The Connecticut Agricultural Experiment Station, New Haven, CT

Guidelines for Integrated Pest Management for Hops in Connecticut

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Introduction: Hops in Connecticut

The United States, mainly the Pacific Northwest, and Germany are the two biggest hop (*Humulus lupulus*) producers worldwide. However, hop cultivation also has a long tradition in the Northeast United States dating back to the 1700s. Hops were one of the first crop plants grown by European settlers in New England, and widely were grown until production disappeared in the 1920s because of disease pressure and the enactment of Prohibition. Nowadays, hop production in New England is on the rise again due to the increasing popularity of microbrew culture, local brewpubs, and the growing demand for regional products. New York, the largest production area in the Northeast, has around 400 acres (Northeast Hops News, February 2017), followed by Vermont. Commercial hop production has recently started in Connecticut.

Successful production of high quality hops in the Northeast requires knowledge and experience. Not only of adequate cultivation practices, but also because strict disease control and pest management is necessary. Integrated pest management (IPM) incorporates multiple control methods, e.g. preventive cultural practices, biological control, and planting resistant or tolerant varieties. This brief guideline provides information about control and management of diseases and pests for Connecticut growers. Attached are non-exhaustive lists of pesticides that are common in Connecticut.

The most common diseases and pests in the Northeast are downy mildew (DM), two-spotted spider mites, Damson-hop aphids, and potato leafhoppers. Potato leafhoppers are a novel pest in the Northeast and do not occur in the Pacific Northwest. Because of the wet and cool spring, DM is the most severe and damaging disease in the Northeast. The pathogen can infect all plant parts and cause up to 100% yield losses. Powdery mildew (PM) has not yet been observed in Connecticut, but has been documented in New York. Beneficial insects and natural enemies should be released at the first occurrence of pests. Above a certain population level, spraying insecticides is almost unavoidable. Threshold levels specific for the Northeast do not yet exist, but recommendations are available for other areas. Broad spectrum insecticides should be avoided due to the negative impact on beneficial insects, which in turn can increase pest populations.

Planting healthy pest-resistant or tolerant plants is the first step in management of diseases. However, disease development varies depending on the strain of the pathogen, environmental conditions, and other factors. Brewer's Gold, Cascade, Centennial, Chinook, Galena, and Nugget, which are popular varieties, are described as susceptible to downy mildew (*Field Guide for Integrated Pest Management in Hops 2015*). Fuggle and Willamette are moderately resistant and Perle and Hallertauer Tradition are supposed to be resistant to downy mildew. However, our studies have showed that AlphAroma, which is described as moderately resistant, is highly susceptible to downy mildew in our two trial hop yards. Newport and Perle were resistant, however Perle had very poor growth and yield. The variety Cascade had low levels of disease.

In general, it is recommended to plant resistant and tolerant plants, but also requirements or preferences for brewers should be considered.

The key to successful management of hop diseases is the ability to identify diseases and pests and knowledge of life cycles and effects of environment that impact management tactics. Monitoring the hop yard weekly and keeping track of the weather and forecast help to act in a timely manner and reduce the incidence and severity of diseases and pests. Preventive cultural practices include crowning (removal of the top of the crown), pruning, stripping of lower leaves, and removing diseased leaves or plants. Removal of weeds may also assist in disease control, as will planting trap crops (plants, which attract a pest away from the cash crop) and crops which are favored by beneficial insects that help to control the population of pests. Furthermore, irrigation (overhead irrigation increases the disease pressure) and fertilization (avoid extensive nitrogen fertilization) management should be optimized. Keep in mind that diseases can be transferred with equipment from one hop yard to another. Therefore, you should sanitize or wash soil off your equipment after use.

These cultural control practices help to reduce diseases as well as pests. However, spraying chemical fungicides and insecticides may be unavoidable at a certain point. Minimal application of effective low-environmental impact chemicals should be targeted. The combination of all these practices is the key to producing high quality hops in CT.

Resources:

Several sources about how to grow hops successfully are available in the form of books or as online resources. There are many information sources on the Internet, but be aware that not all are proven and suitable for commercial production. The *Field Guideline for Integrated Pest Management in Hops* (2015) (https://www.usahops.org/resources/field-guide.html) is a very informative control management guideline for the United States, mainly the Pacific Northwest, but has included information for the Northeast recently. The guidebook *Compendium of Hop Diseases and Pests* (2009, APS PRESS, edited by Mahaffee WF, Pethybridge SJ and Gent DH) provides detailed information about symptoms, disease cycles, epidemiology and disease management. Furthermore, Cornell Cooperative Extension (http://madisoncountycce.org/agriculture/hops-program) and the University of Vermont (http://www.uvm.edu/extension/cropsoil/hops) provide a wide range of resources on hop production in the form of newsletters and a hops web blog, as well as reports and updates of applied research programs on hop varieties, pest management, cultivation and much more for the Northeast. There are numerous resources for Michigan at http://msue.anr.msu.edu/resources/michigan_fresh_growing_hops The book *The Hop Grower's Handbook* by Laura Ten Eyck and Dietrich Gehring (2015), explains in detail how to grow hops in small, commercial scale systems.

Management - Pesticides

Due to the high disease and pest pressure often experienced in Connecticut and the Northeast, the application of conventional chemical and/or biological pesticides may not be avoidable to achieve high quality hops and good yields. Below are lists of selected pesticides from 2017, which are currently registered in Connecticut. The lists are not exhaustive and the efficacies of the individual products have not always been evaluated on hops in CT. The listed commercial products do not imply endorsement by The Connecticut Agricultural Experiment Station or bias against those not mentioned. The pesticide lists, which follow after each disease and pest section, shall rather give examples of fungicides and insecticides, which may be used to control pathogens and insects. Check the accuracy of the presented information, as pesticide labels can and do change frequently. Read the label for more information, e.g. maximum product rate per year or maximum number of sequential application. For further information and questions, please check with the CAES, your local Extension Office or the Connecticut Department of Energy and Environmental Protection. The website Kelly Solutions (http://www.kellysolutions.com/ct/) provides a good search tool for pesticides. Always read the entire label carefully before applying any pesticide. The product has to be labeled for hops in your state. It is illegal to use chemicals on crops or on pests for which it is not specifically labeled. Use proper personal protection equipment and follow the restricted entry and pre-harvest intervals.

For choosing the right pesticide and application time, it is important to understand the life cycle and biology of the pathogen or pest, the pesticide efficacy, as well as the plant. Choice of pesticide product and timing depends on different factors like plant stages, plant resistance, disease infestation in the previous year, weather conditions and forecast. Hence, early, mid, late, and after-harvest treatments have to be considered. For example, after-harvest and early spring fungicide treatments are applied to combat downy mildew (DM), which overwinters in buds and crowns. Different types of pesticides exist: a) protectants, which prevent diseases and sometimes may slow or stop development of new symptoms, and b) systemic pesticides, which are absorbed by the plant and circulate through the plant, killing pathogens or insects which feed on them. The plant itself has to be considered too. The burr is very sensitive to mechanical damage during applications. Oils used to smother insects may be applied up to that point, but may cause plant damage if applied at or after flowering. Apply an effective protectant product with a longer residual just before flowering. Pre-harvest intervals, which are on the label, have to be followed. Furthermore, diversify the fungicide and insecticide class and vary modes of action to prevent resistance development. Each class may be used a specified number of times per season, which is usually specified on the label. Follow label directions for rotating modes of action to delay the development of resistance.

Downy Mildew

Pseudoperonospora humuli


Figure 1: Angular leaf lesions

Downy mildew (DM) occurs worldwide and can infect all parts of the hop plant and cause up to 100% yield losses. Understanding the life cycle is very important to manage the disease (see *Field Guide for Integrated Pest Management in Hops* for more information: https://www.usahops.org/resources/field-guide.html). Downy mildew systemically infects plants, overwinters in buds and crowns and may spread and affect shoot development. These stunted shoots are called primary basal spikes. DM thrives in moderate temperatures and moist environments. The pathogen sporulates at night temperatures greater than 43°F and relative humidity greater than 90%. Infections occur under mild and warm day temperatures (60-70°F) and free leaf wetness lasting at least 1.5 hours. However, leaf infection can also appear at temperatures as low as 41°F with wetness that persists longer than 24 hours. Spores, which are produced on the underside of leaves, are released in rainy conditions and infect leaves, shoots, and cones (secondary infection). Infected plants and rhizomes become weak, resulting in low yield and eventual die-off.

Symptoms

- Angular leaf lesions on the surface and undersurface, usually delimited by veins (Figure 1).
- Sporulation by the pathogen on the underside of leaves (Figure 3).
- "Spikes" – stunted shoots with short internodes and chlorotic appearance: 1. Primary basal spikes grow from the crown in the spring resulting from systemic infection of buds in the previous year (Figure 3).
  2. Secondary spikes are diseased sidearms (Figure 2).
- Infected inflorescences become dark brown, shriveled and dried up.
- Whole or parts of the cones become brown, hardened and will stop developing.


Figure 2: Spike - stunted shoot with short internodes

Management

The combination of planting healthy as well as resistant (f.ex., Hallertauer Magnum, Hallertauer Tradition, Newport) or moderate resistant cultivars (f.ex. Columbia, Fuggle, Sterling, Willamette), field sanitation practices and timely preventive fungicide application are essential for effective control of DM. Scouting weekly and monitoring weather conditions are the basic prerequisites for a healthy hop yard. Sanitation practices include planting healthy


Figure 3: Sporulation on the underside

plants, crowning (underground pruning), removal of heavily diseased plants early in the spring, elimination of primary basal spikes, mechanically or chemically stripping of infected leaves, and weeding. A timely and aggressive preventive fungicide program in the early season and after DM – prone weather conditions are very important to manage this disease. Rotate the class and mode of action of fungicides because of the high risk of developing fungicide resistance. Postharvest treatment may reduce the inoculum and help manage the outbreak in the next spring.

Table 1: List of examples for fungicides to control downy mildew registered for hops in CT

Trade name	Common name/ Active ingredient	FRAC group	Rates/application	Notes
Champ Formula 2 Flowable	Cooper hydroxide	M1	1.33 pt/A Max 7.3 p/A/year	Apply as a fungicide crown treatment after pruning, before training. After training, additional fungicide treatments are needed at about 10 day intervals. PHI: 14 days.
C-O-C-S WDG	Cooper oxychloride + basic copper sulfate	M1	1.0 lb/A Max 5.1 lb/A/year	Apply soon after training vines (when growth is approximately 18 inches long). The minimum Retreatment Interval is 10 days. PHI: 0 days.
Cueva Fungicide Concentrate	Cooper octanoate	M1	0.5-2.0 gal/A Max 16 gal/A/year	OMRI listed for organic production. Control of downy mildew and powdery mildew. For best control, begin treatment 2 weeks before disease normally appears or when weather forecasts predict a long period of wet weather. Repeat application every 10 days if necessary. PHI: 0 days.
Kocide 2000 / 3000	Cooper hydroxide	M1	2000: 1.5 lb/A; Max 7.57 lb/A/year 3000: 0.75-1.5 lb/A Max 8.8 lb/A/year	Make crown treatment after pruning, but before training. After training, apply at 10 day intervals if needed. PHI: 14 days.
Ridomil Gold SL	Mefenoxam	4	0.50 pt/A	Soil drench: Apply in water or liquid fertilizer to the soil over the crowns after pruning but before training. Apply early when shoots are 6 inches or less. Foliar spray: At the first sign of a secondary infection (primary infection persists after the soil drench and/or there is evidence of foliar infection), apply in combination with copper fungicides. PHI: 45 days.
Ranman, Ranman 400SC	Cyazofamid	21	2.1-2.75 fl oz/A Max 16.5 fl oz/A/year	Make fungicide applications on a 10- to 14-day schedule beginning when warning systems forecast disease infection periods or when disease conditions are favorable for disease development. No more than 6 applications/crop or 3 consecutive applications. PHI: 3 days.
Dupont Curzate 60DF	Cymoxamil	27	3.2 oz/A	Apply CURZATE® 60DF plus a protectant fungicide on a 10-14 day schedule. Use only in combination with a labeled rate of a protectant fungicide, such as products containing copper hydroxide (e.g., DuPont™ KOCIDE®). No more than 4 applications per year. PHI: 7 days.
Agri-Fos Systemic Fungicide	Mono and di-potassium salts of phosphorus acid	33	Foliar: 1.25-3.5 qt/A; Aerial: 1.25-3.5 qt/A	Control of downy mildew and powdery mildew. Application program: When conditions favor disease, apply when A. Shoots are ½ to 1 foot long. B. Post-training when vines are 6 feet high. C. 21 days post-application (B) D. During bloom. Apply at 2-3 week intervals. PHI: 0 days. Harvest when dry.

Fosphite	Mono and di-potassium salts of phosphorus acid	33	Foliar: 1-3 qt/A; Aerial: 1-3 qt/A	Control of downy mildew and powdery mildew. Apply at 2-3 week intervals. Do not apply Fosphite fungicide foliarly to plant treated with copper based compounds at less than 20 day intervals. PHI: 0 days.
Forum	Dimethomorph	40	6 fl oz/A Max 18 fl oz/A/year	Use Forum® fungicide as a preventive application before infection occurs. When disease is present in or near the area, prediction models indicate favorable disease conditions; or when an epidemic is underway, performance may be improved by using Forum as a tank mix with another fungicide. If Forum has been applied as the only downy mildew fungicide, the next sequential application must be another downy mildew fungicide with a mode of action different from Forum (non-Group 40) for at least 1 application. If Forum has been applied as a mix with another downy mildew fungicide, a second sequential application of Forum (alone or as a mix) is permitted before rotating to a non-Group 40 downy mildew fungicide for at least 1 application. No more than 3 applications per year. PHI: 7 days.
Revus	Mandipropamid	40	5.5-8.0 fl oz/A Max 24 fl oz/A/year	Begin applications prior to disease development and continue throughout the season on a 7-10 day interval. Make no more than 2 consecutive applications before switching to an effective non-Group 40 fungicide. For resistance management, no more than 50% of the sprays should be Revus. Revus may be tank mixed with another fungicide labeled for downy mildew that has a different mode of action. The addition of a spreading/penetrating type adjuvant such as a non-ionic based surfactant or blend is recommended. Max 3 applications/year. PHI: 7 days.
Pristine Fungicide	Boscalid + pyraclostrobin	7+11	14 oz/A Max 84 oz/A/year	Control of downy mildew and powdery mildew. Ground application. Begin applications of Pristine prior to disease development and continue on a 10-21 day interval. Max 3 applications per year. Do not make more than 2 sequential applications before alternating to a labeled fungicide with a different mode of action. PHI: 14 days.
Dupont Tanos Fungicide	Famoxadone + cymoxanil	11+27	8 oz/A Max 48 oz/A/year	TANOS ® applications should begin prior to disease development. Make preventive applications on a 6-8 day schedule. TANOS ® must be tank-mixed with an appropriate contact fungicide that has a different mode of action, such as copper (e.g. KOCIDE®). Do not make more than 6 applications of Tanos or other Group 11 fungicides per cropping cycle. PHI: 7 days.
Zampro	Ametoctradin + dimethomorph	45 + 40	11-14 fl oz/A Max 42 fl oz/A/year	Begin applications of Zampro before disease development and continue on a 10-day interval. No more than 3 applications per year and 2 sequential applications before alternating to a labeled fungicide with a different mode of action. PHI: 7 days.

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Powdery Mildew

Podosphaera macularis

Powdery mildew of hops (PM) is only pathogenic on hop plants (*Humulus* spp.). The pathogen infects all above-ground plant parts (buds, stems, leaves, cones). The PM pathogen overwinters in and on buds and infects shoots, called flag shoots. Powdery white spore colonies are the characteristic symptoms. Spores are spread by wind, rain splash, insects, as well as by tractors, equipment, and humans. PM is favored by moderate temperatures (47-82°F), high humidity, and cloudy weather. Infection of cones reduces their quality and may to lead to total crop loss.

Symptoms

- Characteristic circular, powdery, white colonies on buds, stems, leaves, and cones.
- Eventual occurrence of blisters before sporulation.
- "Flag shoot" – shoot, which emerges from infected buds, stunted with distorted leaves, white sporulation on the stem.
- Reddish-brown discolored and distorted cones with reduced size.
- Cone browning after kiln drying.

Management

The most effective control methods for PM are preventive measures including cultural and chemical practices. It is very important to plant healthy rhizomes and plants as well as resistant (e.g. Comet, Crystal) and tolerant varieties (e.g. Fuggle). Due to the high probability of PM infection by late harvest, early-maturing varieties should generally have less disease. Spring cultivation (crowning, pruning and/or scratching) reduces inoculum of PM, which overwinters in buds. Removal of diseased tissues and shoots helps to reduce spread. An intensive preventive spraying program is often necessary. The risk of developing resistance to fungicides is high. Therefore, fungicides with different active ingredients should be rotated. Cueva, Agri-Fos, Foshite, and Prestine are examples of fungicides which control downy mildew (Table 1) as well as powdery mildew. Furthermore, several mineral oils, e.g. Glacial Spray Fluid, JMS Stylet Oil, Omni Supreme Spray, and Purespray control powdery mildew (Table 2). Scouting weekly and keeping track of the weather conditions and forecast is essential. To date, PM has not been seen in Connecticut, but if you observe the disease, report it to the CT Agricultural Experiment Station.

Figure 4: Left: Hop leaves with severe powdery mildew caused by *Podosphaera macularis*. Middle: Cones with reddish-brown discoloration. Right: Hop shoot (flag shoot) colonized by *Podosphaera macularis* resulting from crown bud infection and perennation. Photo credit: David Gent, USDA Agricultural Research Service, Bugwood.org.

Two-Spotted Spider Mite

Tetranychus urticae Koch

Figure 5: Female two-spotted spider mite

Two-spotted spider mites (TSSM) are common arthropods affecting many field, ornamental, and horticultural crops worldwide. Mites feed by sucking plant juices from the cells, on leaves and cones. Infestation of cones results in the most economic damage. Cones become dry, brittle and have a reddish discoloration and hence, may be refused by brewers. Mite feeding reduces productivity of leaves and direct damage to the hop cones resulting in up to total yield losses. The yield is reduced in quantity and quality (lower alpha acids and storage life). Hop plants may tolerate TSSM if cones are not infested. Mite populations can increase rapidly during hot and dry conditions.

Females overwinter on plant debris in the hop yards. In spring, these females lay eggs (ca. 240 eggs over the summer) underneath the leaves and, depending on the weather conditions, in 1 to 3 weeks adult mites develop. Females are small (1/50-inch), yellow to yellow-green insects with two large black spots on the abdomen. The population can explode in hot and dry conditions (5-8 generations/summer). Eggs are clear to white and approximately 1/200 to 1/150-inch in diameter. Mites and eggs are visible with a 10X or 20X hand lens. Mites are spread by wind.

Figure 6: Male (left), female (right) two-spotted spider mite and cast skin

Symptoms

- Occurrence on the leaf undersurface and cones.
- Silvery discoloration on leaf surfaces and reddish discoloration of infested cones.
- White webs on the underside of leaves.

Management

Steadily weekly monitoring for mite presence and population density should be conducted during hot and dry conditions. Natural predatory mites and beneficial insects (e.g. big-eyed bugs, minute pirate bugs, lady beetles, spiders, and lacewings) can be encouraged or applied at first occurrence. The economic threshold is 1-2 adult mites/leaf in June and 5-10 mites/leaf by mid-July taking leaf samples from 10-30 plants. Above that level, spraying is necessary. Warning: broad spectrum insecticides (e.g. pyrethroid, organophosphate, carbamate, and neonicotinoid insecticides) have a negative impact on beneficial insects and therefore, the application may actually increase the TSSM populations. Several miticides are available which do not harm beneficial insects. To avoid the development of resistance, rotate miticides with different active ingredients and modes of action. Stripping of lower leaves of the hop plants, minimizing dusts, and providing habitat for natural enemies helps to keep the population under control.

Table 2: Examples for insecticides to control two-spotted spider mites registered for hops in CT

Trade name	Common name/ Active ingredient	IRAC group	Rates/application	Notes
Epi-Mek 0.15EC, Reaper 0.15 EC, Reaper Clearform, Reaper Advance, Zoro	Abamectin	6	8-16 fl oz/A Max 32 fl oz/year	Apply product when two-spotted spider mites reach treatment thresholds. For applications at 1/2 trellis growth (6-8 ft. height) apply 8-16 fl oz/A. For applications beyond 1/2 trellis growth, do not use less than 16 fl oz/A. If a second application is necessary to maintain control, wait at least 21 days before repeating application and repeat application only after an alternative miticide with a different mode of action has been used. No more than two applications/season. High mortality of predatory mites and lady beetles. PHI: 28 days.
Neem Oil 70%	Clarified Hydrophobic Extract of Neem Oil	-	1-2 gal/A	OMRI listed for organic production. Powdery mildew, downy mildew, mites, and other insects. Kills eggs, larvae, and adult insects. Make sprays on a 7-14 day interval depending on the severity of the pest problem. Use the 7-day schedule until the pest population is reduced. Then use a 14-day interval for control. PHI: 0 days.
Zeal SC Miticide	Etoxazole	10B	6-8 fl oz/A	Zeal SC Miticide is predominately an ovicide/larvicide. Apply Zeal SC Miticide at or prior to threshold for your area. 1 application/season. PHI: 7 days.
Glacial Spray Fluid	Mineral oil	-	1-2 gal/A	Mite and powdery mildew control. Discontinue sprays at burr development. 10-14 days interval. Oils not compatible with sulfur. PHI: 0 days.
JMS Stylet Oil, Organic JMS Stylet Oil	Mineral oil	-	1-2 gal/A	Mite and powdery mildew control. Discontinue sprays at burr development. 10-14 days interval. Oils not compatible with sulfur.
Omni Supreme Spray	Mineral oil	-	1-2 gal/A	Mite and powdery mildew control. Discontinue sprays at burr development. 10-14 days interval. Oils not compatible with sulfur.
Purespray Green, Purespray 10E	Mineral oil	-	1-2 gal/A	Aphids, Mites, Powdery Mildew, Whiteflies. Discontinue sprays at burr development. 10-14 days interval. PHI: 0 days.
PyGanic Crop Protection EC 1.4 II	Pyrethrins	3A	16 fl oz/A	Broad spectrum insecticide: Kills more than 100 listed insects (e.g. leafhoppers, aphids, mites). Spraying should begin when the insects first appear. It is recommended that the final spray mix be buffered to a pH of 5.5-7.0. PHI: 0 days.
Microfine Sulfur, Yellow Jacket wettable sulfur	Sulfur	-	33-44 lb/A	For organic production. Begin when infestation first appears and repeat at 5-10 day intervals. Repeat as necessary. Do not use sulfur in combination with oil or within 21-60 days of an oil spray.

Always read the entire pesticide label and check the accuracy of the presented information. Label and registration status can change. The lists are not exhaustive and the efficacies of the individual products have not been evaluated on hops in CT. The listed commercial products do not imply endorsement by CAES or bias against those not mentioned. IRAC group = Insecticide Resistance Action Committee. PHI = Pre-harvest interval. OMRI listed for organic production. Check the OMRI website: https://www.omri.org.

Potato Leafhopper

Empoasca fabae

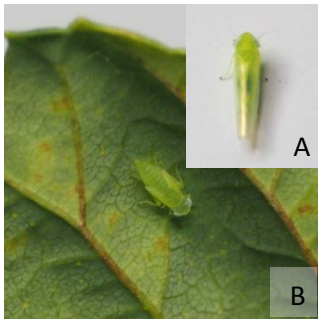

Figure 7: (A) Adult and (B) nymph

Potato leafhoppers infest more than 200 species of broadleaf plants. They occur in the Northeast between late spring and mid-June. Leafhoppers overwinter in the south and wander north during storm season in spring. Adults are bright green with wings and only 1/8-inch (3 mm) long (Figure 7A). They are able to move quickly forward, backward, and sideways, leaping and flying. The nymphs are smaller than adults, wingless and pale green (Figure 7B). Potato leafhoppers start appearing in hop yards as early as May and their occurrence increases slowly until June and July. Most of the damage occurs from mid-June to mid-August. The entire life cycle lasts 1 month and 2-3 generations may occur each year. The insects suck the plant juices out of the veins in the leaves using their mouth-parts. A saliva toxin blocks the veins and reduces nutrient availability. The first sign is yellowing at the leaf tip following by necrosis and curling (Figures 8 and 9).


Figure 8: Hopper burn

Symptoms

- "Hopper burn" – necrosis of the leaf, the outer edges and tip of the leaf turn brown and form a distinctive "V" (Figure 8).
- Yellowing of the leaf at the tip followed by necrosis and leaf curling.
- Shortening of internodes, stunted growth, fewer flowers and cones.


Figure 9: Symptoms on leaves

Management

Scout weekly! Count leafhoppers per leaf (undersurface) and/or use sweep nets. There is no economic threshold developed so far, but the University of Vermont recommends a threshold level of 2 leafhoppers per leaf.

Broad spectrum insecticides such as acephate, bifenthrin, and chlorpyrifos are registered in Connecticut for use against leafhoppers. More environmentally friendly means are insecticidal soap and oils as well as insect growth regulators. Natural predators, lady beetles, lacewings, ants, spiders, or Nabid bugs can be applied at first occurrence. Neonicotinoid insecticides used to manage aphids may help suppress leafhoppers.

Table 3: List of examples for insecticides to control potato leafhoppers registered for hops in CT

Trade name	Common name/ Active ingredient	IRAC group	Rates/application	Notes
Azera Insecticide	Pyrethrins, azadirachtin	3A, -	1-3.5 pt/A	OMRI listed for organic production. Broad spectrum insecticide: e.g. aphids, spider mites, potato leafhoppers. Kills larval, pupae, and adult stages of listed insects. Adjust spray pH to 5.5-7.0 to retain effectiveness of pyrethrins. No more than 10 applications per season. PHI = 0 days.
AzaGuard	Azadirachtin	-	10-16 fl oz/A	OMRI listed for organic production. E.g. two-spotted spider mites, potato leafhoppers. Buffer spray solution to pH of 5.5-6.5. Use in combination with 0.25–1.0% nonphytotoxic crop oil. PHI: 0 days.
Ecozin plus 1.2% ME	Azadirachtin	-	15-30 oz/A	OMRI listed for organic production. Spray when pests first appear. Repeat application in 7-10 days. Buffer spray solution to pH of 5.5-6.5. PHI: 0 days.
Evergreen Crop Protection EC60-6	Pyrethrins	3A	2-16 fl oz/A	Begin applications when insects first appear. Adjust spray pH to 5.5-7.0 to retain effectiveness of pyrethrins. PHI: 0 days. Do not harvest until spray has dried.
PyGanic Crop Protection EC 1.4 II	Pyrethrins	3A	16 fl oz/A	Broad sprectrum insecticide: e.g. leafhoppers, aphids, mites. Spraying should begin when the insects first appear. It is recommended that the final spray mix be buffered to a pH of 5.5-7.0 to retain effectiveness of pyrethrins. PHI: 0 days.
Tersus	Pyrethrins	3A	4.5-17 fl oz/A	Begin applications when insects first appear. Adjust spray pH to 5.5-7.0 to retain effectiveness of pyrethrins. PHI: 0 days.

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Damson-Hop Aphid

Phodrodon humuli (Schrank)


Figure 10: Wingless hop aphid

Damson-hop aphids are small (1/20 to 1/10 inch), pear-shaped, soft-bodied and range from pale white (nymphs) to yellow - light green (adults) in color. They occur in wingless (Figure 10 and 11) and winged forms, winged (female) adults are darker green to brown with black markings. Aphids have piercing-sucking mouthparts, which are used to suck the phloem, water and the nutrients from the vascular tissue of hop leaves and cones. These insects are typically found on the underside of the leaves. Aphids which feed on developing cones cause the most economic damage because the cones turn limp and brown. Aphids overwinter on nearby species of *Prunus* (stone fruits) as eggs and winged aphids can migrate to the hop yards in early May.

Symptoms


Figure 11: Wingless hop aphid

- Leaves can curl and wilt leading to defoliation because of the feeding.
- Feeding on cones causes browning and wilting.
- Leaves and cones stick together from a sugary excretion, called “Honeydew”.
- Honeydew supports the black sooty mold fungi.
- Honeydew can interfere with leaf photosynthesis.
- Sooty mold on leaves reduces plant productivity and the black discoloration reduces the quality of the cones and hop marketability.
- Hop aphids can transmit plant viruses (Carla viruses, Hop mosaic virus).

Management

Scout weekly. There is no hard economic threshold in the Northeast, but control is often recommended at thresholds of 5 – 10 aphids per leaf before flowering in the Pacific Northwest. Aphids are not tolerated at all after flower formation. Aphids prefer mild temperatures and can disappear during the hot and dry conditions often experienced during July and August without insecticide treatments. Application of excessive nitrogen can increase aphid populations. There are many naturally occurring enemies to control this pest. These include lady beetles, lacewings, and parasitic wasps. The insecticides Purespray Green, Purespray 10E, PyGanic Crop Protection EC 1.4 II, Azera, which are listed above, can be used to control aphids, but there are many other effective insecticides as well as insecticidal soaps and horticultural oils.