Overview
- Introduction to IPM
- Scouting in the hopyard
- Primary Pests
- Resources

Modern agriculture
Condensed cultivation led to a heavy reliance on pesticides
- Resistance
- Residue
- Effects on natural processes
- Emergence of new pests
- Non target issues

What is IPM?
"a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks"
Today IPM is:
A comprehensive program:
• Knowledge and information intensive
• Multidisciplinary
• Focused on multiple tactics
• Cognizant that 100% control is rarely economically necessary and or possible
• Based on the concept that cropping systems and pests are not static
• Applicable to commercial agriculture, home gardens, urban horticulture, homes, schools, public buildings
• Encompasses insects, pathogens, weeds, and vertebrate pests

Tenants of IPM (PAMS)
• Prevention
• Avoidance
• Monitoring
• Suppression

Prevention
Exclusion of plant pests
• Pest you don’t have are the easiest to control
• “Pest free” planting material is critical to hop production!!
• Consider ordering a few plants from prospective suppliers and check the quality and cleanliness before committing to a large order

Prevention
Anticipate problems
• What pests have commonly occurred
• Select resistant plant varieties
• Handle plants properly

Avoidance
• Start transplants in pathogen free soil
• Sanitation: remove diseased material
• Follow best management practices
Avoidance

Plant in well drained soils and provide adequate irrigation and nutrients
- Root drenches or fumigants may provide protection
- Fusarium will be more severe in poorly drained soils

Fusarium on hop

Avoidance
- Uniform stands of a competitive crop - one of best weed control strategies
- Optimal fertility-healthy crop is more tolerant of pest pressures
- Environmental modification

Monitoring

- Observe pest populations-scout regularly
- Monitor weather
- Nutrients-soil samples, tissue samples
- Proper identification—friend or foe?
- Abiotic or biotic?

Decision to treat based on economics

Unchecked population
Control
Economic injury level
Economic threshold

Time

Number of pests

*the amount of injury which will justify the cost of an artificial control measure*

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

Hop IPM Resources and suppliers

- MSUE Bookstore
- Hops.msu.edu
- MSUE News
- MSU Diagnostic services
- Great Lakes IPM
Scouting for pests of hop

- Scouting protocol
- Primary pests
- Beneficials
- Scouting resources

Scouting

- Scouting involves monitoring the crop and cropping area for insects and diseases
- Scouting should begin as soon as plants begin to grow or pests become active and should continue until the crop is dormant or the risk of the pest has passed.

Scouting

- Scouting is a critical step in quantifying the potential damage that can be caused by a pest
- Aids in determining if intervention to control the pest is warranted
- Helps growers determine the present life stage of the insect or disease which is often critical to the proper selection and timing of management strategies
- Assists in determining the efficacy of a management strategy (farmer scientists)

Scouting

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

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

Scouting

- Growers should keep records of their scouting, including maps of their fields, a record of sampling and pest pressure, as well as the control measures utilized
Scouting protocol

- Section your farm off into manageable portions based on location, size and crop or variety and scout them separately
  - It's easier to deal with blocks that are 10 acres or smaller and that contain plants of the same variety, age and spacing—it's also often how we make management decisions
  - If degree day tools or biological information are available to predict the emergence or arrival of certain pests, use them to gauge when you might scout more intensively

General scouting protocol

- Walk a transect when scouting 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
  - Pockets of less vigorous or dying plants
  - Anything out of the ordinary

General Protocol

- Gently shake strings 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
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

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

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 two-spotted spider mite populations and should be protected when possible

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

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-Ohio Hops and Michigan State University Hop News
- Hop IPM Field Guide 2016
- http://southcenters.osu.edu/horticulture/other-specialties/hops

Primary pests of hop
- 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

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 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

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), phosphonate fungicides (Agri-Fos, Aliette, Fosphite, etc.)
• Strobilurin compounds such as Flint (trifloxystrobin) and Pristine (strobilurin+boscalid) will only provide suppression of downy mildew and are more commonly used for powdery mildew control

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 in the PNW

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 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

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
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

Primary pests

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 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 on the bine
- 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
  - NO CALENDAR SPRAYS—SCOUT
- Consider using a true miticide (e.g. Agri-mek, Acramite, Dicofol, Envidor, Fujimite, Savey, Zeal) to minimize the impact on predatory mites
- OMRI-approved products containing oils, befenazate, and azadirachtin are labeled for mites

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

**Symptoms of hop aphid feeding**
- Symptoms 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
- 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**
- 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), neonicitinoids (Provado or Platinum), 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

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

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
Registered pesticides

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

Hops.msu.edu