

Introduction to Hop Integrated Pest Management

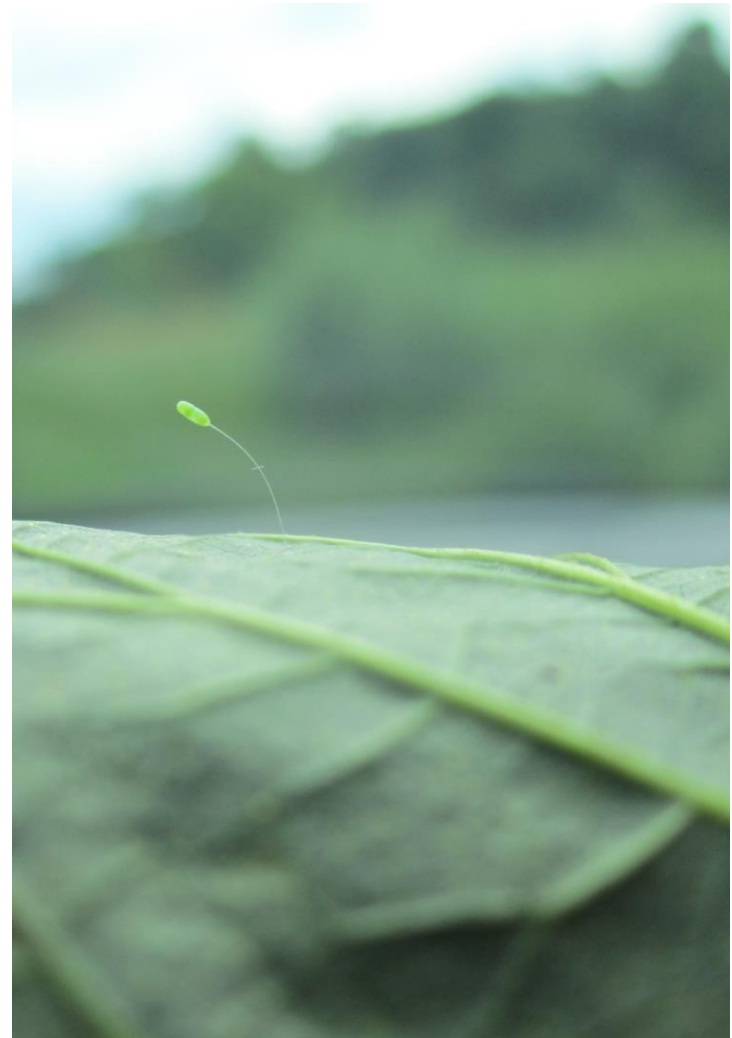


Erin Lizotte, IPM Educator
Michigan State University Extension



Overview

- Scouting protocol
- Primary pests
- Beneficials
- IPM resources



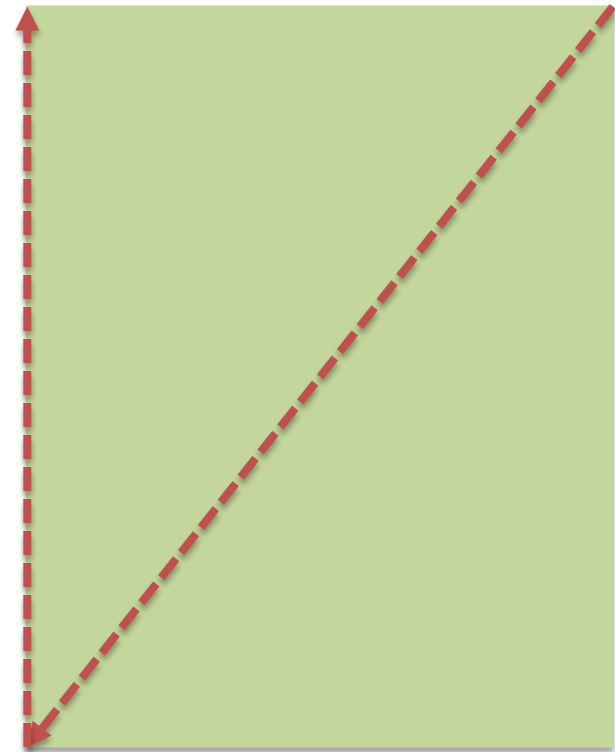
Scouting protocol

- The more you look-
the more you see
- How many leaves
you collect or
evaluate should
depend on the pest
- Find what works for
you!



General scouting protocol

- Divide and scout fields separately variety or location, up to a five acre block
- Walking a transect and an edge
- Change your route each time to cover new ground
- Revisit problem areas
- Make up a scouting sheet and keep good records



General protocol

What am I looking for?



- This becomes more clear over time
- Look for anything out of the ordinary
 - Stunted plants
 - Damaged or cupped leaves
 - Discoloration, chlorosis, bronzing
 - Failure to thrive
 - A huge group of insects (usually it's not valuable to sweat the individual insect you spot munching on a leaf)



General Protocol

- 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
- If checking for a specific pest threshold follow sampling protocol



Resources for scouting

- Hops.msu.edu—includes downloadable copies of the registered pesticide guide
- **Sign up to receive the MSU hop scouting reports News.msu.edu**
- Facebook-Michigan State University Hop News
- Hop IPM Field Guide 2016



Primary Pests for MI growers

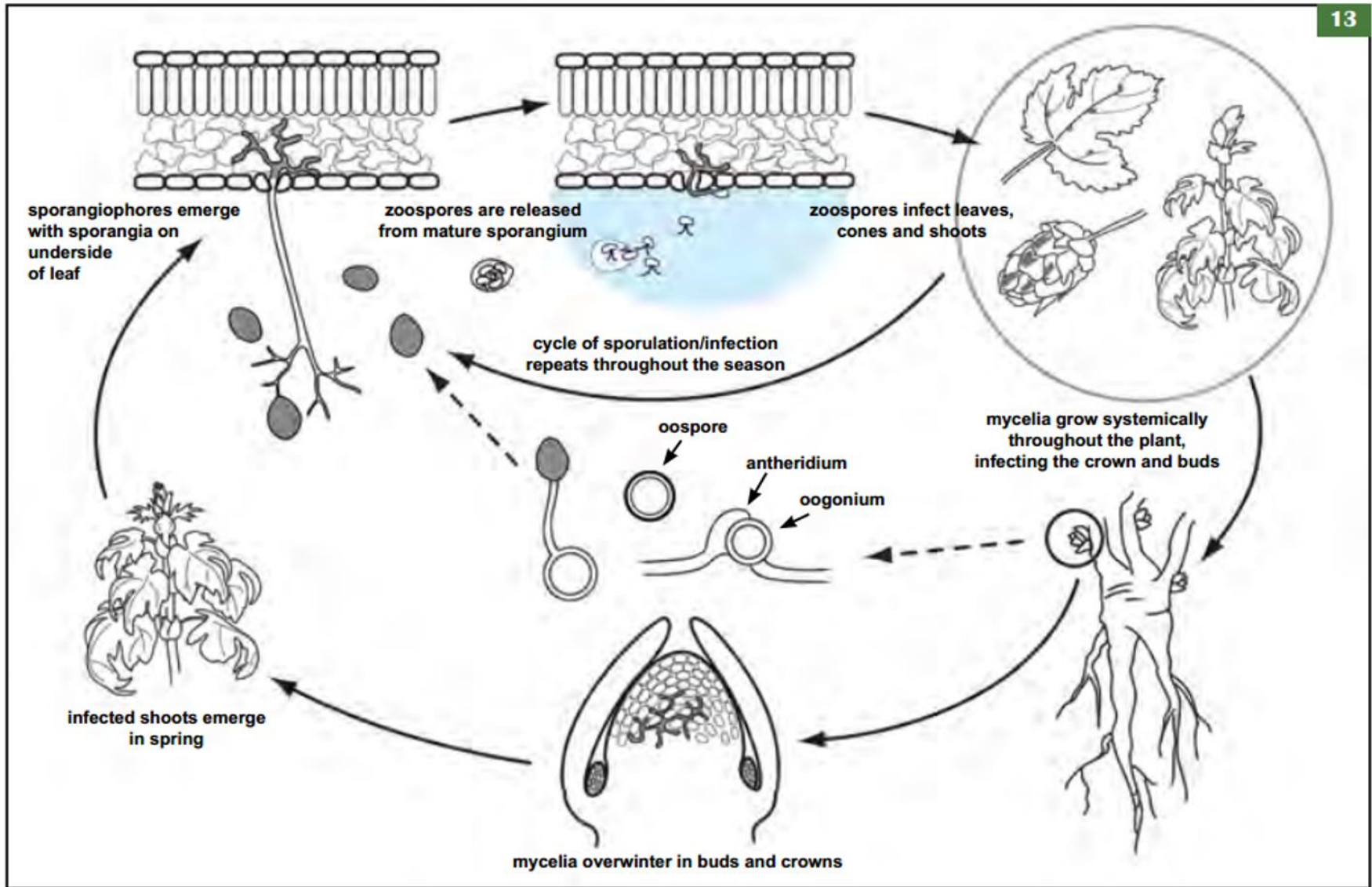
- Downy Mildew
- Potato leafhopper
- Mites
- Damson hop aphid
- Beetles (chafer and Japanese)



Primary pests – Downy Mildew

- Caused by the fungi *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 70 F) when free moisture is present for at least 1.5 hours
- Leaf infection can occur at temperatures as low as 41° F 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 vines 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



Downy mildew



Downy mildew



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

- Begin fungicide applications just after the first spikes emerge to minimize infection levels season long
- Subsequent applications should be made in response to conducive environmental conditions every 7-10 days
- Copper, boscalid, fosetyl-AL, pyraclostrobin, and a number of biopesticides have varying **protectant** activity against downy mildew
- Potential resistance to fosetyl-AL?



Downy mildew management, post infection

- Weather conditions may necessitate “curative” applications in addition to preventative sprays
- *Cymoxanil* (Curzate) has about 2d post-infection activity and provides 3d of protection
- *Cymoxanil+famoxadone* (Tanos) provides 2d post infection activity and 5-7d protection
- *Dimethomorph* (Forum) and *mandipropamid* (Revus) have the same mode of action and offer 7d of protectant activity and 1-2d of post-infection activity
- *Phosphorous acid* (e.g. Agri-fos) fungicides have been shown to provide about 4-5d protection and post-infection activity of 5-7d



Know thy enemy!

- Downy AND Powdery mildew
- Downy mildew = *Pseudoperonospora humuli*
- Powdery mildew = *Podosphaera macularis*
- *Powdery* mildew has a much lower incidence in Michigan, 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 which carry the first populations north



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—VT, varietal susceptibility research results coming in 2015



PLH Management

- PLH can be managed with neonicotinoids (imidacloprid or thiamethoxam), pyrethroids (bifenthrin or beta-cyfluthrin), organophosphates (malathion) or spinosyns (spinosad)
- Consider that pyrethroids have been shown to cause increases in mite populations
- Neonicotinoids 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



Primary pests

Two-spotted spider mites

- A significant pest of hop in Michigan 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



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 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

- Take leaf samples from 3-6' up the bine, as the season progresses samples should be taken from higher on the bine as the mites migrate
- Use a hand lens to evaluate 2 leaves from 20 plants per yard
- Thresholds developed in the Pacific Northwest
 - 2 adult mites/leaf in June
 - By mid-July, the threshold increases to 5-10 mites/leaf
- 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
- There are a lot of products that control TSSM
- Consider using a true miticide to minimize the impact on predatory mites
- OMRI-approved products containing oils, bifenazate, and azadirachtin are labeled for mites
- Consider the PHI (quality?) if close to harvest



Primary Pest

Damson hop aphid

- Hop aphids can reduce plant productivity
- DHA excretes 'honeydew' which makes an excellent growth medium for sooty mold and can greatly reduce the quality and salability of a crop
- Under heavy infestations defoliation can occur
- Aphids may also feed within cones and cause economic damage to the crop even at low levels



Damson hop aphid

- Hop aphids overwinter as eggs on Prunus species
- In early spring eggs hatch into stem mothers which give birth to wingless females that feed on the Prunus host
- In May winged females are produced and travel to hop plants where additional generations of wingless females are produced
- As cold weather approaches winged females and males are produced, move back onto a Prunus host, mate and lay eggs for before winter



Damson hop aphid



Damson hop aphid

- Symptoms of hop aphid feeding include leaf cupping and the appearance of honeydew and the associated black sooty mold
- Hop aphids can be found on the upper and lower surface of the leaves
- Currently we are observing nymphs primarily on the underside and unwinged adults on the upper and lower leaf surface
- More commonly seen on first year plants, aphids are a problem pest in the nursery



Management

Damson hop aphid

- Control before the flowering stage may be important to protect crop quality when populations are high
- 8-10 per leaf are tolerated in the Pacific Northwest until cones are present
- Insecticides containing neem (some of which are organic), neonicotinoids (imidacloprid or thiamethoxam), flonicamid or spirotetramat all have activity against hop aphid



Primary Pests

Rose chafer and Japanese beetle

- Both beetles are generalists and feed on dozens of plants
- Beetles are prevalent near grassy areas, particularly irrigated turf
- Grubs feed on grass roots in early spring and again in the fall and can cause significant damage to turf
- 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

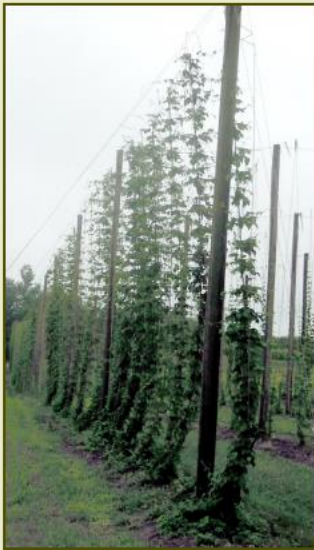


Rose chafer and Japanese beetle

- 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
 - Neonicotinoids (imidacloprid or thiamethoxam) have contact toxicity for 2-5 days, and residual anti-feedant activity
 - 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
- 

Registered pesticides

Pesticides registered for use on hops in Michigan 2015



Fungicides registered for use on hops in Michigan 2015¹

Trade name	Common name	FRAC ² group/ resistance risk	Downy or powdery mildew	Rates/notes	PHI ³	REI ⁴
Accrue	spiroxamine	5/ low to med	PM	18 fl oz/A	7	12 hr
Agri-Fos	phosphorous acid, mono & dipotassium salts	33/ low	DM	1.25 qt/ A in 100 gal water. Apply when shoots are 0.5-1 ft long, post training, 21 d post training, bloom, when conditions favor disease.	not listed	4 hr
Aliette WDG	fosetyl-Al	33/ low	DM	2.5 lb/A. Apply when: shoots are 6-12 in tall, after training when vines are 5-6 ft tall, 3 wks after 2nd application, at bloom. Maximum 10 lb/A/season. Do not use with copper compounds— see label.	24 d	12 hr
Badge SC	copper oxchloride copper hydroxide	M1/low	DM	1.8 pt/A. Make crown treatment after pruning but before training. After training additional treatments are needed 10 d intervals.	14 d	48 hr
Champ Dry Prill Champ Formula 2 Flowable, NuCop 3L Kentan DF Kocide 2000 Kocide 3000 Other formula- tions/ manufacturers exist.	copper hydroxide	M1/low	DM	1.33 lb/A; no more than 7.07 lb/A/yr. 1.33 pt/A; no more than 7.3 pt/A/yr. 1.33 pt/a no more than 7 pt/A/yr. 1.32 lb/A 1.5 lb/A no more than 7.57 lb/A/yr. 0.75-1.5 lb/A no more than 8.8 lb/A/yr. Apply as a crown treatment after pruning but before training. After training, additional fungicide treatments are needed at about 10 d intervals. Minimum retreatment interval:10 d.	14 d	48 hr

Compiled by:

Diane Brown-Rytlewski, Erin Lizotte, and Rob Sirrione, Extension Educators

Pest management considerations for new growers

- Get your pesticide applicators license-organic applicators too!
- 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



Beneficials

Don't forget about the good guys!

- As research into beneficial insects (natural enemies) continues, our understanding of the importance of these partners continues to grow



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



Common Natural Enemies

Braconid wasps-Parasitoid

- Parasitize larvae of beetles, caterpillars, flies and sawflies
- Adults usually are less than $\frac{1}{2}$ inch long with an abdomen that is slender and longer than the head and thorax combined



Common Natural Enemies

Soldier beetle-Predator

- Adults of some species feed on nectar and pollen and are often found at flowers, other adults eat aphids, insect eggs and larvae or feed on both flowers and insects
- Larvae are dark, flattened and elongate, and feed in soil, leaf litter or under bark, primarily on eggs and larvae of beetles, butterflies, and moths



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 $\frac{1}{4}$ 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
- Predatory mites play an important role in balancing the pest mite populations and should be protected when possible



Attracting 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



Resources for beneficial insects

- MSU Native Plants Website: www.nativeplants.msu.edu
- Identifying Natural Enemies in Crops and Landscapes, MSU Bulletin, MSUE Bookstore Online



IPM Resources at MSU

Integrated Pest Management:
A guide to resources from Michigan State University
 by Erin Lizotte, Michigan State University Extension

Extension Bulletin E3220

There are many valuable integrated pest management (IPM) resources and tools available to producers through Michigan State University (MSU). As production systems become more heavily reliant on real-time information and address evolving issues such as invasive pests, pesticide resistance and challenging environmental conditions, MSU Extension is here to assist producers in maintaining an IPM program that supports economic and environmental sustainability.

Real-time information


When it comes to keeping up with the latest developments that affect agriculture, MSU Extension is an excellent resource. MSU Extension News for agriculture offers the expertise of MSU scientists and educators through online articles addressing pest management and provides scouting reports for many cropping systems. You can sign up to receive customized digests via email that address topics or cropping systems of interest to you. To access these resources, visit msue.msu.edu and click the Agriculture tab at the top of the page.

Keeping up with the latest weather developments is a critical component of every IPM program. The Enviro-weather program at MSU is a sustainable weather-based information system that helps users make pest, production, and natural resource management decisions in Michigan. Enviro-weather's website offers general weather information such as rainfall, temperature, degree day accumulations, wind direction and wind speed. Additionally, the Enviro-weather website houses dozens of pest and disease models to help growers more accurately gauge pest pressure, development, and optimal treatment timings throughout the season. Lastly, Enviro-weather offers irrigation scheduling tools and evapotranspiration data. The tools and models on the website use data collected by 70 weather stations located around Michigan. Growers can select the weather station closest to their farm to localize the information, increasing its relevance for individuals around the state.

Enviro-weather addresses pest and disease issues in the following production systems:

- Field crops
- Fruit
- Trees
- Turfgrass
- Vegetables
- Landscape & Nursery

Visit enviroweather.msu.edu



IPM: Integrated Pest Management

MICHIGAN STATE UNIVERSITY Extension

- Enviroweather
- MSUE news and linked resources
- IPM website and associated pages
- Diagnostics lab
- Soil and nutrient testing





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. 2013-41534-21068. 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.