



Hop scouting pocket guide for the U.S. Upper Midwest and Northeast, and Eastern Canada

**Erin Lizotte,
Michigan State University**

**Erin Hodgson,
Iowa State University**

**Melanie Filotas,
Ontario Ministry of Agriculture,
Food and Rural Affairs**

MSU is an affirmative-action, equal-opportunity employer, committed to achieving excellence through a diverse workforce and inclusive culture that encourages all people to reach their full potential. Michigan State University Extension programs and materials 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. Issued in furtherance of MSU Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Jeffrey W. Dwyer, Director, MSU Extension, East Lansing, MI 48824. This information is for educational purposes only. Reference to commercial products or trade names does not imply endorsement by MSU Extension or bias against those not mentioned.



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

This work was supported by the USDA National Institute of Food and Agriculture, Crop Protection Pest Management Program and the North Central IPM Center 2014-70006-22486 and under Agreement No. 2015-09785 and 2016-70006-25834. 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.

1P-2M 02:2017-APOLLO-MF/JNL



Hop scouting pocket guide

**for the U.S. Upper Midwest and
Northeast, and Eastern Canada**

Authors: Erin Lizotte, Michigan State University; Erin Hodgson, Iowa State University; Melanie Filotas, Ontario Ministry of Agriculture, Food and Rural Affairs

Produced by the MSU Integrated Pest Management Program with ANR Creative

MSU Extension Bulletin E3348
Order more online at shop.msu.edu

Contents

Recommended resources	3
Hop pest scouting calendar - diseases.....	4
Hop pest scouting calendar - insects.....	5
Growth stages	6
Sections	
Diseases	8
Insect pests	31
Natural enemies	46
Index of species.....	56

References

- Isaacs, R., Schilder, A., Zabadal, T., and Weigle, T. A Pocket Guide for Grape IPM Scouting in the North Central and Eastern United States. Michigan State University Extension Publication E2889.
- O'Neal, S., et al. 2015. Field Guide for Integrated Pest Management in Hops, Third Edition. Washington State University, USDA ARS and USA Hops. www.ipmimages.org (Bugwood.org)

Recommended resources

Websites

- USA Hops www.usahops.org
- Michigan State University www.hops.msu.edu
- North Carolina State University <http://ncherb.org>
- North Dakota State University <https://www.ag.ndsu.edu/plantsciences/research/high-value-crops>
- Ohio State University <https://southcenters.osu.edu/horticulture/other-specialties/hops>
- Ontario Ministry of Agriculture, Food and Rural Affairs <http://www.omafra.gov.on.ca/english/crops/hort/hops.html>
- Purdue University <https://ag.purdue.edu/hla/Extension/Pages/Hops.aspx>
- University of Kentucky <http://www.uky.edu/ccd/production/crop-resources/other/hops>
- University of Vermont www.uvm.edu/extension/cropsoil/hops
- Virginia Tech <http://www.ext.vt.edu/agriculture/commercial-horticulture/hops.html>

Publications

- Field Guide for Integrated Pest Management in Hops (free download at www.usahops.org)

Hop pest scouting calendar

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

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

Insects	Dormancy	Sprouting	Leaf expansion	Bine elongation & sidearm formation	Flowering	Cone development	Cone maturity	Senescence
Twospotted 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

Growth stages

1 - Sprouting



2 - Leaf expansion



3 - Sidearm formation



4 - Bine elongation and sidearm development



Growth stages

5 - Flowering (burr stage)



6 - Cone development



7 - Cone maturity



8 - Senescence



Downy mildew

Pseudoperonospora humuli

When it occurs:

Sprouting-senescence.

Where seen: May affect all plant parts.

Comments. Downy mildew is the most prevalent, damaging and intensively managed pest of hops in central and eastern North America.

Symptoms. Symptoms include distorted and stunted spikes and side-arms with shortened distance between whorls. Aerial tissues may appear yellowed and lesions can form on leaves, and then produce gray-black, fuzzy spore masses on the underside of leaves. Leaf infections



Erin Lizotte, MSU Extension

Stunted downy mildew spike emerging with systemic infection in spring.



Erin Lizotte, MSU Extension

Angular, necrotic downy mildew leaf lesions.

Downy mildew continued

may follow primary leaf veins or appear as angular leaf lesions. Infected vines may fail to climb the string.

Disease cycle. *Pseudoperonospora humuli* overwinters in dormant buds or crowns and may move into the basal spikes as shoots expand in spring. Infected crowns may produce uninfected shoots as well. The pathogen produces copious spores on the underside of infected leaves, which move to new tissue and cause infection through the stomata. Buds, growing points, cones and leaves are all susceptible to infection. Leaf infections produce a second source of spores, which can infect all parts of the plant. Leaf sporulation is limited under dry conditions. Infections occurring on the terminal growing point can become systemic and can also produce spores, further contributing to the spread of infection.



Erin Lizotte, MSU Extension

Gray-brown and fuzzy downy mildew colony on a hop leaf underside.

Downy mildew continued



Erin Lizotte, MSU Extension

Stunted terminal growth with cupped and distorted leaves failing to climb the string due to systemic infection.

Once the fungus is systemic, it grows down the plant toward the crown and can persist in the buds and crown for a prolonged period.

Management. Growers should select resistant cultivars and healthy planting material when available. Apply fungicide treatments on a protectant basis as soon as vines emerge in spring, regardless of the presence or absence of visible downy mildew symptoms. Continue applications throughout the season on a seven-to-10 day reapplication interval until harvest. The time between applications may stretch longer

Downy mildew continued

Hop cones with necrotic symptoms of downy mildew.



Erin Lizotte, MSU Extension

when the weather is dry and if hopyards do not have active infections. Several periods in the season are particularly critical for disease control: immediately before and after training; when lateral branches begin to develop; bloom and cone development. Covering young, developing bracts before cones close up is critical to protecting against downy mildew cone infections when conditions for disease are favorable. Getting adequate coverage on undersides of bracts where infection occurs becomes increasingly difficult as cones mature. Use cultural practices aimed at reducing humidity in the hopyard, such as thoroughly removing foliage during spring pruning and stripping basal foliage after training, with chemical treatments to help manage this disease.

Powdery mildew

Podosphaera macularis

When it occurs:

Sprouting-senescence.

Where seen: Buds, shoots, leaves.

Comments. Powdery mildew is most commonly seen on plants in the greenhouse and baby plants in the field. A bigger issue for producers in the Pacific Northwest and parts of Canada, it may cause issues for growers in eastern North America, particularly if it enters a hopyard on infected planting material.

On the rare occasions powdery mildew does occur in eastern North America, it can be



David Gent, USDA Agric. Res. Serv., Bugwood.org

Round, white colonies are a sign of powdery mildew infection.



Melanie Filotas, OMAFRA
©Queen's Printer for Ontario 2016-Reproduced with permission

Infected cones.

Powdery mildew continued

very severe. Infections can develop rapidly, so frequent scouting is required to catch the disease. Infections should be managed aggressively.

Symptoms. Infected bines called “flag shoots” appear white upon emergence in spring. Powdery mildew forms white, powdery and round colonies on the upper leaf surface or on cones. Burr and cone infection can distort growth or kill the plant. Plants can be infected with downy mildew and powdery mildew at the same time. Infected cones may also appear brown without the white sporulation. After drying, infected cones appear bleached.



Leaves displaying the dark, angular and necrotic lesions of downy mildew as well as white, circular colonies formed by powdery mildew.

Powdery mildew continued



David Gent, USDA Agric. Res. Serv., Bugwood.org

Browning of cones infected with powdery mildew.

Disease cycle. *Podosphaera macularis* overwinters in crown buds, which yield infected “flag” shoots in spring. It may also overwinter in a sexually produced structure, the chasmothecia. Flag shoots or the chasmothecia then produce spores that move via wind from infected crowns to newly emerged leaves where they cause new infections. These new infections yield more spores and the leaf and cone infection cycle continues throughout the growing season.

Powdery mildew continued



David Gent, USDA Agric. Res. Serv., Bugwood.org

White flag shoot infected with powdery mildew.

Management. Manage powdery mildew through varietal selection, sourcing healthy planting material, good farm sanitation practices and protectant fungicide application. The Field Guide for Integrated Pest Management in Hop (www.usahops.org) contains a table listing the relative susceptibility of many hop varieties. Remove early spring growth and use season-long fungicide applications in locations with known infection.

Fusarium canker

Fusarium sambucinum

When it occurs: Flowering-senescence.

Where seen: Where the bine meets the crown.

Comments. Fusarium canker is more prevalent following wet conditions. It is common at low levels, and may be worse in bines infected with hop stunt viroid.



Erin Lizotte, MSU Extension

Swollen, bulbous base of hop bine girdled by fusarium canker.

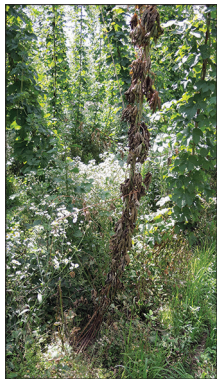
Symptoms. The most obvious symptom is bine wilt or collapse. The affected bine's base becomes swollen where it attaches to the crown, and either completely breaks free or is very easily detached from the crown. Severely affected young hops may die over winter or under wet conditions. White-pink mold may also be produced on the lower stem's outer surface.

Disease cycle. The disease cycle is not well-understood. The fungus that causes

Fusarium canker continued

the disease is a common soil inhabitant and may just be affecting stressed plants when wounded at the soil line. High humidity and moisture around the crown favor disease. In the northeastern states, the disease is most prevalent during the rainy season, or when irrigation is poorly managed.

Management. Remove diseased plants if practical. Growers may also hill up soil to encourage the growth of new, healthy rhizomes and bines. Minimizing injury to bines is important; consider chemical pruning instead of mechanical pruning in spring when applicable. Ensure plants dry out between irrigation events to avoid long periods of exposure to very wet soil. No fungicides are registered for control.



Erin Lizotte, MSU Extension

Burr collapse caused at burr stage by fusarium canker.

Fusarium cone tip blight

Fusarium avenaceum, *F. crookwellense*, *F. sambucinum*

When it occurs:

Cone development.

Where seen:

Cones.

Comments. Generally of minor importance in managed hopyards.

Symptoms. Up to 60 percent of the cone tip turns brown.

Disease cycle. Little is known about the disease cycle. The fusarium species associated with the blight are common in the soil and can also be found on healthy cones. High moisture and rainfall during bloom and cone development may contribute.

Management. There are no known control methods, but fungicide applications made to control mildews will likely suppress it.



Sarah Pethybridge, Cornell University

Brown, necrotic cone tips caused by fusarium. Note the absence of visible mold or mildew that is present with other cone disorders.

Alternaria cone disorder

Alternaria alternata

When it occurs:

Cone development.

Where seen: Cones.

Comments. Alternaria is widespread in agricultural systems. While typically of minor economic importance to hop producers, it can be a problem on cones with wind damage or other mechanical injury when humid conditions or extended wetness occurs.



Browning of hop cones caused by Alternaria cone disorder.

Symptoms. Infection may be limited to bracts and bracteoles or the entire cone may become reddened. Symptoms begin as red-brown discoloration on the tips of bracteoles, making cones appear striped. Symptoms can also appear on the cone as

Alternaria cone disorder continued

a generalized browning. The disease progresses rapidly and tissue becomes brown, making it easy to confuse with downy mildew or powdery mildew damage.

Disease cycle. *Alternaria alternata* is generally a weak pathogen that invades plant wounds. The pathogen may survive between seasons on decaying plant material. The severity of powdery mildew infections has a direct association with *Alternaria* cone disorder severity.

Management. Minimize disease by reducing damage to cones from wind abrasion, insect pests and pathogens. No fungicides are registered. Products registered for controlling powdery mildew likely provide some suppression if applied when cones are present.

Gray mold

Botrytis cinerea

When it occurs: Cone development-maturity.

Where seen: Cones.

Comments. Gray mold is a minor disease favored by wet or humid conditions. It affects dozens of crops including hops.

Symptoms. Infected cones have a browning on the bracts and bracteoles, which may appear striped and eventually becomes a browning of the entire tip. Symptoms are similar to *Alternaria*, but gray mold causes a gray and fuzzy fungal growth. *Botrytis* infections are often found in conjunction with injury from other pathogens, such as downy mildew.



Sebastien Radisek, Slovenian Insti. Hop Research/ Brewing

Gray mold infection on hop cone tip. Note fuzzy, gray and fine mold on the necrotic tissue.

Gray mold continued



Sebastien Radisek, Slovenian Insti. Hop Research/ Brewing

Gray mold infection on hop cone tip.

Disease cycle. The gray mold fungus survives on organic materials like leaves or in a dormant resting structure. The pathogen is active when moisture is available and temperatures are moderate with an optimal temperature of 68 degrees Fahrenheit. Infection is favored by wet weather and injury to cones.

Management. Fungicide applications can reduce gray mold. Cultural practices that minimize drying time and improve airflow can also reduce incidence of gray mold.

Verticillium wilt

Verticillium nonalfalfae and *V. dahliae*

When it occurs: Flowering-harvest or moisture stress periods.

Where seen: Bine tissue just above crown.

Comments. *Verticillium* species have a wide host range. Hop infection severity is variable. In Europe, it can cause plant death. In the U.S., it causes wilt.



David Gent, USDA Agricultural Research Service

Verticillium wilt symptoms include leaves wilting and upwards cupping as well as bine swelling. When affected bines are cut open, the vascular tissue is brown.

Verticillium wilt continued

Symptoms. Symptoms often appear first on lower leaves with yellowed and necrotic tissue between major leaf veins and leaves curling upward. Bines are swollen and when cut open, the vascular tissue is brown. Symptoms generally develop near the flowering stage or during water stress.

Disease cycle. The pathogen survives in the soil and moves into hop plants through the root system, eventually invading the vascular system of the bine and even leaves. The fungal growth and resulting plant toxins disrupt the flow of water and nutrients, causing wilt. The verticillium wilt pathogen is spread during soil cultivation, in infected pruning and chopped post-harvest plant material, during propagation and via infested soil. Weeds can also support verticillium wilt.

Management. Using resistant cultivars and proper sanitation practices are key to limiting spread. Infested material should not be composted and returned to the yard.

Carlavirus complex

Hop latent virus, American hop latent virus, hop mosaic virus

When it occurs:

Present year-round.

Where seen:

May affect all plant parts.

Comments. All carlaviruses are known to occur in mixed infections. Carlaviruses may also occur in conjunction with other viruses, such as apple mosaic or hop stunt viroid. Infected plants may not have visible symptoms.



Erin Lizotte, MSU Extension

Speckled, yellow appearance of hop mosaic virus on hop.

Symptoms. Hop latent virus and American hop latent virus do not cause obvious symptoms on commercial varieties. Hop

Carlavirus complex continued

mosaic virus can cause yellow mottling on sensitive varieties under the right environmental conditions. The carlaviruses can cause weak bine growth and affected bines may fail to climb the string. Early potato leafhopper and mite feeding injury can appear similar; growers should eliminate those pests as possibilities before virus testing.

Disease cycle. Carlaviruses are transmitted through mechanical means including propagation, root grafting and potentially mechanical pruning. Carlaviruses can also be transmitted by aphids. It is not known whether leafhoppers are capable of spreading these viruses.

Management. Using virus-free planting stock is the best method of limiting virus. Controlling aphids may help reduce spread within a yard, but will not completely prevent these insects from transmitting virus to new plants. Culling visibly infected plants can also help reduce virus spread.

Apple mosaic virus

Apple mosaic virus

When it occurs: Present year-round.

Where seen: May infect all plant parts.

Comments. One of the most important viruses of hop, apple mosaic virus reduces the ability to propagate from cuttings and reduces hopyard establishment success.



Hop leaf exhibiting oak-leaf patterned symptoms.



Melanie Filotas, OMAFRA
©Queen's Printer for Ontario 2016-Reproduced with permission

Apple mosaic virus continued

Symptoms. Apple mosaic virus causes yellow circular patterns to form on leaves. These rings become necrotic and merge to form a distinctive oak-leaf pattern. Symptoms become most severe as temperatures warm to over 80 F. Infected plants may appear asymptomatic until the right environmental conditions are met. Under severe infection, yield can be reduced by as much as 50 percent.

Disease cycle. Propagation is the primary source of apple mosaic virus. Mechanical transmission from pruning may also spread the virus. The rate of spread is dependent on variety, climate and farm management practices. There are no known insect vectors.

Management. Using virus-free planting stock is the best method to limit the virus. Using herbicides instead of mechanical pruning to control basal growth may help reduce virus transmission. Culling visibly infected plants can also help reduce the spread of virus.

Hop stunt viroid

Hop stunt viroid

When it occurs: Present year-round.

Where seen: May affect all plant parts.

Comments. Hop stunt viroid can reduce alpha-acid yields by 60-80 percent.

Symptoms. Severity is dependent on variety and environmental conditions. Symptoms may not appear until three years after infection, causing accidental distribution through propagation. Early-season bine growth may be delayed and foliage may appear paler than healthy bines. Internode length is reduced, making plants appear stunted.



Leaves exhibiting yellow speckling along leaf veins that is associated with hop stunt viroid.

Hop stunt viroid continued

Side-arm development may be reduced with smaller cones and delayed maturation. Some varieties exhibit yellow speckling along major leaf veins. Hop stunt viroid can occur in conjunction with other viruses, such as apple mosaic virus or the carlavirus complex.

Disease cycle. Propagation is the primary source of hop stunt viroid. Mechanical transmission from pruning and leaf stripping readily spreads the virus. The rate of spread is dependent on variety, climate and farm management practices. There are no known insect vectors. Hop stunt viroid can remain infectious in dry plant tissue for up to three months.

Management. Using virus-free planting stock is the best method of limiting virus. Using herbicides instead of mechanical pruning to control basal growth may help reduce virus transmission. Culling visibly infected plants and their adjacent neighbors can also help reduce the spread of virus.

Twospotted spider mite

Tetranychus urticae

When it occurs:

Sprouting-senes-
cence.

Where seen: Leaves
and cones.

Description.

Twospotted spider mites are small pests and generally require a hand lens to easily view them. Females are 0.4-0.6 millimeter long with

oval bodies and four pairs of legs. Bodies are slightly hairy and yellow, and most life stages have two dark spots on the abdomen. They can be distinguished from many predatory mites by their smaller size and tendency to move much more slowly.



Erin Lizotte, MSU Extension

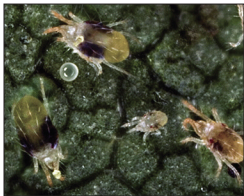
Twospotted spider mite
injury to hop.

Important life stages and damage.

Nymphs and adults can feed on leaves and flowers; however, feeding on the cones is considered most important. Feeding dam-

Twospotted spider mite continued

age causes a patchy discoloration, or bronzing, on affected tissue that is often accompanied by significant webbing produced by the mites as they feed. Feeding injury can make cones dry and brittle, reducing quantity and quality.



David Cappaert, Bugwood.org

Adult mites, clear round eggs and a small larva under magnification.

Management. Twospotted spider mites tend to thrive under drought-stressed conditions and can reproduce quickly during ideal weather. Check on the undersides of leaves weekly and note webbing, cast skins and leaf discoloration. Predators can suppress spider mite populations, and supplemental irrigation and weed control can further discourage outbreaks. Avoid using broad spectrum insecticides when possible to protect predatory mites and beneficial insects. When pesticide use is warranted, true miticides are recommended.

Potato leafhopper

Empoasca fabae

When it occurs: Leaf expansion-senescence.

Where seen: Leaves.

Important life stages: Adults and nymphs.

Description. Potato leafhoppers are a bright green, wedge-shaped insect that are about 0.125 inch long when mature. When disturbed, the winged-adults take flight. Wingless immature leafhoppers are commonly found on the underside of leaves and move rapidly. Potato leafhoppers overwinter in the Gulf States and are carried north during spring thunderstorms on wind currents.



Erin Lizotte, MSU Extension



Erin Lizotte, MSU Extension

Above, mint-green potato leafhopper adult on a hop leaf. Below, bright green and wingless immature nymph on a leaf underside.

Potato leafhopper continued

Important life stages and damage. Immature and adult potato leafhoppers feed with piercing-sucking mouthparts on hop leaves, causing a phytotoxic reaction that causes a distinct leaf yellowing and death around the margin. These symptoms are commonly referred to as “hopperburn.” Feeding damage from potato leafhoppers may reduce crop yield and quality.



Erin Lizotte, MSU Extension

Yellowed and necrotic leaf margins caused by potato leafhopper feeding.

Management. Control potato leafhoppers using one to two insecticide applications with the goal of limiting populations and not complete eradication. There are many natural enemies of potato leafhoppers that are beneficial and should be protected when possible. Avoid using broad spectrum pesticides.

European rose chafer

Macrodactylus subspinosus

When it occurs:

Bine elongation-flowering.

Where seen:

Leaves.

Description.

Rose chafers are a light tan beetle with a darker brown head and long, orange legs.

Adults are substantial in size, about 12 millimeters long. Rose chafer larvae are white, C-shaped grubs that live in the soil.



Erin Lizotte, MSU Extension

European rose chafers mating and feeding on hop. Note the bright orange legs.

Important life stages and damage. Adults emerge from the ground during late May or early June and live for three to four weeks feeding on foliage. Populations may be larger around areas of turf or grasses.

European rose chafer continued

Visual observation is the best method for locating them. Because of their aggregating behavior, they tend to be found in larger groups and are relatively easy to spot. Rose chafer populations tend to be localized within and between hopyards. They often appear in the same spot over multiple years.

Management. There are no established treatment thresholds or data on how much damage a healthy hop plant can sustain, but growers should consider that well-established and vigorous plants will likely not require aggressive control. First-year plantings with limited leaf area may need to be managed more aggressively. Managing rose chafers can be a frustrating endeavor as they can reinfest from surrounding areas, which is often misinterpreted as an insecticide failure. There are a variety of contact pesticides that can be used for control. Apply these materials as spot-treatments to heavily infested areas of the hopyard to avoid impact on beneficial insects.

Japanese beetle

Popillia japonica

When it occurs: Side-arm formation-cone development.

Where seen: Primarily flowers, leaves, and occasionally cones.

Description. Japanese beetles are robust beetles, with adults measuring up to 1.25 centimeters long with a metallic green thorax and copper-colored wing covers.



Erin Lizotte, MSU Extension

Adult Japanese beetle on hop. Note the emerald green thorax and white tufts of hair along the abdomen.

Adults have 12 distinct tufts of white hairs along the abdomen, the legs and head are black. Japanese beetle larvae are white, C-shaped grubs that live in the soil.

Important life stages and damage. Adult Japanese beetles aggregate, feeding and mating in large groups after emergence,

Japanese beetle continued



Erin Lizotte, MSU Extension

Japanese beetle feeding damage on hop.

often causing severe and localized damage. They feed on the top surface of leaves, skeletonizing the tissue between the primary leaf veins. If populations are high, they can remove all of the green leaf material from entire plants. Japanese beetles may feed on other plant parts, including developing flowers, burrs and cones. These beetles begin feeding at the top of plants and move down, so early damage is often concentrated on the upper bine near the wire where it is less noticeable.

Japanese beetle continued

Management. At this time, there is no established treatment threshold for Japanese beetles in hops. Growers should consider that established, unstressed and robust plants can likely tolerate a substantial amount of leaf feeding before any negative effects occur. Those managing hopyards with small, newly established or stressed plants should be more aggressive with management, as plants with limited leaf area and those already under stress will be more susceptible to damage.

It is important to carefully observe beetle behavior in the hopyard; if flowers, burrs or cones are being damaged, growers should consider more aggressive management as yield and quality are directly affected. Managing this pest can be frustrating as they can reinfest from surrounding areas, which is often misinterpreted as an insecticide failure. There are a variety of pesticides registered for control. Apply these materials as spot-treatments to heavily infested areas of the hopyard.

Damson hop aphid

Phorodon humuli

When it occurs: Leaf expansion-cone maturity.

Where seen: Leaves and cones.

Description. Damson hop aphids are small (1-2 millimeters), pear-shaped and soft-bodied insects that may be winged or wingless. Wingless aphids are pale white to green and are typically found on the underside of leaves. Winged aphids are dark green or brown with black markings on the head and abdomen. Aphids have two cornicles or “tailpipes” at the end of the abdomen.

Important life stages and damage. Immature and adult aphids remove nutrients



Erin Lizotte, MSU Extension

Note the diagnostic “tailpipes” at the end of the aphid abdomen. Below, a winged aphid.



David Gent, USDA Ag Research Serv., Bugwood.org

Damson hop aphid continued

and moisture from leaves and cones with their piercing and sucking mouthparts. Damaged leaves may curl and wilt; heavy infestations can cause defoliation. Cone feeding can cause wilt-like symptoms in the cones and browning. Aphids secrete sugary frass when feeding that can support growth of secondary fungi and bacteria, most notably sooty mold. Sooty mold reduces photosynthesis and can make cones unsaleable. Aphids can also transmit viruses.



David Gent, USDA Ag Research Serv, Bugwood.org

Damage from damson hop aphid feeding and the associated black sooty mold.

Management. Excessive nitrogen application and large flushes of new growth favor outbreaks. Apply early-season pesticides to limit population growth over the season when present.

European corn borer

Ostrinia nubilalis

When it occurs: Bine elongation and side-arm formation.

Where seen: Bine.

Description. Larvae are 2-2.5 centimeters long, gray-pink and have a distinct black head. The abdomen has dark brown spots on each segment. Adults are small, tan moths that hold their wings in a delta shape at rest. Females have light tan wings while males' wings are darker tan-to-brown.



Erin Lizotte, MSU Extension

European corn borer larva inside of hop bine. Note the brown spots on each body segment.

European corn borer continued

Important life stages and damage. Larvae initially may feed on leaves and then tunnel into bines, causing collapse of adjacent side-arms and potentially entire bines. They are more problematic in areas adjacent to alternate hosts like corn.



Wings on the adult male are darker compared to the females.

Management. European corn borers are an occasional hop pest and likely will not require control. If control is required, hang yellow sticky traps to catch adults and scout carefully for leaf-feeding larvae in the weeks following adult flight. Applying *Bacillus thuringiensis* (Bt) to externally feeding larvae works well. Control is impossible once larvae enter the bine.

Hop looper

Hypena humuli

When it occurs: Leaf development-cone maturity.

Where seen: Leaves and cones.

Description. Hop looper larvae are pale green with two white stripes on each side of the back and one white line on each side. They are approximately 2.5 centimeters long at maturity and have four pairs of prolegs located on abdominal segments four, five and six, and on the last segment. This causes them to move in a distinct, looping fashion. When disturbed, they may drop from bines, often on a silken thread.



Hop looper larvae in hop plants. Note the four sets of legs and striping.

Important life stages and damage. Hop looper larvae feed on leaves, resulting in a lacy appearance. They feed on cones

Hop looper continued

later in the season, resulting in a jagged feeding pattern at the tips of bracts and bracteoles. In the northeastern states, hop looper feeding is generally not sufficient to cause economic damage; however, in some circumstances, populations can build sufficiently high to cause severe leaf and cone defoliation.



Hop looper feeding damage to leaves.

Management. In most years, natural predators and parasites keep hop looper populations well-below damaging level. Consequently, treatment is generally not required. If populations reach economically damaging levels, a number of insecticides are registered for controlling caterpillar pests in hopyards. Avoid using broad spectrum insecticides when possible to protect predatory mites and beneficial insects.

About natural enemies

Natural enemies are beneficial organisms that can enhance pest control, often suppressing many indirect pests, such as mites and leafhoppers. Conserve beneficial insects by being cautious when selecting pesticides and timing applications, and restricting use of predator-toxic products, particularly late in the season.

Predatory mites

Predatory mites are white, orange or clear and can be distinguished from pest mites by their movement. When disturbed, predators generally move quicker than pest mites. A ratio of one predator to 10 pest mites is often sufficient for effective biological control.



File photo

The predatory mite *Zetzellia mali* is bright yellow with orange markings and has a somewhat pointed posterior.

Spiders

Dozens of **spider** species are commonly observed in the hopyard, but perhaps most prevalent are a group of spiders commonly referred to as “crab spider.” Crab spiders rest with their legs oriented as a crab does and so earned this nickname. Spiders are generalist predators and will feed on a variety of insect pests.



Erin Lizotte, MSU Extension

Lacewings

Green lacewing adults (10 to 12 millimeters) have net-veined wings and gold-colored eyes. They feed on nectar, pollen and aphid honeydew.



File photo



Erin Lizotte, MSU Extension

Green lacewing adult.

Egg on its stalk.

Lacewing eggs are suspended at the tips of long, erect stalks.



David Cappaert, Bugwood.org

Lacewing larvae are alligator-shaped with long, piercing mandibles. They are active predators of soft-bodied insects.

Lacewings continued

Brown lacewing adults are reddish-brown. They have large, membranous, brown wings and long antennae with a long, thin body. They are smaller than the green lacewing.

The brown lacewing lays several hundred oval eggs per female on the undersides of leaves; the eggs are *not* on stalks like green lacewing eggs.

The larvae appear similar to green lacewing larvae. They are gray to brown and alligatorlike. They have large, sickle-shaped mandibles.

File photo



At left, brown lacewing egg, brown lacewing larva and below, brown lacewing adult.

Jon Yuschok; Bugwood.org



File photo

Beetles

Several species of **lady beetles** are active in hop-yards. They are generally oval and red to orange with varying numbers of dark spots. Both adults and larvae are predators, eating soft-bodied small insects.



David Cappaert, Bugwood.org

Larvae have dark, elongated bodies with orange markings and well-developed legs.



File photo



David Cappaert, Bugwood.org

Above, adults.



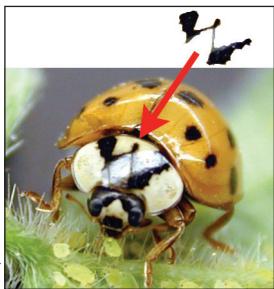
File photo

Lady beetle eggs are yellow and barrel-shaped and laid in clusters.

Beetles continued



File photo



Doug Landis, MSU Entomology

The **multicolored Asian lady beetle**, an introduced species, feeds on pests during summer. They may be many colors with several or no spots and can be distinguished from other ladybugs by the black M or W (depending on the viewing direction) between the head and abdomen (see photo).

Ground beetles eat insects and weed seeds. They feed on insect eggs, larvae and pupae found on the ground, or search in the hop plant for food.



Joseph Berger, Bugwood.org

Flies

Syrphid fly adults resemble bees but have only one pair of wings and much shorter antennae. They can be seen hovering in the air near plants. The larvae are usually light green, legless maggots, rounded at the rear and tapering to a point at the head. When the maggot is crawling, the head moves from side to side. The larvae are predators that eat soft-bodied insects.

Tachinid fly adults are hairy and bristly. Their larvae feed on the larvae of some pests.



Syrphid fly adult.



Syrphid fly larva.



Tachinid fly adult.

File photo

Frank Peairs; CO St Univ; Bugwood.org

David Cappaert; Bugwood.org

Flies continued

File photo



Tachinid fly larvae emerging from a caterpillar.

Robber flies are general predators that eat aphids, moths, beetles and many other pests.



David Cappaert, Bugwood.org

Robber fly adult.

True bugs

Damsel bugs have long bodies that narrow slightly toward the head. They have stout beaks and large front legs for grasping prey.



File photo

Damsel bug.

Adult **minute pirate bugs** are black with white markings.



File photo

Minute pirate bug.

Adult **assassin bugs** are medium to large insects, and their color ranges from brown to green. They have long heads with a groove between the eyes and curved beaks. The nymphs are also important predators.



File photo

Assassin bug.

Many **shield bugs**, or stink bugs, are predatory and can attack beetles and caterpillars.



File photo

Shield bug.

Parasitic wasps

Most **parasitic wasps** are tiny, and they often develop inside their hosts, so detecting them can be difficult. Some recognizable signs of parasitism include unusual host (pest) behavior, host body darkening and emergence holes or cocoons on the pest.

Trichogramma wasps are egg parasites of many insects, including grape berry moth and leafrollers. Parasitized eggs are dark black rather than the yellow-cream of healthy eggs.

Braconids and ichneumonids are small black, orange or yellow wasps that prey on larvae of grape berry moth and other insects. Adults are less than 10 millimeters long, and many species are found in hopyards and surrounding woods.



Ichneumonid wasp.

Hop scouting pocket guide index

Diseases

Alternaria cone disorder.....	19
American hop latent virus	25
Apple mosaic virus	27
Carlavirus complex	25
Downy mildew.....	8
Fusarium canker	16
Fusarium cone tip blight	18
Gray mold.....	21
Hop latent virus	25
Hop mosaic virus.....	25
Hop stunt viroid.....	29
Powdery mildew	12
Verticillium wilt	23

Insect and mite pests

Damson hop aphid	40
European corn borer.....	42
European rose chafer	35
Hop looper.....	44
Japanese beetle.....	37
Potato leafhopper	33
Twospotted spider mite	31

Natural enemies

About natural enemies.....	46
Assassin bug	54
Braconids	55
Brown lacewing	49
Damsel bug	54
Green lacewing	48
Ground beetle	51
Ichneumonids	55
Lady beetles.....	50
Minute pirate bug.....	54
Multicolored Asian lady beetle	51
Parasitic wasp.....	55
Predatory mite	46
Robber fly	53
Shield bug	54
Spiders	47
Stink bug	54
Syrphid fly.....	52
Tachinid fly.....	52
Trichogramma wasp.....	55



MSU Extension Bulletin E3348

MICHIGAN STATE
UNIVERSITY | Extension

4

3

2

1

0 inches

0mm 10 20 30 40 50 60 70