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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 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 were grown widely 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 followed by Vermont and Massachusetts (IHGC, 2017). 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 that do not cause damage in the Pacific Northwest. Because of typical wet and cool spring conditions, DM is the most severe disease in the Northeast. The pathogen can infect all plant parts and cause up to 100% yield losses. Powdery mildew (PM) was reported at two farms in Connecticut in 2018 and has been documented in New York. Although it is still uncommon in the state, active scouting for this disease should be performed. 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 shown 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 knowledge of life cycles and the ability to identify diseases and pests. Monitoring the hop yard weekly and keeping track of the weather and forecast help growers act in a timely manner to 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. However, it is important to be careful that trap crops are not mown or harvested while hops are growing nearby as pests will move from the disturbed trap crop to the hops. 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 and debris 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 certain times. Minimized application of chemicals should be targeted. Early and correct identification of pests and pathogens are necessary to select effective materials and control problems before they become difficult to manage. The combination of all these practices is the key to producing high quality hops in CT.

Additional Hop Growing Resources

Several sources about growing 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.

Pesticide Management

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 be unavoidable to achieve high quality hops and good yields. Below are lists of selected pesticides from 2019, which are currently registered in Connecticut. The lists are not exhaustive and the efficacies of the individual products have not necessarily 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 give examples of fungicides, insecticides, and herbicides which may be used to control pathogens and insects. Check the accuracy of the presented information, as they 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 Department of Agriculture. 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 growth stage, plant resistance, disease infestation in the previous year, weather conditions and forecast. Hence, early, mid, late, and post-harvest treatments have to be considered. For example, post-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 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, insecticide, and herbicide classes, thereby varying the modes of action, to prevent resistance development. Follow label directions for rotating modes of action to delay the development of resistance. Calculation of spray rates for hops is volume or weight per treated acre, which in hops would be the area of the in-row strips only, excluding the unsprayed area between hop rows (the drive rows).

Encouraging beneficial insects

There are many natural predators to the insect pests that feed on hops, such as lady beetles, lacewings, minute pirate bug, big-eye bug, damsel bugs predatory mites, syrphid fly, parasitoid wasps, and spiders to name a few. The use of broad-spectrum insecticides can reduce the populations of these beneficial insects. Newer, site-specific chemistries are often less harmful to non-target insects. The Field Guide for Integrated Pest Management in Hops, 3rd edition provides a table created by the International Organization for Biological Control that shows the impact of different pesticides on beneficial insects of hops. The guide can be accessed at https://www.usahops.org/resources/field-guide.html

Downy Mildew
Pseudoperonospora humuli

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). DM 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 during 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 1.5 hours. However, leaf infection can also appear at temperatures as low as 41°F with wetness that persists longer than 24 hours. Sporangia, 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 and signs

- 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).

Figure 1: Angular leaf lesions

- "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 2).
  2. Secondary spikes are diseased sidearms (Figure 2).

Figure 2: Spike - stunted shoot with short internodes

Figure 3: Sporulation of the downy mildew pathogen on the underside of leaves

- Infected inflorescences become dark brown, shriveled and dried up.
- Whole or parts of the cones become brown, hardened, and will stop developing.

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 plants, crowning (underground pruning of systemically infected buds), removal of heavily diseased plants early in the spring, elimination of primary basal spikes, mechanically or chemically stripping infected leaves, and weeding. A timely and aggressive preventive fungicide program in the early season and after favorable weather conditions for DM 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 therefore outbreak in the next spring. In additional to the chemicals listed in Table 1, the neem oil, Trilogy, has efficacy against downy mildew as well as insects (Table 3).

Powdery Mildew

Podosphaera macularis

Powdery mildew of hops (PM) is only pathogenic on hop plants (*Humulus* spp.) and hops cannot become infected with powdery mildews infecting other plant species. The hop PM 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. This pathogen was detected in Connecticut in 2017 and 2018 and therefore growers should actively scout for this disease. Only one mating type was found, therefore, at this time there is no evidence for both mating types meaning the fungus cannot produce over-wintering spores that can survive in the soil. The ways this pathogen can currently spread would be through movement of spores within a growing season or on infected root stock.

Symptoms and signs

- Characteristic circular, powdery, white colonies on buds, stems, leaves, and cones (Figure 4A).
- Eventual occurrence of blisters before sporulation.
- "Flag shoot" – shoot, which emerges from infected buds, stunted with distorted leaves, white sporulation on the stem (Figure 4C).
- Reddish-brown discolored and distorted cones with reduced size (Figure 4B).
- Cone browning after kiln drying.

Figure 4: A) Hop leaves with severe powdery mildew caused by *Podosphaera macularis*. B) Cones with reddish-brown discoloration. C) 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.

Management

The most effective control methods of PM are preventive measures including cultural and chemical practices. It is very important to plant healthy disease-free 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 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, Confine Extra, OxiPhos, Foshite, Pristine, Sonata, Serenade Max, REglia, Pxidate, Carn-O-Nator, Milstop, and Prev-Am Ultra 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, Purespray, and the insecticide Microfine Sulfur, control powdery mildew (Table 3). The neem oil, Trilogy, has efficacy against powdery mildew and downy mildew as well as insects (Table 3). Oils may cause damage to hop flowers and cones, especially during hot weather, so may best be utilized early in the season. A critical period for control of powdery mildew using one or two fungicide applications is between mid-July to mid-August. Scouting weekly and keeping track of the weather conditions and forecast are essential for managing PM.

Diaporthe Leaf Spot

Diaporthe humulicola

A new disease was observed on hops in Windsor and Hamden, CT in 2018 that is similar to the description of Phoma wilt on hops, but was not caused by the same pathogen. The disease observed in Connecticut is caused by a fungus new to science that we described as a new species, *Diaporthe humulicola*. The disease affected all hop cultivars growing at these locations and was observed on leaves and cones. Yields were affected at both locations in 2018, and 2019. Additional research will be conducted to determine how severely this new pathogen affects hops in Connecticut, its disease cycle, ideal conditions for its growth, and best management practices.

Symptoms and signs

- Brown lesion on upper leaf surface that is restricted to within the main leaf veins. Often grayish-white rings of fungal mycelia can be seen (Figure 5A and 5B).
- Yellowing of hop cones with areas of brown discoloration that progresses to include the entire hop cone, similar to other diseases such as powdery mildew and Alternaria (Figure 5b).

Figure 5: A and B) Hop leaves with lesions characteristic of *Diaporthe* B) Cone yellow in appearance with areas of reddish-brown discoloration.

Management

Since this is a new disease on hops in this region, research needs to be done for best management strategies. Management practices that generally reduce fungal growth, such as reducing leaf wetness, stripping lower leaves to increase air flow, and applying fungicides, may help reduce disease severity of this disease. Research is on-going at the CT Agricultural Experiment Station to determine the best management practices for this disease, but Pageant fungicide inhibited the pathogen in laboratory tests.

If you suspect Phomopsis-like wilt on your hops, please contact the CAES so we may assess your diseased plants to increase our understanding of this fungal disease and how to management it on hops in Connecticut

Two-Spotted Spider Mite

Tetranychus urticae Koch

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 results 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, 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 (Figures 6 and 7). 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.

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

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 adults/leaf in June and 5-10 mites/leaf by mid-July taking leaf samples from 10-30 plants. Above that level, spraying is often necessary. Warning: broad spectrum insecticides (e.g. pyrethroid, organophosphate, carbamate, and neonicotinoid insecticides) have a negative impact on beneficial insects and therefore, the application of these materials may increase the TSSM populations. Several miticides are available which do not harm beneficial insects. To avoid resistance, use miticides with different active ingredients. In addition to the insecticides listed in Table 3, the fungicide, Prev-AM Ultra also has efficacy against TSSM (Table 1). Stripping of lower leaves of the hop plants, minimizing dusts, and providing habitat for natural enemies helps to keep the population under control. Be careful spraying oils during hot, dry conditions or when hops are flowering as the oils can damage the plants.

Figure 6: Female two-spotted spider mite

Figure 7: Male (left), female (right) two-spotted spider mite and cast skin

Potato Leafhopper

Empoasca fabae

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 the storm season in spring. Adults are bright green with wings and only 1/8-inch (3 mm) long (Figure 8A). They are able to move quickly forward, backward, and sideways, leaping and flying. The nymphs are smaller than adults, wingless and pale green (Figure 8B). Potato leafhoppers start appearing in hop yards in May and their occurrence grows 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 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 to get nutrients. The first sign is yellowing at the leaf tip followed by necrosis and curling (Figures 9 and 10).

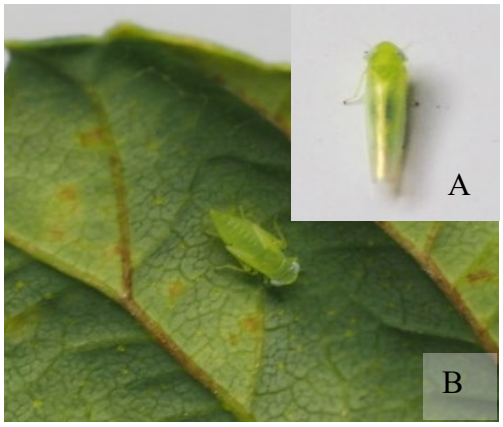

Figure 8: (A) Adult and (B) nymph

Symptoms

- "Hopper burn" – necrosis of the leaf and the outer edges and tip of the leaf turn brown and form a distinctive "V" (Figure 9).
- Yellowing of the leaf at the tip followed by necrosis and leaf curling.
- Shortening of internodes, stunted growth, fewer flowers and cones.

Figure 9: Hopper burn

Management

Figure 10: Symptoms on leaves

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. Our current understanding would suggest that the first observation /presence of leafhoppers in a hopyard should initiate management as plants with hopper burn and stunting do not recover after leafhoppers have been controlled.

Broad spectrum insecticides such as acephate, bifenthrin, and chlorpyrifos are registered in Connecticut for use against leafhoppers. In addition to the insecticides listed in Table 4, azadirachtin, pyrethrins, the neem oil Trilogy, and M-Pede used on TSSM also work on PLH (Table 3) 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.

Damson-Hop Aphid
Phodrodon humuli (Schrank)
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 11 A and B) 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 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

- 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 can interfere with leaf photosynthesis.
- Honeydew supports the black sooty mold fungi. 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).

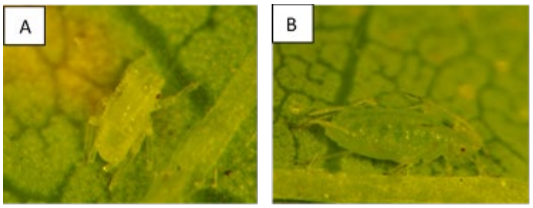

Figure 11 A and B: Wingless hop aphid

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 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, and other listed in Tables 3 and 4, can be used to control aphids, but there are many other insecticides as well as insecticidal soaps and horticultural oils. Other examples of insecticdes that can control aphids on hops are imidacloprid such as Admire Pro, Couraze 2F, Macho 2.0 FL, Malice 2F, Montana 4F, Nuprid 4F, Provado 1.6F and the thiamethoxam Platinum.

Minor caterpillar pests
Although not considered major pests of hops, many lepidopteran, or caterpillar, larvae will feed on hop leaves, reducing overall plant health. Within Connecticut, some of the most commonly reported pests are Fall webworm, saddleback caterpillars, bagworm, and loopers.

Fall Webworm *Hyphantria cunea* (Drury)
Fall webworms are a very visible but minor pest on hops that cause little damage, although high populations were reported in 2018. The larval stage of this caterpillar can cause damage to hop plants. The black-headed form is most common in Connecticut and is greenish-yellow in color with two rows of black spots, a black head, and a covering of white hairs (Figure 12). The larvae live and feed within a white web formed to encompass an entire hop leaf (Figure 13). Fall webworms are common pests of shade trees and shrubs, affecting over 90 different species, and they are ubiquitous and native to North America. Rarely do they cause enough damage to defoliate a whole plant. The webs are most often seen in the fall, but can appear as early as July.

Symptoms and signs

- Chewing marks on the leaves
- Webs filled with larvae


Figure 12: Black-headed Fall webworm larvae Photo courtesy of M. Salvas

Figure 13: Webs surrounding hop leaves of Fall Webworm

Photo courtesy of Michelle Salvas

Saddleback Caterpillar

Acharia stimulea (Clemens)

Saddleback caterpillars are common in southern New England and feed on many different plants, including fruits, cabbage, corn, grass, and ornamental species. Young caterpillars may not have developed the distinct dark green saddle (Figure 14), but can be identified by the spikes on their anterior and posterior (Figure 15). These spikes and those surrounding their cocoons are stinging spines that contain irritants, so be cautious when handling either caterpillars or cocoons to avoid being stung.

Symptoms

- Skeletonized chewing of leaves for young caterpillars, chewing marks for older caterpillars
- young caterpillars, chewing marks

Figure 14: Saddleback caterpillar Photo courtesy of Rose Hiskes

Bagworm

Thyridopteryx ephemeraeformis (Haworth)

Bagworms are usually found on coniferous hosts and some deciduous trees, but recently have been spotted on hop leaves. The larvae feed on foliage and while they do so they form "bags" around themselves using a combination of the silk they produce and plant material from their host (Figure 16). As the larvae continue to grow, they expand their bag, making it the most conspicuous sign of an infestation. Mature males will leave the bag to find females, who remain within the bag to mate and lay eggs. The eggs will overwinter in the bags and hatch the following spring.

Symptoms

- "Bag" of silken thread mixed with plant material hanging securely from hop leaves.

Figure 16: Bagworm "bag" formed on a hop leaf

Looper moths

Subfamily Plusiinae and Hypeninae

Caterpillars in the subfamilies Plusiinae and Hypeninae are sometimes found feeding on the foliage of hop plants in the Northeast. Members of these two groups are green and elongate (Figures 17 and 18). The hop looper, also referred to as hop vine snout, (*Hypena humuli* Harris) was detected on hops in Vermont. This species is thin, with white stripes along its body and small black spots. It feeds on hops and nettles. The cabbage looper (*Trichoplusia ni* Hübner) is thicker, with smaller, white stripes along its body and small vestigial prolegs, whereas hop looper lacks a proleg on A3. The cabbage looper feeds on a wide variety of herbaceous plants, including cabbage, corn, tomatoes, and tobacco. Additional looper species look very similar to hop looper and

cabbage looper and feed on a wide variety of hosts, and may be detected feeding on hops.

Symptoms and signs

- Chewing marks on the leaves
- Small green larvae on underside of leaves

Figure 17: Cabbage looper feeding on hop leaf

Figure 18: Head of cabbage looper

Management of minor insect pests

Since they are minor pests and often do not infect large numbers of leaves within a hop yard, hand removal of larvae or hand pruning out leaves surrounded by the webs of fall webworm or the bags of bagworm may be control options. If populations are high enough, insecticides can be applied. The abamectin, azadirachtin, and pythrethins recommended for two spotted spider mites (Table 3) and potato leaf hopper (Table 4) will also provide control for lepidopteran larvae.

Spotted Lanternfly

Lycorma delicatula (White)

Spotted lanternfly is an invasive pest that was recently discovered in Pennsylvania in 2014. The nymph stage of this insect feeds on plant stems, and it has been noted that they can cause damage to hop plants. The adult stage feeds on woody plant tissues, and is mostly found on grapes, apples, stone fruits, tree of heaven, and willows. Although, no living spotted lanternflies have been found in Connecticut, there have been reports of dead insects and the potential of some infested nursey plants having been delivered to the state. Therefore, active scouting for these plants in hops is important to determine their presence in the state and to control populations before they reach damaging levels.

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Figure 19. Spotted Lanternfly egg mass, hatched egg mass, early nymph and late nymph stages. Photo courtesy of Park et al., 2009. Biological characteristics of *Lycorma delicatulata* and the control effects of some insecticides.

Egg masses are grayish with or without a grey mud-like coating (Figure 19A) and are found on wood and smooth surfaces, including tree trunks, vehicles, stone, and wooden structures such as hop poles. After they have hatched they appear like rows of seed-like structures about an inch long (Figure 19B). The early nymph stage is black with white spots, which develop into red patches at the late nymph stage (Figure 19C and D). Adults are approximately 1 inch long and a half inch wide with a black head and legs and yellow abdomen with broad black bands (Figure 20). The hind wings of the adult have patches of red with black spots and a large black and white band, whereas the forewings are grey with black spots and reticulated black outline in grey.

If you suspect you have Spotted Lanternfly in your hop yard, please bring specimens or send photographs to the Connecticut Agricultural Experiment Station for further evaluation. Information on submission, and more information on this pest, can be found at https://portal.ct.gov/CAES/Publications/Publications/Pest-Alerts

Figure 20. Adult Spotted Lanternfly. Photo courtesy of Park et al., 2009. Biological characteristics of *Lycorma delicatulata* and the control effects of some insecticides.

European Corn Borer

Ostrinia nubilalis (Hubner)

The European corn borer is a moth pest whose costly damage to hop bines first became evident in Connecticut in 2019, resulting in significant bine damage and cone loss. ECB is primarily a corn pest but has more than 200 plant hosts and is the most important insect pest in peppers. It is likely that 2019 had the first significant ECB incidence in hopyards due to weather-related delayed corn plantings, as was also the case for Michigan hop growers, whereby moths found hop leaves and bines to be a good alternative for their egg-laying and development. Adult ECB females are 1/2 - 5/8" long light-yellow moths (Figure 21, lower), with wavy brown markings on their wings. Males are slightly smaller and darker (Figure 21, upper). ECB has a four-stage life cycle: egg, larva/caterpillar, pupa and adult moth. The insects overwinter in the stems of last year's host plants.

The first moth flight begins in late May or early June and females lay eggs in ¼" wide clusters (Figure 22) that appear as over-lapping fish scales.

Figure 21. Adult European Corn Borer, male (upper) and female (lower). Photo credit: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org. 2003.

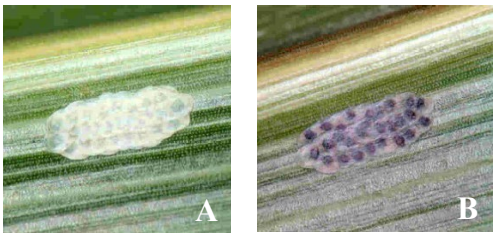

Figure 22. A. ECB, egg mass (¼" in diameter) on a corn leaf. B. ECB, egg mass at blackhead stage on a corn leaf. Photo credit: Jim Kalisch, University of Nebraska Lincoln. 1995.

Larvae are light colored with dark spots on each segment and a dark brown head capsule. Full grown larvae are 3/4 - 1" long (Figure 23C). Foliar feeding of early instar larvae produces minimal damage. However, larvae will then bore into bines (Figure 24), side arms, and leaf petioles, reducing water and nutrient translocation within the plant, and leading to wilted or dead bines, browning cones and reduced hop cone yield and quality. Additionally, fully grown (fifth instar) larvae overwinter in the bines and emerge the following spring ready to pupate (Figure 25).

Symptoms and signs

- Tiny egg masses (¼" wide) on underside of leaves (Figure 22).
- Bore holes in bines (Figure 24).

Figure 23. A. ECB, newly hatched first instar larvae. B. ECB, first instar larvae, enlarged. C. ECB, larva. Photo credit: A. J.C. French Sr., Universities: Auburn, GA, Clemson and U of MO, Bugwood.org. 2011., B. J. Kalisch, University of Nebraska Lincoln. 1995., C. Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org. 2002.

Management

Based on the lack of significant incidence in hops prior to 2019, corn and other plants are likely preferred hosts compared to hop. However, when host plant seeding, transplanting or emergence is delayed, ECB moths may lay eggs on hop plants as in 2019. In addition, hop bines from the previous year should be buried, burned or managed so that ECB do not overwinter and survive.

Figure 24. 2019 Field photo of ECB damage.

Figure 25. 2019 Field photo of ECB larva within a bine, discovered during harvest.

Scout early in the season, after first moth flight, and watch for small larvae and their bore holes. Refer to UConn's pest alert (http://ipm.uconn.edu/pa_vegetable/pestMessages.php), as there are early-season updates on ECB moth flights. Once larvae are inside the bines,

contact-pesticides are ineffective, since the stem provides a physical protective barrier. Therefore, any pesticide applications should target first generation moths to prevent egg laying or kill younger larvae. Insecticides containing Bt (*Bacillus thuringiensis*) may also be used before larvae penetrate plants. An early planting of Bt-corn may act as a trap plant, especially for the second generation as there are often 2 generations per year in southern New England. Early monitoring and translaminar systemic insecticide application of spinosads (Entrust) may impede ECB early, before heavy vascular tissue feeding by larvae affect cone production. A foliar application of chlorantraniliprole (Coragen) may also be used. In both cases, control is best attempted before larvae bore into bines.

Weed Management

Decreasing weed pressure on hops improves cone yield and plant vigor. It also can decrease disease pressure, especially for downy and powdery mildew, by increasing air flow near the base of the bines and reducing the period of time that leaves may remain wet after rain or dew. Generally, hop growers remove weed pressure in-strip and leave a permanent cover crop between hop rows (the drive rows) to decrease soil erosion and water loss and also to attract beneficial insects to the hop plantings. Additionally, having a cover crop between hop rows decreases dust, which may help to reduce two-spotted spider mite populations. Management of weeds in-row is usually achieved through mechanical and chemical removal. In addition to removal of ground weeds, stripping leaves and side arms from the bottom 3 feet of hop bines (once the bines reach 6 feet in height) can decrease disease pressure for downy mildew and reduce two-spotted spider mite populations.

Mechanical weed removal can be accomplished by mechanical cultivation, but this can harm crowns and lead to loss of soil quality. If tilling or disking is selected for weed management, it should be done at shallow depths to avoid disturbing the hop crowns and it is best done in the fall since any summer annual weed seeds that germinate will be killed by winter temperatures. Also tilling and disking during the summer can increase dust on hop foliage which may increase damage by two-spotted spider mites. Additional methods of mechanical weed removal include hand pulling and hoeing, and steam treatments. Machines exist for mechanical stripping of the lower three feet of foliage and side arms on bines, or this can be accomplished by hand removal. Although there is interest in using animals, specifically sheep, to graze the lower 3 feet, please check with our local FDA Food Safety Modernization Act (FSMA) representative for guidance on this practice with hops.

Chemical weed removal is possible to prepare a site for hop planting and to remove weeds in established hop yards (Table 5). Herbicides need to be managed for resistance in the same manner as fungicides and insecticides, so be sure to follow label recommendations for maximum rates, tank-mixing, and rotations. Be sure to follow spray recommendations to avoid damaging the hop plant. Some of the herbicides listed, such as flumioxazin, pelargonic acid, and carfentrazone, can be used to strip the lower 3 feet of bines (Table 5).

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

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval (days)	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Champ Formula 2 Flowable	Copper hydroxide	M1	1.33 p/A Max 7.3 p/A/year	10	48	14		Apply as a fungicide crown treatment after pruning, before training. After training, apply foliar every 10 d.	
Champ DP Dry Prill	Copper hydroxide	M1	1.33 lb/A Max 7.07 lb/A/year						
ChampION++	Copper hydroxide	M1	0.75-1.5 lbs/A Max 8.83 lb/A/year						
Previsto	Copper hydroxide	M1	0.1-7 qt/A Max 35 qt/A/year						
Cuproxat FL	Copper sulfate	M1	1.25-2.25 p/A Max 13.1 p/A/year						
Kocide 2000 / 3000	Copper 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						
Cueva Fungicide Concentrate	Copper octanoate	M1	49 fl oz/1000 sq ft	10	4	0	PM	For best control, begin treatment 2 weeks before disease normally appears or when the weather forecasts predict a long period of wet weather.	Y
Ridomil Gold SL	Mefenoxam	4	0.50 p/A		48	45		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” 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.	

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Ranman, Ranman 400SC	Cyazofamid	21	2.1-2.75 fl oz/A Max 16.5 fl oz/A/year	10-14	12	3		Apply when warning systems forecast disease infection periods or when weather conditions are favorable for disease development. **No more than 6 applications/crop or 3 consecutive applications.**	
Dupont Curzate 60DF	Cymoxamil	27	3.2 oz/A Max 12.8 oz/A/year	10-14	12	7		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.**	
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	14-21	4	0	PM	Harvest when dry.	
Confine Extra	Mono and di-potassium salts of phosphorus acid	33	Foliar: 1-3 qt in min. 20 gal water/A Aerial: 1-3 qt in min. 10 gal. water/A	14-21	4	0	PM		
OxiPhos	Mono and di-potassium salts of phosphorus acid	33	5 qt/A	7-14	4	0	PM	Foliar spray	
Phostrol	Mono and di-potassium salts of phosphorus acid	33	2.5 p/A		4	0		Apply when shoots are 6-12” long, post-training when bines are 6’ high, 21 days post last application, and during bloom.	
Reliant	Mono and di-potassium salts of phosphorus acid	33	1-3 qts in 30-40 gal water/A						
Fosphite	Mono and di-potassium salts of phosphorus acid	33	Foliar: 1-3 qt/A; Aerial: 1-3 qt/A	14-21	4	0	PM	Do not apply foliarly to plant treated with copper based compounds at less than 20 day intervals.	

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval (days)	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Aliette	Fosetyl-Al	33	2.5 lb/A Max 10 lb/A		12	24		Apply when shoots are 6-12" long, post-training when bines are 6' high, 21 days post last application, and during bloom.	
Linebacker WDG	Fosetyl-Al	33	2.5 lb/A Max 10 lb/A		12	24		Use when conditions are favorable for disease development. Apply when shoots are 6-12" long, post-training when bines are 6' high, 21 days post last application, and during bloom.	
Forum	Dimethomorph	40	6 fl oz/A Max 18 fl oz/A/year		12	7		Use as a preventive application, 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 tank mixing with another fungicide. If Forum has been applied as the only DM fungicide, the next sequential application must be another fungicide with a different mode of action (non-Group 40) for at least 1 application. If Forum has been applied as a mix with another DM fungicide, a second sequential application of Forum (alone or as a mix) is permitted before rotating to a non-Group 40 fungicide for at least 1 application. **No more than 3 applications per year.**	
Revus	Mandipropamid	40	8.0 fl oz/A Max 24 fl oz/A/year	7-10	4	7		Begin applications prior to disease. **Make no more than 2 consecutive applications** before switching to an effective non-Group 40 fungicide. No more than 50% of the sprays should be Revus. Revus may be tank mixed with another fungicide labeled for DM 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.**	

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Pristine Fungicide	Boscalid + pyraclostrobin	7+11	14-28 oz/A Max 84 oz/A/year	10-21	12	14	PM	Ground application. Begin applications prior to disease development. **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	
Dupont Tanos Fungicide	Famoxadone + cymoxanil	11+27	8 oz/A Max 48 oz/A/year	6-8	12	7		Applications should begin prior to disease development. 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.**	
Zampro	Ametoctradin + dimethomorph	45 + 40	11-14 fl oz/A Max 42 fl oz/A/year	10	12	7		Begin applications before disease development. **No more than 3 applications per year and 2 sequential applications before** alternating to a labeled fungicide with a different mode of action.	
Sonata	Bacillus pumilus strain QST 2808	44	2-4 qt/A	7-10	4	0	PM	Begin applications when conditions favorable for disease development.	Y
Serenade Max	*Bacillus subtilis*	44	2-4 lbs/100 gal spray	7	4	0	PM	Use higher rates when disease pressure is moderate to high. Begin when environmental conditions conducive to disease. Emergence to training: Apply minimum volume of 20 gal per acre Training to wire: Apply minimum volume of 50 gal per acre Wire touch through harvest Apply minimum volume of 100 gallons per acre.	Y
Serenade ASO			1-4 qt/A when tank-mixed or 2-4 qt/A alone					Apply adequate spray volume to get complete spray coverage.	

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Regalia	*Reynoutria sachalinenssi* extract	P5	1-4 qt/A when tank-mixed or 2-4 qt/A alone	7	4	0	PM	Begin application at disease development or during favorable conditions. For DM control tank mix with another fungicide labelled for DM.	Y
Oxidate 2.0, ZeroTol 2.0	Hydrogen dioxide, peroxyacetic acid		Dilution rates: Preventative 1:200-1:400, Curative 1:100	Preventative 5-10 Curative 3-5	1	0	PM	Use curative rate at first sign/symptom of infection or when conditions favor rapid disease development	
Carb-O-Nator	Potassium bicarbonate		2.5-5 lbs/100 gal water, 20 gal/A	10-14	4	0	PM	Start application at first sign of disease	
Milstop/Agricure	Potassium bicarbonate		2-5 lbs/A	7-14	4	0	PM	Apply when conditions favor disease or symptoms are present.	Y
Prev-AM Ultra	Sodium borate		50 fl oz per gal	7-10	24	0	PM, TSSM	Do not use on hops within 14 days of treating with sulfur, ground applications only	

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Table 2: List of examples for fungicides to control powdery mildew registered for hops in CT

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval (days)	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Quintec	Quinoxyfen	13	Max 8.2 fl oz/A 33 fl oz/A/year	14	12	21		Do not make more than 4 applications per year, no more than 2 consecutive without spraying fungicide with different mode of action, spray alternate product within 14 days of applying Quintec	
Orius 3.6 F	Tebuconazole	3	4-8 fl oz/ A Max 32 fl oz/A/season	10-14	12	14		Best when sprayed with a surfactant	
Tebuzole 3.6 F	Tebuconazole	3	4-8 fl oz/acre Max 32 fl oz per acre per season	10-14	12	14		Protective spray, needs to be on leaves for 2-4 hours before foliage becomes wet from rain or irrigation	
Trionic 4SC	Triflumizole	3	12 fl oz/A	14 (once)	12	7		Foliar spray, Apply before or just at signs of infection. A single repeat application can be made no less than 14 days after first application.	
ProCure 480 SC	Triflumizole	3	12 fl oz/acre Max 24 fl oz/acre/year	14 (once)	12	7		Begin application prior or at first signs of infection, One repeat application 14 days after initial application if needed	
Luna Experience	Fluopyram and tebuconazole	7+3	8-17 fl oz/acre	14	12	14		Apply at critical timings for disease control referring to university or extension guidelines	
Luna Sensation			3-7.6 fl oz/A						
Flint	Trifloxystrobin	11	1-4 fl oz/A	10-14	12	14		For best results apply preventatively. Alternate with a sterol inhibitor fungicide for use against hop powdery mildew. No more than 3 sequential applications of flint and no more than 4 total applications per year.	

Trade name	Common name/ Active ingredient	FRAC group	Rate	Application Interval (days)	REI (hours	PHI (days)	Additional pests	Additional information	OMRI
Vivando	Metrafenone	U8	10.3-15.4 fl oz/acre, Max 30.8 fl oz/acre/year	7-14 (once)	12 h	3		Restricted to 2 applications per year, apply prior to disease development, apply second time on 7-14 day interval, do not apply by air, it has no curative properties, should be tank mixed with a curative fungicide, do not mix with horticultural oils,	
Double Nickel 55 and Double Nickle LC	*Bacillus amyloliquefaciens* strain D747	44			4	0		Mix 0.5-1 lb CX-9030 per 100 gallons of water and apply in minimum of 20 gallons per acre from emergence to training, 50 gallons per acre from training to wire, and 100 gallons per acre from wire touch through harvest LC: Mix 6 to10 fluid ounces CX-9032 per 100 gallons of water and apply in minimum of 20 gallons per acre from emergence to training, 50 gallons per acre from training to wire, and 100 gallons per acre from wire touch through harvest.	Y
Kaligreen	Potassium bicarbonate		2.5-3 lbs per acre		4	1		Do not mix with highly acidic products. Begin application at first sign of disease.	Y

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Table 3: List of examples for insecticides to control two-spotted spider mites registered for hops in CT

Trade name	Common name/ Active ingredient	IRAC group	Rate	Application interval (days)	REI (hours)	PHI (days)	Additional insects	Application Information	OMRI
Malathion 57%, Malathion 5EC	Malathion	1 B	1 pt/A Max 0.63 lbs active ingredient per acre per year	7	12	10	AP	No more than 3 applications per year	
Fanfare ES, Fanfare 2EC	Bifenthrin	3	0.10lb active ingredient/A or 6.4 fl oz./A Max 19.2 fl oz/A/season	21	12	14	AP *, LO *	Ground application: Apply in water minimum 100-150 gal per acre early season or 200-250 gal per acre late season. Air application: Apply in water minimum 10 gal per acre. Make directed spray from ground to 3 ft. up on vine. Use of ultra-low volume application on hops is prohibited.	
Baythroid XL*	Beta-cyfluthrin	3	3.2 fl oz/A Max 16 fl/oz//A per year	14	12	7	AP , LO	Maximum rate of application lbs. active ingredient/acre for products containing cyfluthrin: Beta-cyfluthrin alone: 0.125 cyfluthrin alone: 0.25 Combined: 0.25	
Abacus, Abacus V, Abamex, 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	21	12	28	OI	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, 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.	

Trade name	Common name/ Active ingredient	IRAC group	Rate	Application interval (days)	REI (hours)	PHI (days)	Additional Application Information		OMRI
AzaGuard	Azadirachtin	-	10-16 fl oz/A	7-10	4	0	PLH	Buffer spray solution to pH of 5.5-6.5. Use in combination with 0.25–1.0% nonphytotoxic crop oil.	Y
Ecozin plus 1.2% ME	Azadirachtin	-	8-15 fl oz per acre	7-10	4	0	PLH	Spray when pests first appear or at egg hatch. Buffer spray solution to pH of 5.5-6.5.	Y
Neem Oil 70%, Trilogy	Clarified Hydrophobic Extract of Neem Oil	-	1-2 gal/A 0.5-2% in 25-100 gal min 5 gal	7-21	4	0	PM, DM, AP, OI	Kills eggs, larvae, and adult insects. Use the 7-day schedule until the pest population is reduced. Then use a 14-day interval for control.	Y
Savey 50 DF	Hexythiazox	10A	4-6 oz/A	NA	12	NA		Only one application per season. Apply up to burr formation.	
Zeal SC Miticide	Etoxazole	10B	6-8 fl oz/A	NA	12	7		Zeal SC Miticide is predominately an ovicide/larvicide. Apply Zeal SC Miticide at or prior to threshold for your area. 1 application/season..	
Kanemite 15SC	Acequinocyl	20B	31 fl/ oz/A	21	12	7		Only 2 applications p year. Do not use less than 100 gallons of water per acre.	
Portal XLO	Fenpyroximate	21A	2-3 pts/A	NA	12	15		For best results, apply before population exceeds 5 mites per leaf. See label for phytotoxicity information. Only one application per growing season.	
Envidor 2SC	Spirodiclofen	23	18-24.7 fl oz/A	NA	12	14		Only one application per season	
Movento	Spirotetramat	23	5-6 fl oz/A Max 12.5 fl oz/A/year	14	24	7	AP		
Glacial Spray Fluid	Mineral oil	-	1-2 gal/A	10-14	4		PM	Discontinue sprays at burr development. Oils not compatible with sulfur.	Y
JMS Stylet Oil, Organic JMS Stylet Oil	Mineral oil	-	1-2 gal/A						

Trade name	Common name/ Active ingredient	IRAC group	Rate	Application interval (days)	REI (hours)	PHI (days)	Additional Application Information		OMRI
Omni Supreme Spray	Mineral oil	-	1-2 gal/A						
Purespray Green, Purespray 10E **Damoil, Tritek**	Mineral oil	-	1-2 gal/A	10-14	4	Burr development	AP, PM, OI	Discontinue sprays at burr development.	Y
PyGanic Crop Protection EC 1.4 II	Pyrethrins	3A	16 fl oz/A	As needed	Until dry	0	PLH, AP, OI	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. Avoid spraying in wet conditions. Do not apply more than 10 times per season.	Y
Azera Insecticide	Pyrethrins, azadirachtin	3A	1-3.5 pt/A	1-3	12	0	AP, PLH, OI	Kills larval, pupae, and adult stages of listed insects. Adjust spray pH to 5.5-7.0 to retain effectiveness of pyrethrins. Only reapply after 1 day when under extreme pressure. No more than 10 applications per season.	Y
Evergreen Crop Protection EC60-6	Pyrethrins	3A	2-16 fl oz/A	1-3	12	0*			
Tersus	Pyrethrins	3A	4.5-17 fl oz/A	1-3	12	0			
Skyraider*,	Bifentrhin + imidaclopri d	3 + 4A	6.4 fl oz/A Max rate 19.2 fl oz/A/year	21	12	28	LO*, OI*	Make applications when pets appear. Do not apply more han 0.3 lb ai per acre of imidaclropid or 0.3 lb/A per year of bifentrhin.	
Brigadier HPG	Bifentrhin + imidaclopri d	3 + 4A	12.8 fl oz/A Max 38.4 fl oz/A/ year	21		28	LO*, OI*	Do not apply more than 0.3 lb ai per acre of imidaclropid or 0.3 lb/A per year of bifentrhin.	
Microfine Sulfur, Yellow Jacket wettable sulfur	Sulfur	-	33-44 lb/A	5-10	24			Begin when infestation first. Do not use sulfur in combination with oil or within 21-60 days of an oil spray.	Y
Grandevo and Grandevo WDG	*Chromobacterium*		2-3 lbs/A	4-10	4	0	AP*,	Target recently hatched larvae and nymphs for optimal results. Will affect honey bees 4-6 days after spraying so	Y

Trade name	Common name/ Active ingredient	IRAC group	Rate	Application interval (days)	REI (hours)	PHI (days)	Additional Application Information	OMRI
	subtsuggae						LO *	time do not interfere with pollination.	
M-Pede,	Potassium salts of fatty acids		1-2% v/v solution Or 1% v/v when tank mixed	7	12	0	AP, PLH, OI	Initiate as soon as pest is observed. Do not make more than 3 sequential applications.	Y
Neudorff's insecticidal soap concentrate	Potassium salts of fatty acids		75-200 gal/A	7-14	12	12 hrs	AP, PLH, OI	Initiate as soon as pest is observed.	Y

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Table 4: List of examples for insecticides to control potato leafhoppers registered for hops in CT

Trade name	Common name/ Active ingredient	IRAC group	Rate	Application interval (days)	REI (hours)	PHI (days)	Additional insects	Application Information	OMRI
Molt-X	Azadirachtin	UN	10 oz/A	7-10	4	0	AP*, OI*	The optimum pH range is 5.5-6.5. Recommended to make 2-3 applications. Use in combination with 0.25-1.0% non-phytotoxic crop oil and be sure to cover undersides of leaves	Y
Superneem4.5 -B	Azadirachtin	UN	7-16 floz/A Max rate 20 grams active ingredient per A		4	0	AP*, OI*	Foliar application that is effective against larvae or nymphs.	
Advise Four, Couraze 2F, Couraze 4F, Imidacloprid 4F, Macho 2.0 Fl, Macho 4.0, Malice, Montana 4F, Nuprid 4F, Provada 1.6F	Imidacloprid	4A	See label for specific formulation being used	21	12	28	AP	**Registered for aphids on hops, but if spraying for aphids may have effect on PLH** See spray label for information on soil treatment for aphids.	
Platinum	Thiamethoxam	4A	8 fl oz/A	NA	12	65	AP	**Registered for aphids on hops, but if spraying for aphids may have effect on PLH** Max one application per season	

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Table 5: List of examples for herbicides to control weeds registered for hops in CT

Trade name	Common name/ Active ingredient	HRAC group,	Rate	Application Interval (days)	REI (hours)	PHI (days)	Emergence	Weeds controlled	Application Timing	OMRI
Trifluralin 4EC, Treflan 4D, Treflan HFP, Trifluralin 10G, Triflurex HFP, Trust	trifluralin	K1, 3	Depends on soil texture, see label	NA-Only single applicatio n per year	12	NA	Pre	AG, BL	Apply and incorporate during established crop dormancy.	
Chateau WDG, Valor, Tuscany, Panther	Flumioxazin	E, 14	6 oz/A	NA-Only single applicatio n per year	12	30	Pre	AG, BL	For pre-emergent weed control apply to dormant hops in January through March. For sucker control (bine stripping), apply when hops have reached a minimum of 6 ft in height. Do not use with an adjuvant.	
Alion	Indaziflam	29	Depends on soil texture, see label	Spring and Fall	12	NA	Pre	AG, BL	Do not apply more than 2 applications per year. Can be made as spring dormant application (bud stage up to 2" in height) and fall dormant application after harvest. Do not use on hops grown in sand or with 20% or more gravel content.	
Prowl H2O	Pendimethali n	K1, 3	1.1-4.2 qt/A Max 4.2qt/A/year	30	24	90	Pre	AG, BL	Apply by ground only. Do not apply to hop bines, leaves, or cones.	
Solicam DF	Norflurazon	F1, 12	Depends on soil texture, see label	See label	12	60	Pre	AG, BL	Apply by ground. Needs to be watered in so if no rainfall occurs within 4 weeks of application use irrigation.	
Prizefighter	Ammonium nonanoate	M	Based on target weed, see label		4		Pre	BL, AG, PG	Do not apply within 2 hours of irrigation or rainfall before or after spray. Also has activity against some insects.	Y

Trade name	Common name/ Active ingredient	HRAC group, WSSA group	Rate	Application Interval (days)	REI (hours)	PHI (days)	Emergenc	Weeds controlled	Application Timing	OMRI
Abundit Extra, Alecto 41-S/AgSaver Glyphosate 41% Plus, Buccaneer, Buccaneer Plus, Credit 41 Extra, Nufarm Credit, Duramax, Durango DMA, Four Power Plus, Gly Star, Glyphogan, Honho Plus, Honcho K6, Showdown, Touchdown HiTech	Glyphosate	G, 9	Based on target weed, see label		4	14	Post	AG, PG,B L	Apply only when green shoots, canes, or foliage are not in spray zone.	
Scythe	Pelargonic acid	Z, 17	Based on target weed, see label		12		Post	AG, BL	Avoid contact with hop plant unless using for bine stripping. Works best on younger weeds and on sunny days with temperatures over 60°F	
Aim EC	Carfentrazon e	E, 14	2 fl oz/A Max 7.6 fl oz/A/year	14	12	7	Post	BL	Used for bine stripping to reduce sucker growth or for post-emergent control of weeds. Use of an adjuvant is essential, see label for instructions.	
2,4 D Amine 4, Drexel De-Amine 4, Radar AM, Shredder Amine 4, Weedar 64, Weed RHAP A 4D	2,4 D	O, 4	1 p/A	30	48	28	Post	BL	Max 3 applications. Hop foliage, especially new growth, is susceptible to this herbicide.	
Spur	clopyralid	O, 4	½-2/3 p/A	21	12	30	Post	BL*	*Specifically for Canada thistle Max 2 applications per year	

Trade name	Common name/ Active ingredient	HRAC group, WSSA group	Rate	Application Interval (days)	REI (hours)	PHI (days)	Emergenc	Weeds controlled	Application Timing	OMRI
Arrow 2EC, Clethodim 2E, Clethodim 2EC, Dakota, Intensity Postemergence, Select 2EC, Shadow, Volunteer, Willowood clethodim 2EC	clethodim	A,1	6-8 fl. oz/A	14	24	21	Post	AG, PG	Max 2 applications per season. 1% v/v spray volume crop oil concentrate per acre	
Intensity One, Select Max, Tapout	clethodim	A,1	9-16 fl. oz	14	24	21	Post	AG, PG	Max 4 applications per season. Adjuvant recommended, see label for instructions.	
Shadow 3EC	clethodim	A,1	4-5.33 fl oz/A Max 21.33 fl oz/A/season	14	24	21	Post	AG, PG	Recommended to apply with a non-fertilizer adjuvant, see label for instructions.	
FinalSan	Ammoniated soap of fatty acids	M	Dependent on application type, see label		24		Post	BL, AG, PG	Best on plants less than 5" high. Only plant parts coated in spray will be affected.	Y
FireWorxx, Lava, Homeplate	Caprylic acid, capric acid	-	Based on target weed, see label		12		Post	BL, AG, PG	Only plant parts coated in spray will be affected.	Y

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. HRAC group = Herbicide Resistance Action Committee. WSSA=Weed Science Society of America. REI=re-entry interval PHI = Pre-harvest interval. OMRI listed for organic production. Check the OMRI website: https://www.omri.org AG=annual grasses, PG=perennial grasses, BL=broadleaf weeds