MSU Extension programs and material are open to all without regard to race, color, national origin, gender, gender identity, religion, age, height, weight, disability, political beliefs, sexual orientation, marital status, family status, or veteran status.

Introduction to Hop IPM

Erin Lizotte
Michigan State University Extension

Overview

- Scouting in the hopyard
- Natural enemies
- Primary pests
- 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

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

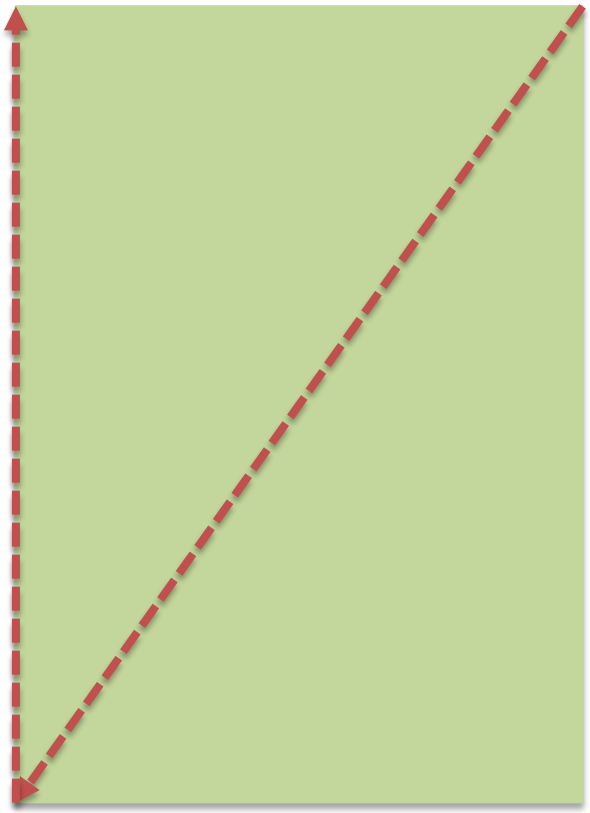
Hop Pest Scouting Calendar

	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

General scouting protocol

- Walk a transect to ensure you view plants from both the edge and inner portion of the yard
- Change the path you walk each time you scout to inspect new areas
- Revisit problem areas
- Make up a scouting sheet and keep good records



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…..

Consider the weather

- One of the greatest allies a grower can utilize to be an effective scout and pest manager is historical and forecast weather data
- This information can inform you of when to intensify your scouting for certain pests and disease, when to apply a pesticide to optimize treatment, and when the ideal conditions might occur to apply a spray

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

Damsel bugs-Predator

- These bugs prey on aphids, leafhoppers, mites, caterpillars, and other insects
- Most often yellowish, gray or dull brown, they are a little over ¼ inch long
- Slender insects with an elongated head and long antennae

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

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

Supporting Natural Enemies

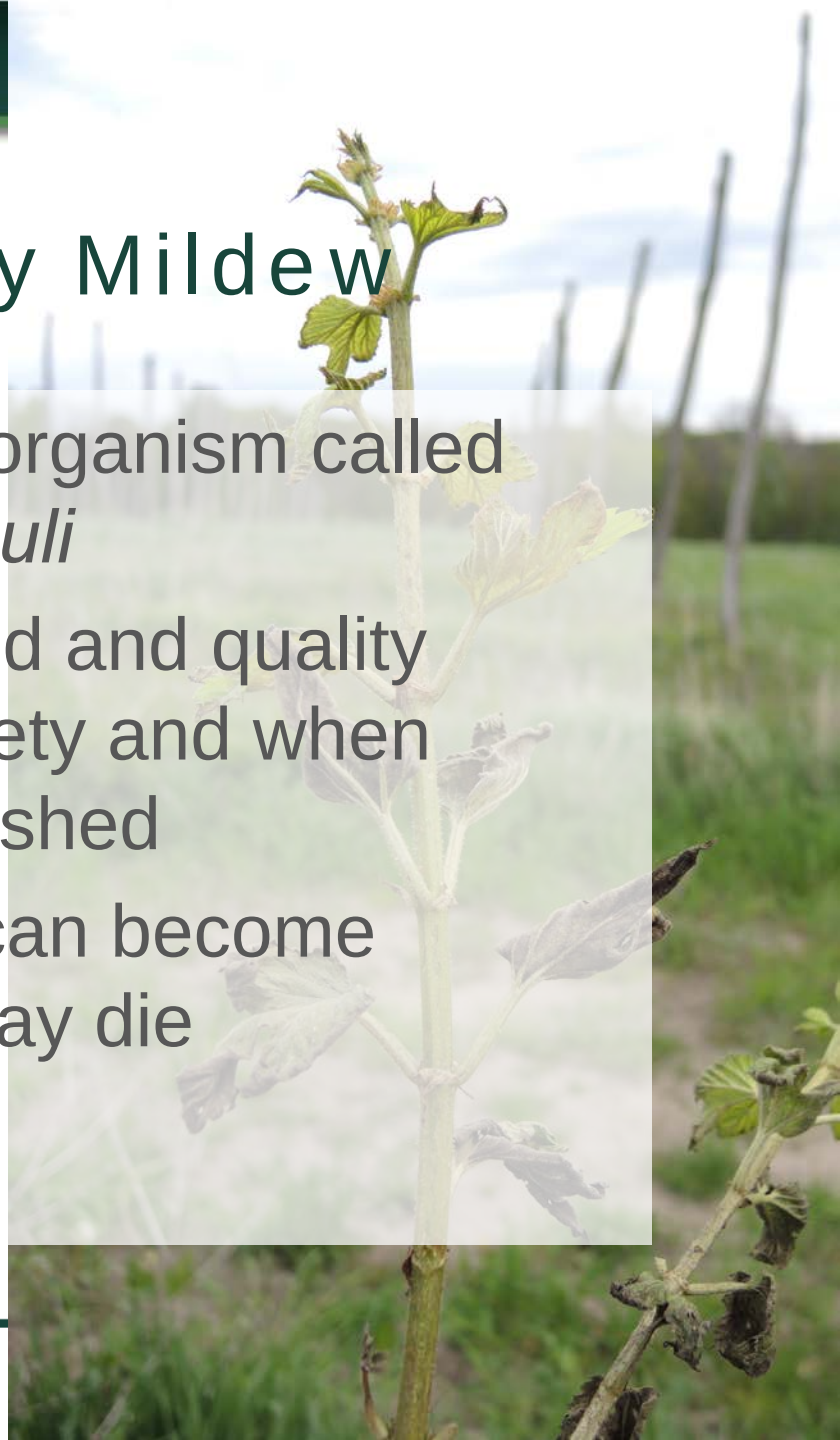
- Natural enemies are more likely to thrive in undisturbed areas that provide overwintering habitat, flowers to support their survival and reproduction, and refuge from pesticide applications in crops
- Natural enemies may be conserved with the same plantings that support pollinators

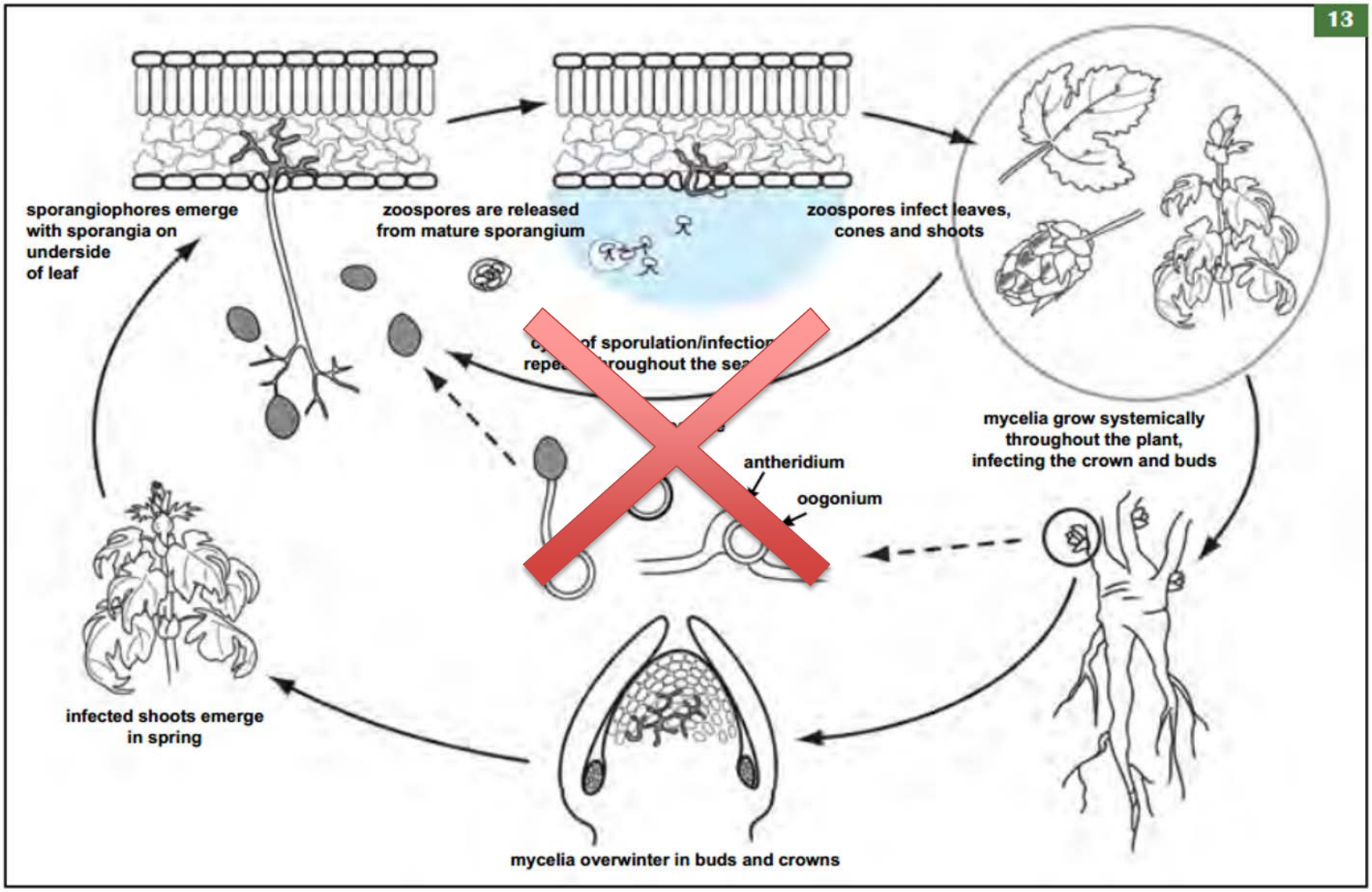
Primary pests of hop

- Downy 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 mildew


xtens
MICHIGAN STATE
UNIVERSITY
Extensio

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

12

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

Downy mildew management in MI

- 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.)
- Flint (trifloxystrobin) and Pristine (strobilurin+ boscalid) will only provide suppression of downy mildew and are more commonly used for *powdery* mildew control

Organic downy mildew management

- Organic growers have fewer options and will need to focus on keeping tissue protected
  - select downy mildew tolerant varieties and follow cultural practices to limit downy infection
- Copper-based products are the mainstay of downy mildew management in organic hopyards and offer 5-7 days of moderate protection but no post-infection activity
- Actinovate, Eco-mate, Armicarb-O and Sonata are additional products that list downy mildew on the label and are approved for organic use in hop

Know thy enemy!

- Downy AND powdery mildew present
- Downy mildew = *Pseudoperonospora humuli*
- Powdery mildew = *Podosphaera macularis*
- *Powdery* mildew has a much lower incidence, likely due to environmental factors
- It is important that growers do not mistake downy mildew for powdery mildew as the effective pesticide classes are very different

Powdery mildew

David Gent, USDA-ARS

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

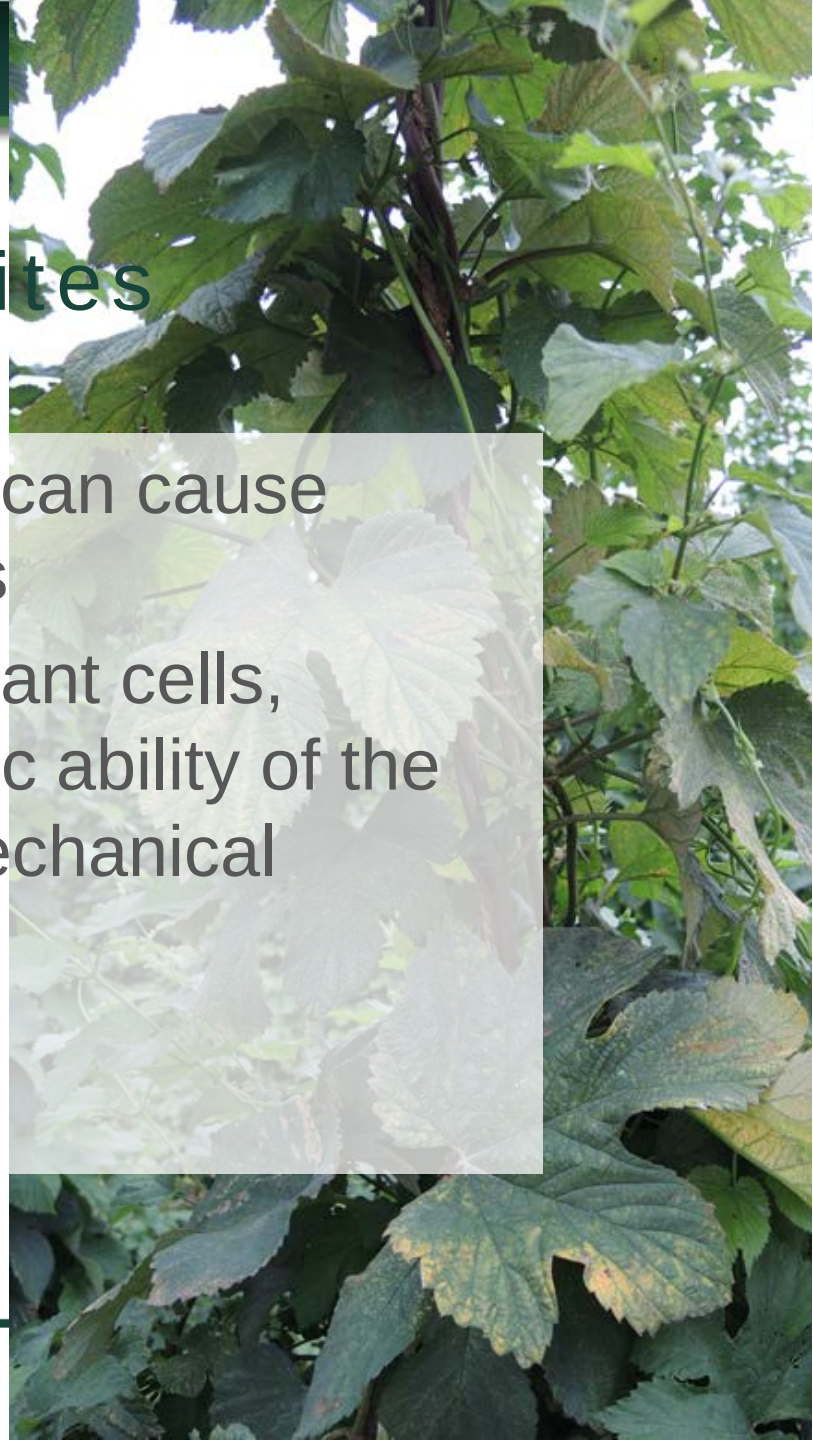
- Shake the bine
- Flip leaves and shoots over
- PLH move in all directions when disturbed
- Hop plants can tolerate some level of feeding and growers should be conservative in the application of insecticides
- At this time there is no set economic threshold for PLH in hops
- Stay tuned, varietal research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

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



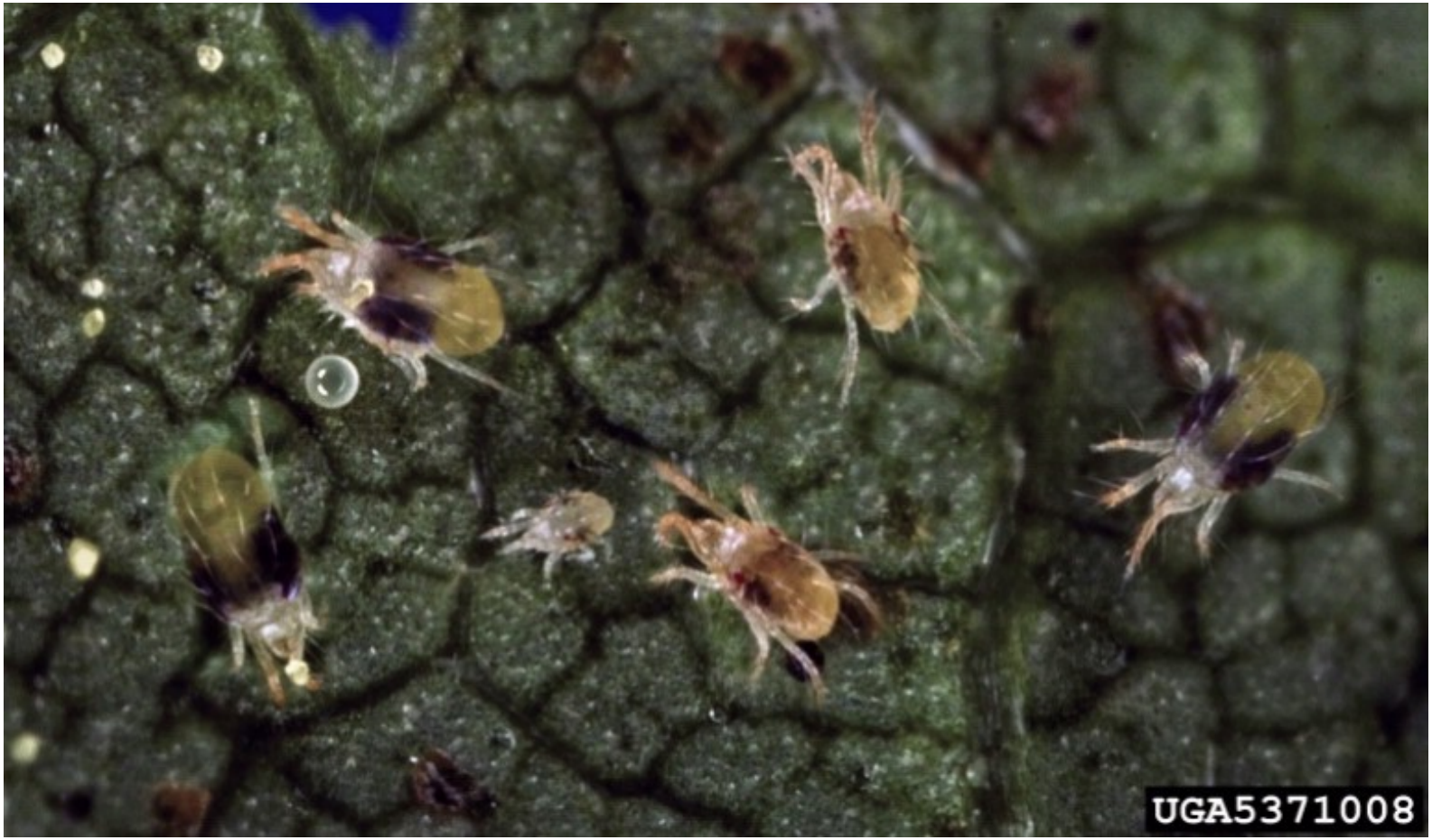
Two spotted spider mite

- 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

- 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 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

TSSM

TSSM

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 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, befenazate, 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

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 confirmed 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, and even downy mildew
- The similarity between symptoms makes field diagnosis of viruses very difficult
- Growers can submit samples for testing to Washington State University

Carlavirus complex

- Occur in mixed infections
- *HLV* and *AHLV* do not cause visually obvious symptoms on any commercial hop varieties
- *Hop mosaic virus* is the most likely to cause symptoms and crop damage
- Chlorotic mosaic mottling can develop between major leaf veins
- Affected plants may establish poorly, have weak bine growth, and fail to climb

Hop mosaic virus

Apple mosaic virus

- Most important virus disease of hop
- Reduces the ability to propagate from cuttings and reduces establishment success
- Induces chlorotic rings or arcs that can become necrotic
- Plants can be infected for several seasons without disease expression until appropriate environmental conditions occur

Apple mosaic virus

Hop stunt viroid

- Can reduce alpha-acids yield by 60% to 80%
- The severity of symptoms is dependent on the hop variety and the weather
- Symptoms may take three to five growing seasons to appear, leading spread through propagation
- Early-season growth of infected bines is delayed and foliage is generally pale relative to healthy bines

Hop stunt viroid

General virus management

- Propagation and distribution of infected plants is the primary mode of introduction
- Mechanical injury, root grafting, and insect vectored spread is most common within a field
- Source from reputable propagators
- Use of contact herbicides rather than mechanical pruning to reduce mechanical transmission
- If a small number of plants are infected, they should be removed promptly along with adjacent plants
- Sanitize farm equipment and tools

Successful IPM Practitioners

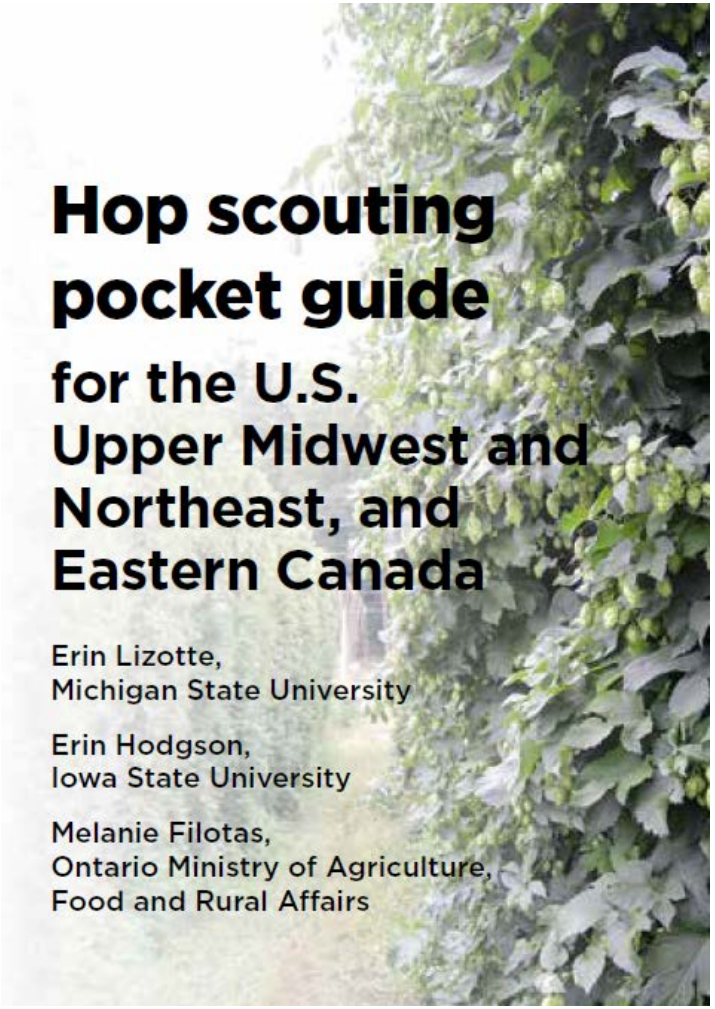
- Understand pest life cycles, epidemiology, ecology
- Monitor the whole system
- Consider all available tools
- Adhere to economic constraints
- Use available technology
- Share information

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 downy mildew
- 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

This material is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Agreement No. 2015-09785. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.