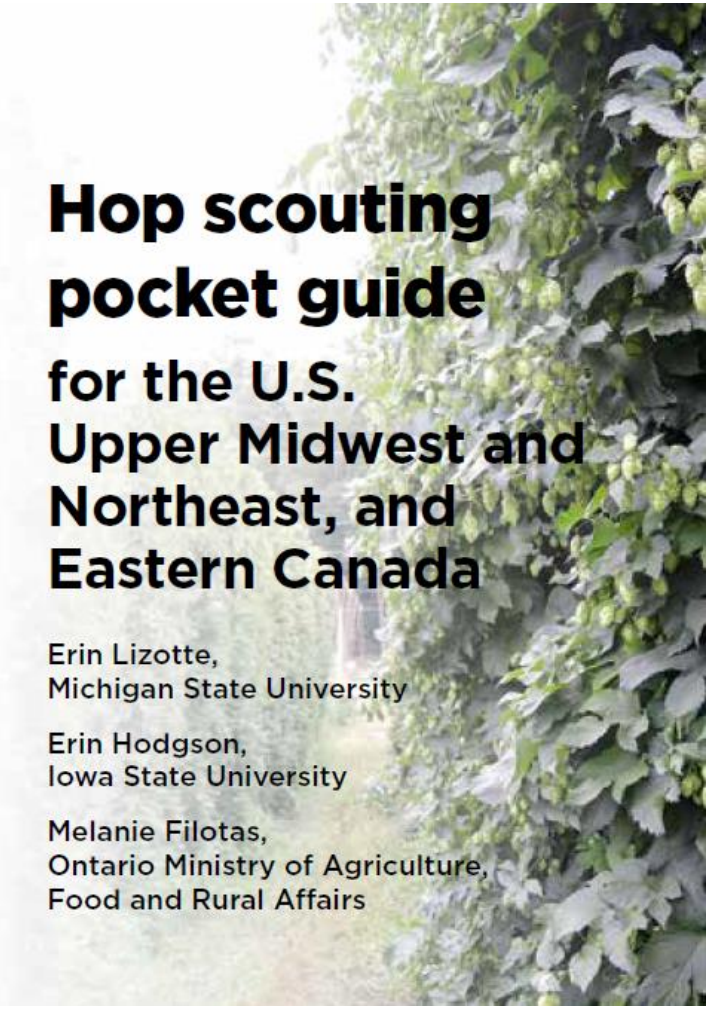
- Understand pest life cycles, epidemiology, ecology
- Monitor the whole system
- Consider all available tools
- Adhere to economic constraints
- Use available technology
- Share information

Recommendations for new growers

- Get your pesticide applicators license-organic producers too
- Carefully consider the current limitations of organic production—ask around
- You should have a tractor and sprayer on farm before planting
- Carefully select cultivars—consider not just the market but the challenge of mildews
- Consider ordering a few plants from prospective suppliers and check the quality and cleanliness before committing to a large order

Resources

- Hops.msu.edu
  - Registered pesticide guide
  - New Hop IPM Field Guide
  - New scouting flip guide
- Facebook
- Sign up to receive scouting reports
- Beginning Farmer Webinar Series
- Desire to Learn IPM Academy



United States Department of Agriculture
National Institute of Food and Agriculture

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