PURDUE UNIVERSITY College of Agriculture

ID-462-W

EXPERT REVIEWED

Hops Production in Indiana

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Integrated Pest Management Guide for Hops in Indiana

Foreword

This guide will help growers select practices to manage weeds, diseases, and insects in hops in Indiana. It also lists pesticides registered for hops in Indiana if their use is warranted.

The recommendations in this guide use integrated pest management (IPM), which helps growers make management decisions that are economically sound and that have minimal impact on the environment. IPM management principles use the most economical means of managing a pest, which may involve cultural, mechanical, or chemical controls.

Please note that while the pesticide products listed in this publication are approved for use on hops, they have not been tested for effectiveness on hops in Indiana. Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. In addition, there are generic versions of some of the products listed in this publication. Individuals using such products assume responsibility for their use in accordance with current directions of the manufacturer. Information presented in this publication does not supersede pesticide label directions. To protect yourself, others, and the environment, always read the label before applying any pesticide — always remember that the label is the law.

We strongly recommend that anyone applying pesticides to crops for sale be a licensed applicator. Anyone who purchases or applies restricted use products (RUPs) — see Table 7 — *must* be a licensed applicator. Details about pesticide licensing are available from the Indiana Office of State Chemist (oisc.purdue.edu) and the Purdue Pesticide Programs (ppp.purdue.edu/).

Weed Management

Weeds in the row can be a major source of competition in hops, especially in new plantings. Weeds compete for nutrients and moisture, and can interfere with crop management. As with most crops, as weed densities increase, hop yields decrease. Consequently, it is important to manage weeds in the hop row.

Most Midwest hopyards maintain permanent cover crops between the rows. This practice reduces erosion and compaction, increases water infiltration, and can attract beneficial insects.

The width of the in-row weed-free strip is a matter of soil type and grower preference. Generally, the strip's width should be wider on soils that have low moisture holding capacity. A width of 4 feet is probably adequate, but we have limited experience with hops on Indiana soils. To manage weeds in this strip, growers can use mechanical or chemical controls.

Mechanical Controls
Mechanical cultivation is very effective at reducing weed populations. However, if performed too frequently, cultivation can destroy soil structure and may damage hop crowns. Avoid cultivating when soil is wet — heavier soils are particularly susceptible to compaction. Hand hoeing and pulling is effective but labor intensive.

Chemical Controls
The number of herbicides registered for use on hops in Indiana is limited. (See Table 1.) Normally, growers will combine pre- and post-emergent herbicides for best results.

Herbicide application methods vary according to their activity. Applicators must apply pre-emergent herbicides very accurately to properly control weeds and avoid damaging the crop. An applicator must have a carefully calibrated sprayer capable of accurately maintaining pressure, flow rate, and ground speed. We generally do not recommend applying pre-emergent herbicides with a backpack sprayer unless care is taken to carefully calibrate the equipment and walking speed of the applicator. A constant flow rate restrictor should be installed on a backpack sprayer to maintain the output pressure and thus the flow rate.

It is also very important to understand the label recommendations and the difference between broadcast rate and banded rate. Herbicide labels typically give application rates as some unit of measure (pounds, quarts, etc.) per acre. However, when applying herbicides in a hopyard remember that you will treat only a narrow band along the row, so applicators must adjust the rate for the bandwidth and the row spacing.

For example, an acre is 43,560 square feet. Let's say you have an acre of a hopyard that has rows planted 14 feet apart. It has 3,111 feet of row (43,560 ÷ 14). If an applicator applies a 4-foot wide band to each row, the total area treated in the acre of hops will be 12,444 square feet (3,111 x 4), or approximately 0.28 of the total acre. So if the herbicide label recommends a rate of 1 pound per acre and you actually apply that full pound banded to the rows in your 1-acre hopyard, you will be applying the herbicide at 3.5 times the labeled rate, enough to severely damage the hop plants.

So in this example, you would apply 0.28 pound of the herbicide in the appropriate volume of water to treat just the band area. Herbicide labels usually recommend application volumes of 10-40 gallons of water per acre (30 gallons per acre is a common volume). Remember, that is the broadcast volume. So in our example, you would calibrate the sprayer to apply 30 gallons per acre, and then fill the tank with 8.4 gallons of water (30 x 0.28) and add and mix the 0.28 pound of product, and then apply carefully to the band beneath the hop plants. That would apply the herbicide at the correct rate of 1 pound per acre in 30 gallons of water per acre to the band beneath the rows in our hopyard.

Post-emergence herbicides are easier to apply with hand-held equipment because you apply them as a dilution rather than a rate per acre. They can be applied at a volume necessary to cover the weeds without exact control over volume per acre. Backpack sprayers, wipers, and other hand-held equipment are suitable for post-emergence herbicides.

Remember that there is always a potential that herbicides can unintentionally injure the crop. Some post-emergence herbicides should not contact any portion of the green hop plant or injury will occur. Glyphosate and 2,4-D are examples of products that must be used with extreme care.

Table 1. *Herbicides Registered for Use in Hops in Indiana*

Trade Name	Common Name	WSSA Code[1]	Pre- or Post-emergence	Weeds Controlled (broad leaves or grasses)	Notes	PHI[2]	REI[3] (hours)
2,4 D (many formulations available)	2,4 D[4]	4	Post	Broadleaves	See labels for rates and timing. Use as a directed spray to row middles. Ester formulations are more likely to cause off-target damage than amine formulations.	28 d	48
Aim 2EC®	carbentrazone	14	Post	Broadleaves (and for sucker management on the basal portion of hop plants)	See label for rates and restrictions.	7 d	12
Alion	Indaziflam	29	Pre	Broadleaves and grasses	Only use on established plantings at least one year old.	14 d	12
Axxe	Ammonium nonanoate	NA	Post	Broadleaves and grasses	Vegetative burndown, directed and shielded sprays, sucker control	0 d	4
Chateau SW 51WDG®	flumioxazin	14	Pre and some post activity	Broadleaves and grasses	Apply Jan-Mar. as a 1-1.5-foot band to dormant hops. See label for sucker control directions. No more than 6 oz/A.	30 d	12
Prowl H2O	Pendimethalin	3	Pre	Broadleaves and grasses	May be used in first year and established plantings.	90 d	24
Roundup® (and others)	glyphosate	9	Post	Broadleaves and grasses	Apply only when green shoots, foliage, or canes are not in the spray zone.	14 d	4
Scythe 4.2L®	pelargonic acid	27	Post	Broadleaves and grasses — burndown	Vegetative burndown, directed spray, prior to crop emergence, dormant or post-harvest spray.	24 hr	12
Select Max 0.97E®	clethodim	1	Post	Grasses — annual and perennial	Annual grasses: 9-16 fl oz/A Perennial grasses: 12-16 fl oz/A Use NIS at 0.25% v/v.	21 d	24
Solicam 80DF®	norflurazon	12	Pre	Broadleaves and grasses	Rate determined by soil type. Wait 6 months after planting for first application.	60 d	12
Spur	clopyralid	4	Post	Broadleaves (especially Canada thistle)	Do not exceed 2 applications per season.	30 d	12
Treflan 4EC® (and others)	trifluralin	3	Pre	Annual broadleaves and grasses	Rate determined by soil type — see label. Apply during dormancy.	N/A[5]	12

[1]WSSA=Weed Science Society of America mode of action code listed for resistance management planning.
[2]PHI= preharvest interval given as hours (hr) or days (d).
[3]REI= restricted entry interval given as hours (hr) or days (d).
[4]In general, avoid using ester formulations of 2,4-D in hopyards that grow near sensitive crops such as grapes or tomatoes because of vapor drift issues.
[5]PHI not applicable since applied during dormancy.

Disease Management

A variety of diseases occur in hop fields throughout the Midwest. Integrated disease management requires knowing the diseases' life cycles, their symptoms on hop plants, and control measures. The two diseases considered the most economically damaging are:

1. downy mildew (*Pseudoperonospora humuli*), which has been detected in Indiana hops
2. powdery mildew (*Podosphaera macularis*), which has not yet been detected on commercial hops in Indiana, but is a concern in Michigan

Other diseases hop growers might encounter include:

- Alternaria cone disorder (*Alternaria alternata*)
- gray mold (*Botrytis cinerea*)
- black root rot (*Phytophthora citricola*)
- Verticillium wilt (*Verticillium dahlia or V. nonalfaflae*)
- apple mosaic virus and a variety of other virus or viroid diseases

We describe these diseases in more detail below.

To manage diseases, it is essential scout the hopyard weekly beginning at plant emergence. Detecting diseases early and following that with best management strategies can significantly reduce disease severity. However, you can usually achieve the best control when you combine cultural practices, mechanical practices, and chemical applications.

Correctly identifying the pest is critical in integrated pest management. This is especially true when combating downy mildew and powdery mildew. Different types of organisms cause these diseases, and the chemicals that protect against one generally do not protect against the other.

The easiest way to distinguish between powdery mildew and downy mildew is to locate where the pathogen is sporulating. Powdery mildew sporulation occurs mostly on the upper surfaces of leaves, while downy mildew produces spore-bearing structures on the lower surfaces of leaves.

Fungicides are usually applied to prevent rather than to cure disease after symptoms appear. By the time the disease is obvious, it is often too late to alleviate the problem.

Several fungicides are labeled for prevention of both downy and powdery mildew on hops. Because of the specificity of fungicides for diseases, we have separated the fungicides into two groups: those that primarily prevent downy mildew and those that primarily prevent powdery mildew. A few broad-spectrum fungicides will prevent both diseases.

Table 2 lists fungicide products approved for managing downy mildew; Table 3 lists products for managing powdery mildew. Table 4 lists fungicides labeled for hops in Indiana that have been approved for organic use by the Organic Materials Review Institute (OMRI) — see omri.org.

It is critical that you know for sure which mildew disease is in the hopyard before choosing the appropriate fungicide. Several resources are available to help you identify these diseases, including the *Field Guide for Integrated Pest Management in Hops*, Third Edition, 2015 (www.usahops.org/cabinet/data/Field-Guide.pdf). The most reliable way to confirm disease is to send a sample to the Purdue Plant and Pest Diagnostic Lab (PPDL). For details about submissions and sample handling fees, contact your Purdue Extension county office (extension.purdue.edu/pages/CountyOffices.aspx) or the PPDL (ppdl.purdue.edu).

Downy Mildew

Pseudoperonospora humuli

Downy mildew is the main disease of concern on hops in Indiana. Downy mildew can cause significant productivity loss if it isn't controlled and can kill sensitive varieties.

Downy mildew infected spike emerging from a crown

Downy mildew becomes systemic in the crowns of infected plants. In the spring, characteristic diseased shoots (called spikes) emerge. They are usually stunted and yellow with curled or cupped leaves. The leaves may become brittle, dry up, and wither from the base of the spike upward. Spike infections can be basal (from the crown of the plant) or secondary (from apical meristems or growing points).

Downy mildew can also cause leaf lesions. These normally appear as yellow spots on the upper surfaces of leaves and as brown spots on the undersides of leaves. They are delineated by the leaf vein and appear angular and water-soaked. Purple to black colored sporangia (the fruiting structures of the organism) will emerge from the lesions on the undersides of leaves.

Inflorescences can also become infected. They will appear shriveled, dark brown, and may dry up and fall from the plant. If infected early, cones will become brown and hard and will stop developing. Later infections can turn cones completely brown or result in a few discolored bracts.

Cultural Controls

Infected plants are a major source of downy mildew infection, so purchase disease-free planting stock if possible. Consider purchasing a limited quantity of plants and test them for diseases before committing to a large purchase. You may also consider purchasing from the National Clean Plant Network-Hops at Washington State University in Prosser.

Varieties vary considerably in their susceptibility to the diseases, but none are completely immune.

Plant varieties reported to be moderately resistant, or avoid varieties that are known to be susceptible. Columbia, Fuggle, Newport, Perle, Tettnanger, and Willamette are reported to be moderately resistant; Cascade, Centennial, Chinook, Galena, and Nugget are reported as susceptible (Gent, et al., 2015).

Mechanical Controls

Downy mildew can spread into hopyards by various means. The wind can blow spores from an infected field, or growers may accidentally bring in spores on clothing or tools after visiting an infected area. Practicing careful sanitation is critical for downy mildew control and will greatly reduce disease severity (especially during pruning and stripping activities in the spring). Prune and strip leaves only in established fields and never within the planting year.

Downy mildew leaf lesions (top) and infected spikes (below)

Pruning removes buds, shoots, and the previous season's bines (hop shoots are called bines, not vines). Prune after shoots emerge but before training. Prune as late as possible in the season without hindering yield. Crowning and scratching are pruning techniques that remove the top inch or two of the crown by raking the soil away. This removes infected buds and shoots, the primary source of inoculum. You can remove them mechanically or chemically, but you should remove them weekly for best control (Skotland and Johnson, 1983).

In areas with high disease pressure, consider stripping leaves from the lower portion of the bines after training. Removing leaves and laterals from the lower 5 feet of the trained bines and then removing trimmed material from the hopyard limits the inoculum that could spread into the upper canopy. Stripping lower leaves will also increase airflow, in turn reducing humidity within the rows. As with removing spikes, you can remove leaves mechanically or chemically.

A final cultural management approach is to hill-up soil mid- and post-season, which can help suppress downy mildew and promote new root growth.

Downy mildew infected cones

Chemical Controls
In addition to good sanitation practices, it may be necessary to apply fungicides to reduce the occurrence or severity of downy mildew, especially in areas with frequent rainfall. When weather conditions favor disease development (warm and wet), preventive spraying is key to managing downy mildew (Johnson, et al., 2009).

Table 2 lists the fungicides labeled for downy mildew prevention in hops in Indiana. Carefully read the entire labels before use because some products should not be tank-mixed or used close together as phytotoxicity may occur. For example, copper products and phosphorous acid products should not be used within 20 days of each other, and copper should never be used within two weeks of an oil application. Thoroughly understanding the various products available is critical to safe and effective downy mildew control.

Powdery Mildew
Podosphaera macularis

Powdery mildew is one of the most important diseases on hops throughout the United States. This disease has been detected on wild hops and on greenhouse-grown hops in Indiana, but it has not yet been detected on commercially grown hops in Indiana. Powdery mildew is a known problem in Michigan, the Northeast, and the Pacific Northwest (where most U.S. hops are grown). It is likely only a matter of time until we detect powdery mildew in Indiana hopyards.

Powdery mildew can infect all green tissue of the plant and cause severe crop damage and substantial economic loss. Leaves commonly show infection as white powdery growth on the upper surfaces; however, fungal growth can be visible on any surface of the hop plant. Fungal growth is a combination of hyphae and spores of the fungus visible on the outside the host plant.

Cones that are infected early in the season may be of unacceptable quality and display distorted shapes and reduced sizes. Infected cones also mature earlier than normal. Cones infected later in the season may show little or no symptoms.

Cultural Controls
Like downy mildew, powdery mildew can be systemic in the plants, and the planting stock you buy could be infected when purchased. Purchase disease-free plants if possible. Varieties vary considerably in their susceptibility to the diseases but none are completely immune.

Plant varieties reported to be moderately resistant, and avoid varieties that are known to be susceptible. Cascade, Comet, Crystal, Fuggle, Mt. Hood, Newport, Nugget, and TriplePearl are reported to range from moderately resistant to resistant. Chinook, Galena, Perle, Tettnanger, and Willamette are reported as susceptible (Gent, et al., 2015).

Mechanical Controls
The wind can blow powdery mildew spores from an infected field, or growers may accidentally bring in spores on clothing or tools after visiting an infected area. For these reasons, sanitation is an important cultural management strategy. Sanitation control measures are very similar to downy mildew

control and are aimed primarily at removing the source of inoculum. Pruning, stripping, crowning, and/or scratching are common practices in areas where powdery mildew is a problem.

Like downy mildew, early spring removal of flag shoots, leaves and laterals from the lower 5 feet of bines after training will help reduce the spread of powdery mildew. Pay attention to fertility and irrigation management. Avoid excess nitrogen applications and irrigation because both may result in excessive growth that is very susceptible to infection.

Chemical Controls
In addition to good sanitation practices, it may be necessary to apply fungicides to reduce the severity of powdery mildew. Table 3 lists the fungicides labeled for powdery mildew control on hops in Indiana.

Alternaria Cone Disorder
Alternaria alternata

Alternaria alternata is considered a weak pathogen that commonly enters the host via mechanical wounds, through lesions caused by other pathogens, or at insect feeding sites. This fungal disease commonly reduces cone quality because it browns and discolors bracts and bracteoles.

The symptoms on cones may be easily confused with other hop diseases, so it is essential to get a correct diagnosis before treatment. There are no fungicides labeled for use against Alternaria cone disorder; however, cultural controls (including increasing air circulation in the canopy and properly timing irrigation) can reduce infections.

Gray Mold
Botrytis cinerea

This disease is favored by humid, wet conditions and is usually considered of minor importance in Midwest hopyards. Symptoms include dark brown spots on the tips of bracts and bracteoles. These spots will gradually enlarge and eventually discolor the entire cone.

Gray mold symptoms may look similar to Alternaria cone disorder. Gray mold can be distinguished by the presence of gray, fuzzy growth on the tip of the cone. The gray mold pathogen may overwinter in fields on organic matter, on leaves, or in the soil, and then become active when the environment is favorable. Fungicides may be needed to reduce gray mold damage in hops.

Black Root Rot
Phytophthora citricola

Black root rot can be an issue in poorly drained fields. Symptoms include diseased tissue that appears water-soaked and blackened. The infection can begin in the crown and progress up the base of the bine. Often, the leaves will turn yellow and the bines will wilt during periods of moisture stress.

The black root rot pathogen survives for many months in the soil as dormant sexual spores called oospores. The pathogen can also infect the plant directly as asexual spores or with motile zoospores in free water. The best way to manage black root rot is to avoid fields with poor water drainage and reduce crown and root injuries, because infection is favored by wounding of the plant.

Verticillium wilt
Verticillium nonalfalfae or V. dahlia

This disease has been reported to be caused by a variety of Verticillium species, but V. nonalfalfae is considered to be a greater economic concern. Multiple strains of V. nonalfalfae have been identified, with only non-lethal strains being identified in the United States.

Infected plants display various symptoms, including upward curling of leaves, yellowing and dying tissue between major veins, and swollen bines with brown vascular tissue. V. dahlia occurs commonly on U.S. hops, and causes a relatively minor wilt.

The pathogens that cause Verticillium wilt can survive in the soil, invade hop roots, and gradually infect the plants' vascular system. As the fungus grows and produces toxins, it causes the characteristic wilt symptoms of disrupted water and nutrient movement in the plant. Control tactics include planting resistant varieties and disease-free plants. Be aware and follow strict sanitation guidelines in all hopyards to prevent spreading lethal strains.

Apple Mosaic Virus

The apple mosaic virus pathogen is the most important viral disease of hop around the world. When the apple mosaic virus infects plants in a hopyard, the likelihood of a successful crop is reduced.

Infected plants show symptoms that include chlorotic rings or arcs that later become dark and necrotic. The symptoms usually are worse when a cool period is followed by higher temperatures. Plants with severe symptoms experience cone and alpha-acid yield reduction up to 50 percent. Propagation of infected plant material is the primary cause of transmission, although mechanical injury and root grafting can transmit the virus within the field. The most successful way to manage this virus is to plant disease-free material.

Apple mosaic virus infected hops leaf

Table 2. ***Fungicides for Downy Mildew Control on Hops in Indiana***[1]

Trade Name	Common Name	FRAC Group[2]/ Resistance Risk	Rates/Notes	PHI[3] (days)	REI[4] (hours)
Agri-Fos®, Fosphite®, Phostrol®, Rampart®, (and others)	phosphorous acid mono & dipotassium salts	33/low	See labels for rates Apply when shoots are 0.5-1 ft long, 21 days post application, when vines are 6 ft high, bloom, or when conditions favor disease.	0	4
Aliette WDG® Linebacker WDG®	fosetyl-Al	33/low	2.5 lb/A Apply after training when shoots are 6-12 in tall; when bines are 5-6 ft tall; 3 weeks after second application; at bloom. No more than 10 lb/A/season. Do not use with copper compounds — see labels.	24	12
Badge SC®	copper oxychloride copper hydroxide	M1/low	.75-1.8 pt/A Treat crowns after pruning but before training.	14	48
Champ Dry Prill®, Champ Formula 2, Flowable®, NuCop 50DF®, Kentan DF®, Kocide 2000, Kocide 3000®(and others)	copper hydroxide	M1/low	See labels for rates Treat crowns after pruning but before training. After training, additional fungicide treatments are needed at about 10- day intervals. Minimum retreatment interval: 10 days.	14	48
Cuprofix Ultra 40 Disperss®	basic copper sulfate	M1/low	1.0-1.25 lb/A (no more than 6.6 lb/A/year) Treat crowns after pruning, but before training. After training, make additional applications at 10-day intervals as needed.	14	48
Curzate 60DF®	cymoxanil	27/low-med	3.2 oz./A Use only with a labeled rate of protectant fungicide such as copper hydroxide. Apply at 10-14-day intervals. No more than 4 applications in 12 months.	7	12
Forum®	dimethomorph	40/low-med	6 fl oz./A No more than 18 fl oz/season. No more than 3 applications per season. Minimum application interval: 10 days. Rotate to another mode of action after 1 application.	7	12
MetaStar 2EAg®	metalaxyl	4/high	1 qt/A (for soil drench when shoots are 6 inches or less after pruning, before training; or foliar spray at sign of secondary infection) 1 qt/A + 2 lb/A Kocide 101®	45	48
Nordox 75WG®	cuprous oxide	M/low	1.25 lbs/A; begin after pruning but before training.	14	12
Pristine®	boscalid pyraclostrobin	7/med-high 11/high	14 oz/A (no more than 84 oz/season) 14 oz/100 gal (no more than 3 applications/season)	14	12
Ranman 400SC®	cyazofamid	21/unknown, assumed med-high	2.1-2.75 fl oz/A No more than 6 applications/season. No more than 3 consecutive applications — alternate with other modes of action.	3	12
Regalia®	*Renoutria sachalinensis*	P5/unknown	1-4 qt/A For downy mildew control, must be tank-mixed with another fungicide labeled for downy mildew.	0	4
Revus®	mandipropamid	40/low-med	8.0 fl oz/A No more than 24 fl oz/season. No more than 2 consecutive applications. Addition of an adjuvant is recommended.	7	4
Ridomil Gold SL®	mefenoxam	4/high	0.50 pt/A Soil drench when shoots are 6 inches or less after pruning, before training; or foliar spray at sign of secondary infection combined with a copper fungicide registered for hops. No more than 3 applications/season.	45	48

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Tanos®	famoxadone cymoxanil	11/high 27/low-high	8 oz/A No more than 6 applications/cropping cycle. No more than 1 application before rotating to a fungicide in another FRAC group.	7	12
Zampro®	ametoctradin dimethomorph	45/med-high 40/low-med	10-14fl oz/A Apply prior to disease development and continue on a 10-day interval. No more than 2 sequential applications. No more than 40 fl oz/A per season.	7	12

[1]Although efforts have been made to check the accuracy of this information at publication, it is still your responsibility to verify that it is correct by reading the entire pesticide label before using the product. Labels can and do change. To look up label and MSDS information, visit these free online resources: greenbook.net, cdms.com, and agrian.com.
[2]FRAC= fungicide resistance action code.
[3]PHI=preharvest interval.
[4]REI=restricted entry interval.

Table 3. *Fungicides for Powdery Mildew Control on Hops in Indiana*[1]

Trade Name	Common Name	FRAC[2] Group/ Resistance Risk	Rates/Notes	PHI[3] (days)	REI[4] (hours)
Flint®	trifloxystrobin	11/high	See label for rates Alternate with of sterol inhibitor (FRAC group 3) fungicides.	14	12
Luna Experience®	fluopyram tebuconazole	7/med-high 3	8.0-17 fl oz/A Can also control gray mold (*Botrytis spp.*)	14	?
Luna Privilege®	fluopyram	7/med-high	3.2 to 6.84 fl oz/A. Can also control gray mold (Botrytis spp.) Do not apply more than 13.7 fl oz/A.	7	12
Luna Sensation®	fluopyram trifloxystrobin	7/med-high 11/high	3.0-7.6 fl oz/A Do not use more than 27.1 fl oz/A per season. Can also control downy mildew (*P. humuli*) and gray mold (*Botrytis spp.*)	14	12
Orius 3.6F® Tebustar 3.6F® Toledo 3.6 F® (others may be available)	tebuconazole	3/med	4-8 fl oz/A No more than 32 fl oz/crop season. Use surfactant (see labels).	14	12
Pristine®	pyraclostrobin boscalid	11/high 7/med-high	14-28 oz/A No more than 3 applications/ season. 84 oz max. /season.	14	12
Procure 480SC®	triflumizole	3/med	12 oz/A No more than 36 fl oz./season	7	12
Quintec®	quinoxyfen	13/med	4-8.2 fl oz/A No more than 4 applications/ season. No more than 2 consecutive sprays before rotating to a different mode of action.	21	12
Rhyme®	flutriafol	3/med	5-7fl oz/A No more than 28 fl oz/A per year. An adjuvant may be used.	7	12
Serenade Max®	*Bacillus subtilis*	44/unknown	2-4 lb/100 gal/A	0	4
sulfur (many formulations available)	sulfur	M2/low	See labels for specific directions. See Table 4.	7	12
TebuStar 3.6L®	tebuconazole	3/med	4-8 fl oz/A No more than 36 fl oz/A	14	12
Vivando®	metrafenone	U8/med	15.4 fl oz/A (max 30.8 fl oz/A); only 2 applications per year.	3	12

[1] Powdery mildew not reported on commercially grown hops in Indiana. Although efforts have been made to check the accuracy of this information at publication, it is still your responsibility to verify that it is correct by reading the entire pesticide label before using the product. Labels can and do change. To look up label and MSDS information, visit these free online resources: greenbook.net, cdms.com, and agrian.com.
[2]FRAC= fungicide resistance action code.
[3]PHI=preharvest interval.
[4]REI=restricted entry interval.

Table 4. *OMRI-listed Fungicides Registered for Use on Hops in Indiana*[1]

Trade Name	Common Name	FRAC[2] Group/ Resistance Risk	Diseases Treated	Rates/Notes	PHI[3] (days)	REI[4] (hours)
Actinovate AG®	*Streptomyces lydicus* WYEC 108	N/A[5]	downy mildew, powdery mildew, verticillium wilt	*Soil drench for verticillium wilt:* 3-12 oz/A *Foliar treatment for downy mildew, powdery mildew, and anthracnose:* 3-12 oz/A every 7-14 days	0	1
Badge X2®	copper oxychloride copper hydroxide	M1/low	downy mildew	0.75-1.8 lb/A Treat crowns after pruning but before training.	14	48
Champ WG® Nu-Cop 30HB® Nu-Cop HB®	copper hydroxide	M1/low	downy mildew	1.00 lb/A (no more than 5.3 lb/A/year) .75-1.50 lb/A (no more than 8.8 lb/A/year) 1.0 lb/A (no more than 5.0 lb/A/year) Treat crowns after pruning but before training. After training, additional fungicide	14	48
Cueva Fungicide Concentrate®	copper octanoate	M1/low	anthracnose, cercospora leaf spot, downy mildew, powdery mildew	50-100 g/A 0.5-2.0 gal/100 gal water	0	4
Double Nickel 55®	*Bacillus amyloliquefaciens* strain D747	44/unknown	powdery mildew	*Emergence-training:* 6-10 fl oz/100 gal water (minimum 20 gal/A) *Training to wire:* 50 gal/A *Wire touch to harvest:* 100 gal/A	0	4
Oxidate 2.0®	hydrogen dioxide, peroxyacetic acid	NC/unknown	downy mildew, powdery mildew	See label for rate	0	1
Tenet WP®	*Trichoderma asperellum strain ICC 012* *T. gamsii strain ICC 080*	44BM02/unknown	phytophthora root rot, verticillium wilt	See label for rates See label for application methods (banded, furrow, chemigation, nursery, greenhouse drench, etc.). Apply up to 7 days before planting to initiate soil colonization and at planting.	1	12
Trilogy®	neem oil	NC/unknown	downy mildew, powdery mildew	See label for rates.	1	4

[1]OMRI-listed products are listed for organic production by the Organic Materials Review Institute. The latest information is available at omri.org. Powdery mildew not reported on hops in Indiana. Although efforts have been made to check the accuracy of this information at publication, it is still your responsibility to verify that it is correct by reading the entire pesticide label before using the product. Labels can and do change. To look up label and MSDS information, visit these free online resources: greenbook.net, cdms.com, and agrian.com.
[2]FRAC= fungicide resistance action code.
[3]PHI=preharvest interval.
[4]REI=restricted entry interval.
[5]Biological products do not have a FRAC code.

Insect Management

Managing insects is slightly different than managing diseases: growers normally wait until insect pests are present in the hopyard in numbers sufficient to cause damage before applying an insecticide. Scouting is critical in integrated pest management. An unnecessary insecticide application may injure beneficial insects, which could lead to even more damaging insects. Table 5 lists insecticides registered for use on hops in Indiana and the pests they control. Table 6 includes OMRI-listed products for organic production.

To legally use a product, the crop and the pest must be listed on the label. If an insecticide includes hops as a crop, you can use it to control Japanese beetle (even if the pest is not listed under hops) as long as Japanese beetle is listed for some other crop. Do not exceed the maximum insecticide rate for hops. Insecticides that are labeled for hops (but do not list Japanese beetle control for hops) are noted in Tables 5 and 6. Be aware that none of these products have been evaluated for efficacy against Japanese beetle on hops in Indiana.

Japanese beetle
An adult Japanese beetle is about 1/2-inch long. It is metallic green with bronze-colored wing covers and white tufts of hair around its abdomen. These beetles skeletonize leaves while leaving most of the veins intact. They also damage cones with their chewing mouthparts. The worst defoliation is usually high on the bines.

Japanese beetle adult (left) and feeding damage (right)

The beetles release pheromones that cause them congregate in large numbers for mating and feeding. This behavior means that infestations are often clumped, and that they prefer certain cultivars. This requires inspections throughout the yard for their presence and damage. We discourage the use of Japanese beetle traps (often used by homeowners), because they often draw numerous beetles and the traps soon become inundated.

There isn't an established treatment threshold for this pest. Leaf defoliation often looks worse than it is, and healthy plants can withstand considerable damage. However, if beetles begin to damage burrs or cones, then treatment may be warranted. There are many effective products for treating Japanese beetle. However, the difficulty may be applying the product high in the canopy where they are feeding.

Potato Leafhopper
An adult potato leafhooper is about 1/8-inch long, yellowish green, and wedge-shaped. The immature stage (called a nymph) is smaller, wingless, and more yellow. A nymph cannot fly, so it walks sideways at a rapid pace when disturbed. An adult will either fly or jump away.

Both the nymphs and adults suck plant juices from the leaves with their piercing-sucking (straw-like) mouthparts.

As leafhopper populations increase, so does their plant sap removal. Initially, damaged leaves will yellow around the margins ("hopperburn") and begin to curl. This progresses to necrotic tissue with severe distortion as feeding continues. It is easy to confuse these symptoms with other problems (such as herbicide injury, nutrient deficiencies, etc.).

Potato leafhoppers do not overwinter in Indiana. They arrive on weather fronts in the spring. Their numbers begin to build during warm weather, and adults can be seen gathered at lights at night.

Leafhoppers may thrive on certain cultivars, which makes it necessary to frequently inspect the entire hopyard. Ideally, you should begin inspecting for leafhoppers before leaf yellowing.

Carefully approach bines and inspect the undersides of leaves for both adults and nymphs. If populations are increasing and the forecast calls for warm and dry weather, then treatment may be necessary.

Potato leafhopper adults and nymphs on underside of leaf (top) and "hopper burn" on hops foliage (bottom)

Fungal pathogens that thrive during extended wet/high humid conditions can dramatically reduce potato leafhopper populations. Also, many predatory insects (such as lady beetles) will feed on leafhoppers — insecticide treatments will kill both the leafhoppers and these beneficial predators.

Twospotted Spider Mite

A spider mite is tiny and only visible with magnification. It is white, green, or reddish and, as its name indicates, has two distinct dark spots on each side of its body. Spider mites are closely related to spiders and will create webbing when infestations are heavy.

Two spotted spider mites on underside of leaf (top)
Leaf bronzing caused by two spotted spider mite feeding (bottom)

Spider mites pierce plant cells with their mouthparts, then suck out the contents. Initially, this damage is a yellowish stippling of the leaf, then progresses to bronzed/brown. Unchecked, whole bines (most importantly cones) can quickly become necrotic under severe infestations. Early symptoms can be confused with other problems (such as herbicide injury, nutrient deficiencies, etc.).

Spider mites overwinter in Indiana in grasses and clovers. Most seasons, they are content to stay in these locations. However, when it is hot and dry and their food sources dry up (which can sometimes be exacerbated by mowing in the hop yard), the mites will move to bines and colonize. This may initially be in an isolated area of the yard — for example, they may infest areas planted in lighter soil that stresses first, then spread to other areas.

Mites "balloon" to other bines and areas of the yard by spinning a web and getting carried by wind currents. During hot and dry periods, inspect the undersides of leaves for spider mites and their webbing. We recommend using a 10X magnifying lens. Watch for green leaves that subtly show yellow specks. If mites are present, attempt to determine whether their presence is isolated or widespread in the yard.

If mite populations appear to be rising, take note of the beneficial insects (such as lady beetle adults and larvae) that are present. Control decisions are based on the numbers of these natural enemies present, the weather forecast, and the severity of mite presence and foliage/cone damage. If the foliage is beginning to bronze, you see mites on the cones, their webbing is increasing, and the forecast calls for continued hot and dry conditions, then a treatment is warranted. Remember that an insecticide treatment will also control all beneficial organisms, and it will take longer for these beneficials to rebound than the mites. If hot and dry conditions persist, that may require follow-up applications.

Significant rain and high humidity can dramatically decrease the mite population, because they are vulnerable to fungal pathogens (epizootics). Continual irrigation during these droughty periods will help water the plants, but the ambient humidity is the over-riding factor determining spider mite outbreaks.

Caterpillars

Numerous species of caterpillars from moths and butterflies feed on hops foliage. Some roll the leaves together with webbing and others bore into bines. Although caterpillar defoliation is unsightly, most of it is of little economic importance.

One of the many species of caterpillars that feed on hops, common brushfoot

Furthermore, outbreaks are often isolated to just a few bines or so, which means that removing the larvae by hand or making spot sprays can achieve sufficient control. There is a wide range of life cycles and preferred hosts among these caterpillar species. In general, removing weeds early will deter many species from being attracted to, and laying eggs in, the yard.

Table 5. *Insecticides Labeled for Hops in Indiana*[1]

Trade Name	Common Name	IRAC Group[2]	Pests Controlled	Japanese Beetle Elsewhere on Label[3]	Rates/Notes (RUP=Restricted Use Product)	PHI[4] (days)	REI[5]
Acramite 50WS®	bifenazate	UN	mites	no	0.75-1.5 lb/A 1 application/season.	14	12 hr
Admire Pro®	imidacloprid	4A	aphids	yes	*Soil application (to moist soil):* 2.8-8.4 fl oz/A *Foliar application:* 2.8 fl oz/A	60 28	12 hr
Agrimek® (and others)	abamectin	6	mites	no	1.75-3.5 fl oz/A RUP[6]	28	12 hr
Athena®	abamectin bifenthrin	6 3A	mites, aphids	yes	10-17 fl oz/A RUP[6]	28	12 hr
Baythroid XL®	beta-cyfluthrin	3A	flea beetles, loopers, plant bugs	yes	3.2 fl oz/A RUP[6]	7	12 hr
Beleaf®	flonicamid	9C	aphids	no	1.7-2.8 oz/A	10	12 hr
BioCover MLT®	petroleum oil	Not listed	mites (powdery mildew)	no	1-2 gal/100 gal/A Apply every 10-14 days until burr development.	0	4 hr
Brigade 2EC®	bifenthrin	3A	armyworms, cutworms	yes	3.2-6.4 fl oz/A RUP[6]	14	12 hr
Brigadier®	bifenthrin imidacloprid	3A 4A	aphids, armyworms, leafhoppers, other	yes	*Aphids and leafhoppers:* 3.8 -12.8 fl oz/A *Armyworms, loopers, root weevils:* 12.8 fl oz./A 21-day treatment interval. RUP[6]	28	12 hr
Delegate®	spinetoram	5	thrips, leafrollers, armyworms	no	2.5-4 oz/A	1	4 hr
Dicofol 4E®	dicofol	UN	mites	no	2-2.33 pt/A	7	29 d
Dipel DF® Dipel ES®	*Bacillus thuringiensis* var. *kurstaki*	11	loopers	no	0.5-2 lb/A OMRI-listed: 1-2 pt/A	0	4 hr
Envidor 2EC®	spirodiclofen	23	mites	no	18.0-24.7 fl oz/A No more than 1 application/season	7	12 hr
Fujimite XLO®	fenpyroximate	21A	mites	no	3 pt/A	14	12 hr
Fulfill®	pymetrozine	9B	aphids	no	4-6 fl oz/A	14	12 hr
Leverage®	cyfluthrin imidacloprid	3A 4A	aphids	yes	3.2 fl oz/A RUP[6]	28	12 hr
Kanemite 15 SC	Acequinocyl	20B	Mites	no	31 fl oz/A	7	12 hr
Malathion 57EC® (other formulations available)	malathion	1B	aphids	yes	1 pt/A	10	12 hr
Movento®	spirotetramat	23	aphids	no	5-6 fl oz/A	7	24 hr
Platinum®	thiamethoxam	4A	aphids, root weevils garden symphlan	yes	8 fl oz/A As banded soil application. No more than 8 fl oz/season	65	12 hr
Platinum 75 SG®	thiamethoxam	4A	aphids, root weevils garden symphlan	yes	2.67 oz/A As banded soil application. No more than 2.67 oz/A/ season	65	12 hr
Portal XLO	Fenpyroximate	21A	Mites	No	2-3 pts/A	15	12 hr
Pyganic® (and others)	pyrethrin	3A	aphids, Japanese beetles	yes	1 pt-2 qt/A Pyganic® is OMRI-listed. Check labels of others.	0	12 hr
Savey 50DF®	hexythiazox	10A	mites	no	4-6 oz/A No more than 1 application/year. Apply up to burr formation.	No later than burr stage	12 hr
Sivanto®	flupyradifurone	4D	aphids, leafhoppers	no	7-10.5 fl oz/A	21	4 hr
wettable sulfur	formulations vary	M	mites	no	2-6 lb/A (see labels for specific rates) Apply when mites first appear.	0	24 hr
Zeal®	etoxazole	10B	mites	no	3.0-4.0 oz/A Apply when mite populations are low. No more than 1 application/season.	7	12 hr

[1]Although efforts have been made to check the accuracy of this information at publication, it is still your responsibility to verify that it is correct by reading the entire pesticide label before using the product. Labels can and do change. To look up label and MSDS information, visit these free online resources: greenbook.net, cdms.com, and agrian.com.
[2]IRAC= Insecticide Resistance Action Committee code included for resistance management planning.
[3]To use an insecticide the site (crop) must be listed on the label. It is legal to use a pesticide for a pest that is not listed for a particular crop, but the rate listed on for that crop (hops) cannot be exceeded. Insecticides that have Japanese beetle listed for a crop other than hops (but are silent about Japanese beetle in hops) are noted in the table. None of these products have been evaluated for efficacy against Japanese beetle on hops in Indiana.
[4]PHI=preharvest interval.
[5]REI=restricted entry interval given as days (d) or hours (hr).
[6]Restricted Use Product (RUP).

Table 6. *OMRI-listed Insecticides Labeled for Use on Hops in Indiana*[1]

Trade Name	Common Name	IRAC Group[2]	Pests Controlled	Japanese Beetle Listed Elsewhere on Label[3]	Rates/Notes	PHI[4] (days)	REI[5] (hours)
Azadirect® Ecozin Plus 1.2%ME®	azadiractin (neem)	UN	aphids, Japanese beetles, others	yes	1-2 pt/A 15-30 oz/A Buffer water pH to 5.5-6.5.	0	4
Azera®	azadiractin pyrethrins	UN/3A	aphids, armyworms, Japanese beetles, others	yes	1.0-3.5 pt/A Buffer water pH to 5.5- 7.0.	0	12
Deliver® Javelin WG®	*Bacillus thuringiensis* var. *kurstaki*	11	loopers	no	0.5-1.5 lb/A 0.25-1.0 lb/A	0	4
Des-X Insecticidal, Soap®, M-pede®	potassium salts of fatty acids	M	aphids, mites	no	2 gal/100 gal water in 75-200 gal/A 1-2 gal/100 gal water in min 50 gal/A	0	12
Dipel DF®	*Bacillus thuringiensis* var. *kurstaki*	11	loopers	no	*Loopers:* 0.5-1.0 lb/A *Armyworms:* 1.0-2.0 lb/A	0	4
Entrust® Entrust SC®	spinosad	5	armyworms, loopers, thrips	no	1.25-2.0 oz/A 4.0-6.0 oz/A	1	4
Grandevo®	*Chromobacterium subtsugae*	11	armyworms, aphids, loopers mites, thrips	no	1-3 lb/A 2-3 lb/A	0	4
Mycotrol ESD®	*Beauvaria bassiana*	biological	aphids, thrips, caterpillars, mites	no	0.25-1.0 qt/A Read label for adjuvant and tank- mix restrictions.	0	4
Omni Supreme Spray®	mineral oil	M	mites	no	1-2 gal/100 gal/A Discontinue at burr development. Do not mix with sulfur or apply within 30 d of a sulfur application.	0	12
Purespray Green®	mineral oil	M	aphids, mites, whiteflies	no	1-2 gal/A in a minimum of 50 gal water/A Discontinue at burr development. See label for sulfur and other pesticide application restrictions.	0	4
PyGanic EC1.4® PyGanic EC 5.0®	pyrethrins	3A	aphids, Japanese beetles, loopers, thrips	yes	1 pt-2 qt/A 4.5-18 fl oz/A	0	12
Sil-Matrix®	potassium silicate	M	aphids, mite suppression	no	2-4 qt/100 gal	0	4
SuffOil-X®	mineral oil	M	aphids, mites	no	1-2 gal/100 gal water 20-100 gal/A	0	4
Surround WP®	kaolin clay	UN	flea beetles, thrips suppression	yes	25-50 lb/A	0	4
Trilogy®	azadiractin (neem oil)	UN	mites	no	0.5-1.0% in 25-100 g/A 1>0-2.0% in 25-100 g/A	0	4
XenTari DF®	*Bacillus thuringiensis* var. *kurstaki*	11	loopers	no	0.5-2.0 lb/A	0	4

[1]OMRI-listed products are listed for organic production by the Organic Materials Review Institute. The latest information is available at omri.org. Although efforts have been made to check the accuracy of this information at publication, it is still your responsibility to verify that it is correct by reading the entire pesticide label before using the product. Labels can and do change. To look up label and MSDS information, visit these free online resources: greenbook.net, cdms.com, and agrian.com.

[2]IRAC= Insecticide Resistance Action Committee code included for resistance management planning.

[3]To use an insecticide the site (crop) must be listed on the label. It is legal to use a pesticide for a pest that is not listed for a particular crop, but the rate listed on for that crop (hops) cannot be exceeded. Insecticides that have Japanese beetle listed for a crop other than hops (but are silent about Japanese beetle in hops) are noted in the table. None of these products have been evaluated for efficacy against Japanese beetle on hops in Indiana.

[4]PHI=preharvest interval.

[5]REI=restricted entry interval.

In IPM, pesticides are essential tools when other management tactics fail to achieve acceptable pest control. Pesticides expose humans, nontarget organisms, and the environment to some risk. Table 7 outlines the relative toxicity of specific pesticides to humans and their impact on nontarget beneficial arthropods.

A pesticide's signal word (column 2 of table) indicates the potential hazard these pesticides pose to a mixer or applicator. Pesticide labels include these signal words and describe any personal protective equipment (PPE) applicators are required to wear.

The *Danger* signal word identifies Category 1 pesticides. These products are the most toxic and could injure or irritate individuals who are exposed to low concentrations. The PPE required for Category 1 pesticides can be extensive.

The *Warning* signal word identifies Category 2 pesticides. These products are toxic, but require substantially greater exposure levels than Category 1 pesticides to injure or irritate. The PPE requirements are generally less stringent than Category 1 pesticides.

The *Caution* signal word identifies Category 3 pesticides. These products can injure or irritate individuals at a relatively high exposure rate. The PPE required for Category 3 pesticides typically include safety glasses, long pants, rubber boots, gloves, and long-sleeved shirts.

A different set of categories are used to identify the effects on beneficial arthropods. Obviously, humans are physiologically different from arthropods — and there are substantial differences among arthropods. A pesticide's effect on beneficial arthropods vary by the arthropod population's susceptibility and resilience. The International Organization for Biological Control (IOBC) ranks pesticides on a 1 to 4 scale to measure mortality.

In the IOBC system, pesticides rated 1 are *Harmless,* meaning less than 30 percent of a beneficial arthropod population dies following direct exposure.

Pesticides rated 2 are *Slightly Harmful,* meaning 30-79 percent of the beneficial population dies.

Pesticides rated 3 are *Moderately Harmful,* meaning 79-99 percent of the beneficial population dies.

Pesticides rated 4 are *Harmful,* meaning more than 99 percent of the beneficial population dies.

Table 7 provides information about three key beneficial arthropods that occur on hops: predatory mites, lady beetles, and lacewing larvae. The rankings are summarized from an amalgam of research projects that have been conducted on these organisms.

Table 7. *Signal Words and Relative Impact of Pesticides Registered for Use on Hops on Representative Non-target Beneficial Arthropods*

Active Ingredient	Signal Word	Beneficial arthropod IOBC Rankings[1]			
		Trade Name	Predatory Mites	Lady Beetles	Lacewing Larvae
Fungicides					
Bacillus pumilus	Caution	Sonata®	1	ND	ND
boscalid	Caution	Pristine®	1	ND	ND
copper	Caution	various formulations	1	ND	ND
cymoxanil	Warning	Curzate 60DF®	ND	ND	ND
dimethomorph	Caution	Acrobat® (renamed Forum®)	ND	ND	ND
famoxadone & cymoxanil	Caution	Tanos®	ND	ND	ND
fosetyl-Al	Caution	Aliette WDG®	ND	ND	ND
kaolin	Caution	Surround®	3	ND	ND
mandipropamid	Caution	Revus®	2	2	ND
mefenoxam	Caution	Ridomil®	ND	ND	ND
metalaxyl	Warning	MetaStar®	ND	ND	ND
mineral oil/petroleum distillate	Caution	various formulations	2	ND	ND
myclobutanil	Warning	Rally 40W®	2	1	ND
phosphorous acid	Caution	Fosphite® (and others)	ND	ND	ND
pyraclostrobin	Caution	Pristine®	ND	ND	ND
quinoxyfen	Caution	Quintec®	1	ND	ND
sodium borate	Warning	Prev-Am®	2	ND	ND
spiroxamine	Caution	Accrue®	ND	ND	ND
sulfur	Caution	various formulations	2	ND	ND
tebuconazole	Caution	Folicur 3.6F®	1	ND	ND
trifloxystrobin	Caution	Flint®	1	ND	ND
Active Ingredient	**Signal Word**	**Beneficial arthropod IOBC Rankings[1]**			
		Trade Name	**Predatory Mites**	**Lady Beetles**	**Lacewing Larvae**
Herbicides					
2,4-D	Danger	Weedar 64® (and others)	ND	ND	ND
clethodim	Warning	Select Max®	1	ND	ND
flumioxazin	Caution	Chateau®	2	2	ND
glyphosate	Caution	Roundup® (and others)	1	ND	ND
norflurazon	Caution	Solicam®	ND	ND	ND
pelargonic acid	Warning	Scythe®	ND	ND	ND
trifluralin	Caution	Treflan® (and others)	2	ND	ND
Insecticides/Miticides					
abamectin	Warning (RUP)	Agri-Mek® (and others)	3	3	ND
Bacillius thuringiensis var. *aizawal*	Caution	Xentari® (and others)	1	1	ND
Bacillius thuringiensis var. *kurstaki*	Caution	Dipel® (and others)	1	1	ND
beta-cyfluthrin	Warning (RUP)	Baythroid XL®	4	4	4
bifenazate	Caution	Acramite 50WS®	1	2	ND
bifenthrin	Warning (RUP)	Brigade® (and others)	4	4	4
cyfluthrin	Danger (RUP)	Baythroid 2E®	4	4	4
dicofol	Caution	Dicofol®	1	1	ND
etoxazole	Caution	Zeal®	2	2	ND
fenpyroximate	Warning	Fujimite®	1	3	ND
hexythiazox	Caution	Savey 50DF®	1	1	ND
imidacloprid	Caution	Provado® (and others)	1	3	3
malathion	Warning	various formulations	3	4	3
pymetrozine	Caution	Fulfill®	1	1	1
pyrethrin	Caution	Pyganic® (and others)	2	2	2
spinosad	Caution	Success® (and others)	2	2	1
spirodiclofen	Caution	Envidor®	2	2	1
spirotetramat	Caution	Movento®	1	1	1
thiamethoxam	Caution	Platinum®	1	2	ND

[1]International Organization for Biological Control (IOBC) has categorized pesticides using a ranking of 1 to 4. The rankings represent relative toxicity based on data from studies conducted with tree fruit, hops, mint, and grapes. 1=less than 30% mortality following direct exposure to the pesticide. 2=30-79% mortality. 3=79-99% mortality. 4=greater than 99% mortality. ND=not determined.

[2]IOBC rankings not available for this newly registered product. Tests in 2009/2010 determined these compounds safe on predatory mites and Stethorus.

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November 2018