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Hops Production in Indiana

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Integrated Pest Management Guide for Hops in Indiana 2014

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. 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.

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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. There are three pre-emergent herbicides and four post-emergent herbicides labeled for hops in Indiana (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 do not recommend applying pre-emergent herbicides with a backpack sprayer because they cannot be applied precisely.

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 only treat 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 or 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
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
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
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

Integrated disease management requires knowing the diseases' life cycles, their symptoms on hop plants, and control measures. Two diseases are described below: downy mildew (which has been detected in Indiana hops) and powdery mildew (which has not yet been detected in Indiana).

It is essential to scout the hopyard to manage diseases. Early detection and cultural management can significantly reduce disease severity. However, you can usually achieve the best control when you combine cultural practices and chemical applications. 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 control the problem.

Correct pest identification is critical in integrated pest management. This is especially true for downy and powdery mildew control. Different types of fungi cause these diseases, and the chemicals that control one generally do not control the other.

The easiest way to tell the difference between powdery mildew and downy mildew is where the

fungus grows. Powdery mildew colonies form on the outside of the plants, almost always on the upper surfaces of leaves. Downy mildew grows inside leaves and produces spore-bearing structures only on the lower surfaces of leaves.

There are several fungicides labeled for control 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 control downy mildew and those that primarily control powdery mildew. A few broad-spectrum fungicides will control both diseases.

Table 2 lists fungicide products approved for downy mildew control; Table 3 lists products for 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. There are several resources available to help you identify these diseases, including the *Field Guide for Integrated Pest Management in Hops* (ipm.wsu.edu/field/pdf/HopHandbook2009.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 fees, contact your Purdue Extension county office (extension.purdue.edu/pages/CountyOffices.aspx) or the PPDL (ppdl.purdue.edu).

Downy Mildew

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 becomes systemic in the crowns of infected plants. In the spring, characteristic diseased shoots (called spikes) emerge. They are usually stunted and yellow with curling or cupping leaves. The leaves may become dry and brittle and dry up from the base of the spike upward. Infected spikes 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. Sporangia (the fruiting structures of the fungus) will emerge from the lesions on the undersides of leaves and are purple to black.

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. 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. Cascade, Chinook, Columbia, Fuggle, Perle, Tettnanger, and Willamette are reported to be moderately resistant; Cluster, Centennial, Galena, and Nugget are reported as susceptible (Johnson, et al., 2009).

Mechanical Controls
Downy mildew can spread into hopyards by various means. The wind can blow spores from an infected field, or growers may accidently bring in spores on clothing or tools after visiting an infected area.

So strict sanitation is critical for downy mildew control. Remove infected spikes as they appear in the spring to greatly reduce disease severity. You can remove them mechanically or chemically, but should be removed weekly for best control (Skotland and Johnson, 1983).

Well-timed pruning is another management strategy. Spring pruning removes buds, shoots, and the previous season's bines (hop shoots are called bines, not vines). Prune after shoots emerge but before training. Crowning and scratching are 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.

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 five feet of the trained bines limits spread into the upper canopy. 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.

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

Table 2 lists the fungicides labeled for downy mildew control in hops in Indiana. Carefully read the entire labels before use because some products should not be tank-mixed or used close together or 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

Powdery mildew has not been reported on hops in Indiana but is a problem in the Pacific Northwest (where most U.S. hops are grown) and in the Northeast. So, it is likely that powdery mildew could become a problem in Indiana.

Powdery mildew can infect all green tissue of the plant. Leaves commonly show infection as white colonies on the upper surface. Colonies can also occur on stems and cones. These colonies are the hyphae and spores of the fungus living on the outside the host plant. Cones that are infected early in the season may be distorted and reduced in size. 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, or to avoid varieties that are known to be susceptible. Brewers Gold, Cascade, and Nugget are reported to be moderately resistant; Chinook, Fuggle, Galena, Mt. Hood, Perle, Tettnanger, and Willamette are reported as susceptible (Gent, et al., 2009).

Mechanical Controls
The wind can blow downy mildew spores from an infected field, or growers may accidently 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 aimed primarily at removing the source of inoculum. Pruning, crowning, and/or scratching are common practices.

Like powdery mildew, removing leaves and laterals from the lower 5 feet of bines after training will help reduce the spread of downy 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. However, since we have not seen this disease in Indiana yet, we do not know if chemical control will be necessary. Table 3 lists the fungicides labeled for powdery mildew control on hops in Indiana.

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®, Fungiphite®, 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 training, 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	1.8 pt/A Treat crowns after pruning but before training.	14	48
Champ Dry Prill®, Champ Formula 2, Flowable®, NuCop 3L®, 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
Copper-Count N®	copper diammonia diacetate complex	M1/low	2 qt/A Apply as needed at 10-day intervals. Treat crowns after pruning but before training. Discontinue 2 weeks before harvest. No more than 13.7 qt/A/year.	14	48
Cuprofix Ultra 40 Disperss® Basic Copper HB®	basic copper sulfate	M1/low	1.0-1.25 lb/A (no more than 6.6 lb/A/year) 0.5-1.0 lb/A (no more than 5 lb/A/year) Treat crowns after pruning, but before training. After training, make additional applications at 10-day intervals as needed. Discontinue 2 weeks before harvest.	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
Pristine®	boscalid pyraclostrobin	7/med-high 11/high	28 oz/A (no more than 70 oz/season) 14 oz/100 gal (no more than 3 applications/season)	14	12
ProPhyt®	potassium phosphite	33/low	2-4 pt/A When shoots are 6-12 in high, after training; when bines are 5-6 ft tall; 3 weeks after the second application; during bloom.	0	4
Ranman®	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.	24	12
Revus®	mandipropamid	40/low-med	8.0 fl oz/A No more than 24 fl oz/season. No more than 2 consecutive applications.	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 that 3 applications/season.	45	48
Sonata®	*Bacillus pumilus* strain QST 2808	44/unknown	2-4 qt/100 gal — see label for acre rates Can be used for organic production	0	4
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

[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)
Accrue®	spiroxamine	5/low-med	18 fl oz/A	7	12
Flint 50W®	trifloxystrobin	11/high	See label for rates Alternate with of sterol inhibitor (FRAC group 3) fungicides.	14	24
Orius 3.6F® Solera Tebuconazole 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
Procure 480SC®	triflumizole	3/med	12 oz/A No more than 36 fl oz./season	7	4
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.	7	12
Rally 40WSP®	myclobutanil	3/med	*Emergence to training:* 2-4 oz/A (7- 10-day intervals) *Training to wire:* 4-6 oz/A (5-10-day intervals) *Wire to 14 days pre-harvest:* 6-10 oz/A (7-10-day intervals) No more than 4 applications/season. No more than 2.5 lb/A/ season.	14	24
Serenade Max®	*Bacillus subtilis*	44/unknown	2-3 lb/100 gal/A.	0	4
sulfur (many formulations available)	sulfur	M2/low	See labels for specific directions. See Table 4.	7	12
Stylet Oil®	paraffinic oil	NC/unknown	1-2 gal/ 100 gal water Discontinue at burr development. An OMRI-approved organic formulation is available. Be cautious — phytotoxicity has been documented.	N/A	4

[1] 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.

Table 4. *OMRI-listed Fungicides Registered for Use on Hops in Indiana 2014*[1]

Trade Name	Common Name	FRAC[2] Group/ Resistance Risk	Diseases Treated	Rates/Notes	PHI[3] (days)	REI[4] (hours)
Agristar Basic Copper 53®	basic copper sulfate	M1/low	downy mildew	1.0 lb/A No more than 5.0 lb/A/year. Apply to crowns after pruning but before training. After training, additional fungicide treatments are needed at about 10-day intervals.	0	48
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 lb/A Treat crowns after pruning but before training.	14	48
Bio-tam®	*Trichoderma asperellum* strain ICC 012 *T. gamsii* strain ICC 080		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.	N/A	1
Champ WG Nu-Cop 50DF® Nu-Cop HB®	copper hydroxide	M1/low	downy mildew	1.06 lb/A (no more than 5.6 lb/A/year) 1.0 lb/A (no more than 5.0 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 treatments are needed at about 10-day intervals. Minimum retreatment interval: 10 days.	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	N/A[5]	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
Eco-mate Armicarb O®	potassium bicarbonate	NC/unknown	anthracnose, downy mildew, powdery mildew	2.5-5 lb/A	0	4
Kaligreen®	potassium bicarbonate	NC/unknown	powdery mildew	2.5-5 lb/A		4
Sonata®	*Bacillus pumilus*	44/unknown	downy mildew, powdery mildew	2-4 qt/100 gal (see label for acre rates)	24	48
Stylet Oil®	paraffinic oil	NC/unknown	powdery mildew	1-2 gal/100 gal water Discontinue at burr development. Be cautious — phytotoxicity has been documented.	N/A	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]N/A=not applicable. 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.

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	8.0-16.0 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
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	3.8-6.4 fl oz/A RUP[6]	14	12 hr
Brigadier®	bifenthrin imidacloprid	3A 4A	aphids, armyworms, leafhoppers, other Lepidopterous larvae	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
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
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
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.	0	12 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 (2014), 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 2014*[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)
Acoidal® Microthiol Disperss®	sulfur	M	mites	no	2-6 lb/100 gal/A Do not use within 2 weeks of an oil treatment.	0	24
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
Cosavet DF®	sulfur	M2	mites	no	*Mites:* 2-4 lb/100 gal/A *Mildew:* 4-6 lb/100 gal/A Do not use within 2 weeks of an oil treatment.	0	24
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
Ecotec®	rosemary oil peppermint oil	NC	mites, thrips	no	1.0-4.0 pt/100 gal/A Spreader/adjuvant recommended.	0	0
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
Kumulus®	sulfur	M	mites	no	2-4 lb/A Do not use within 2 weeks of an oil treatment.	0	24
Mycotrol O®	*Beauvaria bassiana*	biological	aphids, thrips	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
Silmatrix®	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 (2014), 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®	OK[2]	OK[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

continued on next page...

Table 7, continued

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®	OK[2]	OK[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®	OK[2]	OK[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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