2017

Michigan Hop Management Guide

MICHIGAN STATE UNIVERSITY | Extension

Table of Contents

Information presented here does not supersede the label directions. To protect yourself, others, and the environment, always read the label before applying any pesticide. Although efforts have been made to check the accuracy of information presented, it is the responsibility of the person using this information to verify that it is correct by reading the corresponding pesticide label in its entirety before using the product.

The information presented here is intended as a guide for Michigan hop growers in selecting pesticides and is for educational purposes only. Labels can and do change, greenbook.net, cdms.com, and agrian.com are free online databases for looking up label and MSDS information.

The efficacies of products listed have not been evaluated on hop in Michigan. Reference to commercial products or trade names does not imply endorsement by Michigan State University Extension or bias against those not mentioned.

Questions? For pest management questions, contact Erin Lizotte at taylo548@msu.edu or 231-944-6504, for nutrient management questions contact Rob Sirrine at sirrine@msu.edu or 231-256-8888.

Weed Management Tips to Achieve Best Results[1]

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 practices. 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. The benefits of this practice include less erosion and soil compaction, better water infiltration, and a habitat to attract beneficial insects.

The width of the in-row weed-free strip depends on soil type, and grower preference. Generally, the strip should be wider on soils that have low moisture holding capacity. A width of 4 feet is probably adequate, but there is limited experience with hops on Michigan soils. Either mechanical or chemical means (or a combination of both methods) can be used to manage weeds in this strip.

Mechanical Controls

Mechanical cultivation is very effective at reducing weed populations. However, frequent 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 are effective but labor intensive.

Chemical Controls

There are a limited number of herbicides registered for use on hops in Michigan. Normally, growers will use both pre and post-emergent herbicides to achieve the 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. Applying pre-emergent herbicides with a backpack sprayer is not recommended because they cannot be applied precisely enough.

Post-emergence herbicides are easier to apply with hand-held equipment because they are applied as a dilution instead of 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. Some products require crop oil concentrate or a surfactant added for best results, while others may include an adjuvant. Be sure to read the label to determine what type of adjuvant (if any) is needed.

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. 2,4-D and glyphosate are examples of herbicides that must be used very carefully to avoid injury.

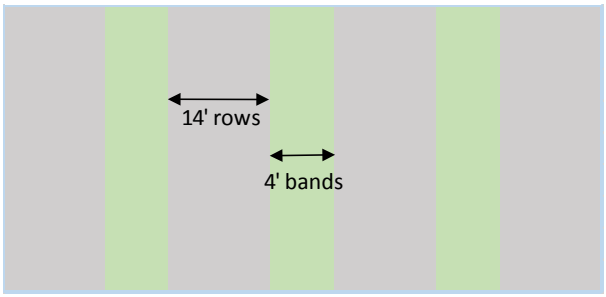
APPLYING BANDED APPLICATIONS

It is 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 only a narrow band along the row will be treated, so applicators must adjust the rate for the band width and the row spacing. An example of applying herbicides as a banded application follows.

An acre is 43,560 square feet. In this example, an acre of a hopyard has rows planted 14 feet apart. That would mean that 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 the applicator applies that full pound banded to the rows in the 1-acre hopyard, that herbicide is actually applied at 3.5 times the labeled rate, enough to severely damage the hop plants.

In the example given, 0.28 pounds of the herbicide should be applied 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. In the example given, the sprayer would be calibrated to apply 30 gallons per acre, and the tank filled with 8.4 gallons of water (30 x 0.28). The 0.28 pounds of product would be added and mixed with the water, and applied 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 the hopyard example provided.

Figure 1. Example for determining banded rates.



1. Divide 1 acre in sq. ft. by row spacing in ft. to determine feet of row per acre. 43,560/14 = 3,111ft

2. Multiply the feet of row by the band width to get the area to be treated. 3,111’ x 4’ = 12,444 sq. ft.

3. Divide the treated area by the area of an acre to get the percentage of acre treated.
12,444/43,560 = 0.28 = 28%

4. Multiply the herbicide broadcast rate by the percentage of an acre as determine in step 3.
1 pound x 0.28 = 0.28 pounds

5. Multiply the recommended volume of water for an acre by the percentage of an acre as determined in step 3. 30 gallons x 0.28 = 8.4 gallons.

1. ID-462-W Hops Production in Indiana, Integrated Pest Management Guide for Hops 2015

REGISTERED HERBICIDES

Application timing[1]	Broadleaf or grasses	Active ingredient (WSSA code[2])	Trade name	REI/PHI[3]	Notes
Postemergent	Both	glyphosate (9)	Abundit Extra, Alecto 41-S, Buccaneer, Buccaneer Plus, Cornerstone Plus, Credit 41, Credit 41 Extra, Credit Xtreme, CropSmart Glyphosate 41 Plus, Duramax, Envy, Envy Intense, Gly Star Original, Glyfos, Glyfos X-tra, Glyphogan, Honcho, Honcho Plus, Roundup PowerMAX, Roundup WeatherMAX, Shar-Max Glyphosate 41% SL, Showdown	see label/14d	Apply only when green shoots, foliage or canes are not in the spray zone. Best combined with a pre-emergent early in spring for control of emerged annual and perennial weeds.
	Both	ammonium nonanoate	Axxe*	24h/0d	Avoid spraying desirable plants. OMRI listed.
	Both	ammoniated soap of fatty acids	Finalsan Total Vegetation Killer*	24h/-	Avoid spraying desirable plants. OMRI listed.
	Both	pelargonic acid (27)	Scythe	12h/24h	Uses in hops-vegetative burndown, directed spray, prior to crop emergence, dormant or post harvest spray.
	Both	cinnamon and clove oil	Weed Zap*	-	Apply to actively growing weeds. Non selective contact herbicide.
	Broadleaf	carfentrazone (14)	Aim EC[4]	12h/7d	Use shielded or hooded sprayers. Used to control small broadleaf weeds as well as hop suckers and lower bine foliage. Allow 19 d between treatments.
	Broadleaf	2,4 D (4)	2,4 D Amine 4, Base Camp Amine 4, Clean Amine, Drexel De-Amine 4, Radar AM, Rugged, Shredder Amine 4, Weedar 64,Weed RHAP A 4D	see label	Controls most annual and perennial broadleaf weeds. Use as a directed spray to row middles. Ester* formulations restricted in certain townships in Berrien, Van Buren and Cass County- May 1-October 1.
	Broadleaf	clopyralid (4)	Spur	12h/30d	Retreatment interval is 21 days. Controls Canada thistle.
	Grasses	clethodim (1)	Arrow 2EC, Avatar S2, Cleanse 2EC, Clethodim 2E, Clethodim 2EC, Intensity, Intensity One, Opti-Amine, Section 2EC, Section Three, Select Max, Shadow, Shadow 3EC, Tapout, Tide Clethodim 2EC, Volunteer	see label	Controls annual and perennial grasses.
Pre- emergent	Annual grasses/ broadleaf	trifluralin (3)	Treflan 4EC, Treflan 4L, Treflan HFP, Treflan TR-10, Trifluralin 10G, Trifluralin 4EC, Triflurex HFP, Trust	12h/-	Rate determined by soil type- see label. Apply during dormancy.
	Both	flumioxazin (14)	Chateau SW, Tuscany, Warfox	12h/30d	Apply Jan-Mar as a 1-1.5 ft. band to dormant hops. Controls most broadleaves and grasses, weak on horseweed. Moisture is necessary to activate herbicide.
	Both	pendimethalin	Prowl H20	24h/90d	Apply as a broadcast or banded treatment using ground equipment. Apply the spray directly to the ground beneath the vines and in areas between rows. Do not apply over the top of vines, leaves or cones.
	Both	norflurazon (12)	Solicam DF	12h/60d	Rate determined by soil type- wait 6 months after planting for first application.

1. Pre-emergent herbicides may be applied to control weeds before germination takes place. Post-emergent herbicides may be applied to actively growing weeds. **2.** WSSA = Weed Science Society of America mode of action code for resistance management planning. **3.** PHI-preharvest interval, REI-restricted entry interval, expressed as h-hours or d-days. **4.** Growers may need to print and retain a copy of the 24C Special Local Need Label to apply Aim, available via MDARD.

***** OMRI approved for organic production. ****** Products containing these active ingredients are classified as a restricted use pesticides and require the applicator to retain a pesticide applicator license.

DOWNY MILDEW OF HOP

QUICK FACTS ABOUT DOWNY MILDEW

- Ranks as the most destructive pest of hop in Michigan.
- Disease is caused by a fungal-like pathogen called *Pseudoperonospora humuli*.
- Significant yield and quality loss occurs, including crown death for sensitive cultivars.
- Regular rainfall favors downy mildew.
- Limit loss by selecting high quality plants, scouting for downy mildew symptoms, monitoring the weather, and applying effective fungicides preventively and at specified intervals.

Disease cycle

The downy mildew pathogen survives Michigan winters in dormant hop buds or crowns and then moves into the expanding basal shoots in the spring. The downy mildew pathogen reproduces via spores on the underside of infected leaves. Spores move to healthy hop buds, growing points, cones, and leaves via wind. If the terminal growing point becomes infected, then the pathogen becomes 'systemic' and can grow down through the plant toward the crown where it persists in the buds and crown. The pathogen can also produce a resistant spore type in some situations but their presence and role in Michigan hopyards isn't clear. Mild to warm temperatures (60-70 °F) are optimum for the pathogen along with at least 1.5 hours of free moisture from rain or dew. If free moisture persists (24 hours or longer) infection can also occur at low temperatures of 41 °F.

Scouting

Scouting for downy mildew should begin when plants begin to grow and continue until the crop is dormant. Weekly scouting and monitoring is recommended and can help determine the level of disease that is present and whether current management practices are effective. Disease symptoms include stunted basal shoots that appear yellowish, bines that fail to climb the coir, brownish leaf lesions and terminal buds on sidearms. Disease signs include a gray to brown, fuzzy appearance on the underside of infected leaves due to the pathogen reproducing. Determine manageable parcels to monitor based on location, size and variety and scout these areas separately. It may be practical to monitor blocks that are 10 acres or smaller with plants of the same variety, age and spacing. Walk diagonally across the yard and along an edge row and change the path that is walked each time so as to inspect new areas. If downy mildew is observed, re-examine those specific areas each week.

Picture A. Stunted downy mildew infected spike with sporulation. B. Downy mildew infected bine with cupped leaves failing to climb the string. C. Downy mildew sporulating on the underside of a leaf. Photo credit: Erin Lizotte, Michigan State University.

Scouting records, including field maps, records of sampling and disease pressure, and fungicides/control measures provide valuable information that can improve overall management strategies and limit loss.

Management

The downy mildew pathogen is aggressive when the weather pattern is wet and humid and a multipronged approach is needed. Currently, most varieties grown in Michigan are considered to be disease susceptible. Efforts to limit downy mildew can fail if the correct fungicides are not chosen or are not applied correctly. Thorough spray coverage is crucial and the days between fungicide sprays may need to be shortened during periods of wet weather. In other hop growing regions of the U.S., the downy mildew pathogen has become resistant to key fungicides. Michigan hop growers should consider using a preventive fungicide spray program along with cultural practices to limit severe infections.

Apply fungicides preventively as soon as bines emerge in the spring. Fungicide use should continue season long on a 7-10 day reapplication interval until harvest. Postharvest applications may also be needed. The time between applications may be increased when the weather is hot and dry and if hopyards do not have evidence of downy mildew. Similarly, the time between applications may need to be shortened when the weather is rainy and humid. Alternating between fungicides with different modes of action is important to delay the development of pathogen resistance. Special attention should be noted to those periods in the season that are particularly critical for disease control including immediately before and after training, when lateral branches begin to develop, bloom, and cone development. Protecting young, developing bracts before cones close is critical to limiting downy mildew when conditions are wet and humid. Covering the undersides of bracts where infection occurs becomes difficult as cones mature. If needed, growers should be prepared to apply post-infection treatments. Refer to the current list of registered fungicides at www.hops.msu.edu for more information.

Cultural practices include arranging the hopyard in a manner that maximizes airflow, rogueing diseased hop plants and removing them from the premises (do not compost, bury). Hop cultivars can vary in their susceptibility to downy mildew and how these cultivars might fare under the severe disease pressure that can occur in Michigan is not known. At this time, if cultivars are available that are considered to be somewhat tolerant that could be helpful. Clean planting materials should be used when establishing new hopyards since downy mildew can be spread via nursery stock with no symptoms.

To minimize downy mildew, it is also recommended that growers pull all basal foliage during spring pruning. Spring pruning should be performed as late as possible and all green plant material should be removed from the hopyard and covered up or burned. Early harvest can also minimize cone infection when infection pressure is high.

If downy mildew occurs in the hopyard after training, diseased shoots on the string should be removed by hand and healthy shoots retrained in their place. Remove extra basal foliage and lower leaves to promote air movement in the canopy and to reduce the duration of wetting periods. If there is a cover crop, it should be mowed close to the ground. Fertilize in moderation to avoid the development of succulent plant tissue that may be especially susceptible to disease.

Organic growers should focus on selecting downy mildew tolerant varieties and following cultural practices to limit disease. Copper-based products are the mainstay of downy mildew management in organic hopyards but offer limited protection. All applications must be preventive. The pre-harvest intervals for copper formulations vary, refer to the label. Additional organic products are available, for a complete list refer to the current hop pesticide guide at www.hops.msu.edu.

REGISTERED FUNGICIDES

	Active ingredient (FRAC code[1])	Trade name	Diseases listed on label[2]	REI/PHI[3]
Single site	cyazofamid (21)	Ranman, Ranman 400 SC	DM	12h/3d
	cymoxanil (27)	Curzate 60 DF	DM	12h/7d
	fluopyram (7)	Luna Privilege	PM	12h/7d
	flutriafol (3)	Rhyme	PM	12h/7d
	mefenoxam (4)	Ridomil Gold SL, Ultra Flourish	DM	48h/45d
	metalaxyl (4)	MetaStar 2E, Metalaxyl 2E Ag	DM	48h/45d
	quinoxyfen (13)	Quintec	PM	12h/21d
	tebuconazole (3)	AmTide Tebu 3.6F, Monsoon, Onset 3.6 L, Orius 3.6 F, Willowood Tebucon 3.6 SC, Tebu-Crop 3.6 F, Tebucon 3.6 F, Tebustar 3.6 L, Tebuzole 3.6 F, Toledo 3.6 F	PM	12h/14d
	trifloxystrobin (11)	Flint	PM	12h/14d
	triflumizole (3)	Procure 480 SC	PM	12h/7d
Multi-site	basic copper sulfate (M1)	Agristar Basic Copper 53*, C-O-C-S WDG, Cuprofix Ultra 40 Disperss, Cuproxat, Mastercop	DM	see label
	copper octanoate (M1)	Cueva*	Anthracnose, DM, PM	4h/0d
	copper diammonia diacetate complex (M1)	Copper-Count-N	DM	48h/14d
	copper hydroxide (M1)	Champ DP Dry Prill, ChampION++, Champ Formula 2 Flowable, Champ WG*, Kentan DF, Kocide 2000, Kocide 3000, Nu-Cop 3L, Nu-Cop 50 DF*, Nu COP 50 WP*, Nu-Cop HB*, Nu-Cop XLR, Previsto	DM	48h/14d
	copper oxychloride + copper hydroxide (M1)	Badge SC, Badge X2*	DM	48h/14d
	cuprous oxide (M1)	Nordox 75 WG*	DM	12h/-
	dimethomorph (40)	Forum	DM	12h/7d
	mandipropamid (40)	Revus	DM	4h/7d
	metrafenone (U8)	Vivando	PM	12h/3d
	sulfur (M2)	Cosavet DF*, Cosavet DF Edge*, Microfine Sulfur*, Thiolux*	PM	see label
Premix	boscalid (7) + pyraclostrobin (11)	Pristine	DM, PM	12h/14d
	famoxadone (11) + cymoxanil (27)	Tanos	DM	12h/7d
	fluopyram (7) + trifloxystrobin (11)	Luna Sensation	DM, PM	12h/14d
	fluopyram (7) + tebuconazole (3)	Luna Experience	PM	12h/14d
	tebuconazole (3) + sulfur (M2)	Unicorn DF	PM	12h/14d
	ametoctradin (45) + dimethomorph (40)	Zampro	DM	12h/7d
Plant defense inducers	fosetyl-Al (33)	Aliette WDG, Linebacker WDG	DM	12h/24d
	phosphorous acid, mono & di-potassium salts (33)	Agri-Fos, Confine Extra, K-Phite 7LP Ag, Phiticide, Phostrol	DM	4h/0d
	potassium phosphite (33)	Fosphite, Fungi-Phite, Prophyt, Rampart	DM	4h/0d

1. FRAC - Fungicide Resistance Action Committee (FRAC) codes are used to distinguish the fungicide groups for resistance management purposes. Consecutive application of fungicides with the same FRAC code is not recommended. **2.** PM-powdery mildew, DM-downy mildew. **3.** PHI-preharvest interval, REI-restricted entry interval expressed as h-hours or d-days. * OMRI approved for organic production.

REGISTERED FUNGICIDES

	Active ingredient (FRAC code[1])	Trade name	Diseases listed on label[2]	REI/PHI[3]
Biopesticide	*Bacillus amyloliquefaciens* strain D747 (44)	Double Nickel 55*	PM	4h/0d
	Bacillus pumilus strain QST 2808 (44)	Sonata*	DM, PM	4h/0d
	Bacillus subtilis(44)	Serenade Max*, Serenade ASO*, Sonata	PM	4h/0d
	extract of neem oil	Trilogy*	DM, PM	4h/0d
	paraffinic oil	Stylet oil*	PM	4h/0d
	potassium bicarbonate	Eco-mate*, Armicarb-O*, Kaligreen*, Milstop*	PM, DM, anthracnose	see label
	Reynoutria sachalinensis extract (P5)	Regalia*	DM, PM	4h/0d
	sodium borate	Prev-Am	DM, PM	12h/0d
	Streptomyces lydicus WYEC 108	Actinovate AG*, Actinovate STP*	Verticillium wilt, DM, PM	1h/0d
	tea tree oil (F7)	Timorex Gold	DM, PM	24h/48h
	Trichoderma asperellum	Bio-tam*	Phytophthora root rot, verticillium wilt	1h/-
	Trichoderma asperellum + Trichoderma gamsii	Tenet WP*	Phytophthora root rot, verticillium wilt	1h/-

1. FRAC - Fungicide Resistance Action Committee (FRAC) codes are used to distinguish the fungicide groups for resistance management purposes. Consecutive application of fungicides with the same FRAC code is not recommended. 2. PM-powdery mildew, DM-downy mildew. 3. PHI-preharvest interval, REI-restricted entry interval expressed as h-hours or d-days. * OMRI approved for organic production.

REGISTERED INSECTICIDES

Chemical Class (IRAC group)	Active Ingredient (IRAC group)	Products Labeled	Pesticide Efficacy[1]				REI/PHI[2]
			Potato leafhopper	Rose chafer	Japanese beetle	Two-spotted spider mite	
Acequinocyl (20B)	Acequinocyl	Kanemite 15SC	N	N	N	G	12h/7d
Avermectins (6)	Abamectin**	Abacus, Abacus V, Abba 0.15, Abamectin 0.15EC, Abba Ultra, Abamex, Agri-Mek SC, Agri-Mek 0.15EC, Borrada, Epi-mek 0.15 EC, Reaper 0.15 EC, Reaper Clearform, Reaper Advance, Temprano, Tide Timectin 0.15EC AG, Zoro	U	G	N	E	12h/28d
Biopesticides	*Bacillus thuringiensis* (11A)	Biobit HP, Deliver, Dipel DF*, Dipel ES, Javelin WG, Xentari*	N,U	N,U	N,U	N,U	see label
	Burkholderia spp.	Venerate XC	N,U	N,U	N,U	U	4h/0d
	Chromobacterium subtsugae[2]	Grandevo*, Grandevo WDG*	U	N	N	U	4h/0d
	Kaolin[2]	Surround WP	U	F	F	N	4h/0d
	Myrothecium verrucaria[2]	Ditera DF*	N,U	N,U	N,U	N,U	4h/-
	Potassium salts of fatty acids[2]	Des-X*, M-Pede*	N	N	N	U	12h/0d
	Oil, mineral	Damoil, Purespray Green, Tritek	N	N	N	U	4h/0d
	Oils, petroleum based	Biocover MLT, Glacial Spray Fluid, JMS Stylet Oil, Omni Supreme Spray, Organic JMS Style Oil*, Suffoil X*, Ultra Pure Oil	N	N	N	U	see label
	Oils, plant based	Ecotec*	N	N	N	U	0/0
Butenolides (4D)	Flupyradifurone	Sivanto 200SL	N	N	N	N	4h/21d
Diamides (28)	Chlorantraniliprole	Coragen	N	N	N	N	4h/0d
Flonicamid (9C)	Flonicamid	Beleaf 50SG	N	N	N	N	12h/10d
Insect growth regulators	Azadirachtin	Aza-Direct*, Azatin O, AzaGuard, Azatrol EC, Ecozin Plus 1.2% ME*, Molt-X, Trilogy	U	F	F	U	4h/0d
	Etoxazole	Zeal Miticide 1, Zeal SC	N	N	N	E	12h/7d
	Hexythiazox(10A)	Savey 50 DF	N	N	N	R	12h/0d
METI (21A)	Fenpyroximate	Fujimite XLO, Portal, Portal XLO	G	N	N	G	see label
Multisite inhibitor (8B)	1,3-dichloropropene + Chloropicrin**	Telone C-17, Telone C-35, Telone II	N	N	N	N	see label
Multisite, Organophosphates (1B)	Malathion	Cheminova Malathion 57%, Malathion 5, Malathion 5EC, Malathion 57EC, Malathion 8 Aquamal, Malathion 8 Flowable	N	F-G	F-G	U	12h/10d
	Ethoprop**	Mocap EC	N	N	N	N	48h/90d
	Naled**	Dibrom 8 Emulsive	N	N	N	N	48h/7d

Pesticide efficacy is based on trials in fruit crops, as reported in the E154 Fruit Management Guide, Michigan State University Extension and South Carolina State University Extension, and UC Davis. 1. Pesticide efficacy ratings; E-excellent, G-good, F-fair, P-poor, U-unknown, N-pest not included on label. 2. PHI-preharvest interval, REI-restricted entry interval, expressed as h-hours or d-days.

* OMRI approved for organic production. ** Products containing these active ingredients are classified as a restricted use pesticides and require the applicator to retain a pesticide applicator license.

REGISTERED INSECTICIDES

Chemical Class (IRAC group)	Active Ingredient (IRAC group)	Products Labeled	Pesticide Efficacy[1]				REI/PHI[2]
			Potato leafhopper	Rose chafer	Japanese beetle	Two-spotted spider mite	
Neonicitinoids (4A)	Imidacloprid(4A)	Admire Pro, Advise 2FL, Advise Four, Alias 2F, Couraze 2F Couraze 4F, Couraze 4, Imidacloprid 4F, Imidacloprid 4SC, Macho 2.0 FL, Macho 4.0, Malice 2F, Malice 75 WSP, Mana Alias 4F, Montana 2F, Montana 4F, Midash 2SC, Midash Forte, Nuprid 2F, Nuprid 2SC, Nuprid 4.6F Pro, Nuprid 4F Max, Pasada 1.6F, Provado 1.6F, Prey 1.6, Provoke, Sherpa, Widow, Wrangler	G	G	G	N	see label
	Thiamethoxam(4A)	Platinum, Platinum 75SG	G	G	G	N	12h/65d
Propargite (12C)	Propargite	Omite 6E**	N	N	N	U	21d/14d
Pyrethroids (3)	Bifenthrin**	Athena, Avenger S3, Bifen 2AG Gold, Bifen25% EC, Bifenthrin 2EC, Bifenture 10DF, Bifenture EC, Brigade WSB, Brigade 2EC, Discipline 2EC, Fanfare ES, Fanfare 2EC, Fanfar EC, Sniper, Tundra EC	G	U	E	U	see label
	Cyfluthrin**	Tombstone, Tombstone Helios	U	N	U	N	12h/7d
	Pyrethrins	EverGreen EC60-6*, Pyganic EC 1.4 II*, Pyganic EC 5.0 II*, Tersus	U	F	F	U	12h/0d
	Beta-cyfluthrin**	Baythroid XL	E	G	G	U	12h/7d
Pyridine azomethine derivatives (9)	Pymetrozine	Fulfill	N	N	N	N	12h/14d
Spinosyns (5)	Spinosad	Entrust*, Entrust SC*, GF-120 NF*, SpinTor 2SC*	N	N	N	U	4h/1d
	Spinetoram	Delegate WG	N	G	N	N	
Tetramic acids (23)	Spirodiclofen	Envidor 2SC	N	N	N	E	12h/14d
	Spirotetramat	Movento	N	N	N	U	24h/7d
Premixed products	Beta-cyfluthrin(3)** + Imidacloprid(4A)	Leverage 360	U	G	G	N	12h/28d
	Bifenthrin(3)** + Imidacloprid(4A)	Brigadier, Skyraider, Swagger, Tempest	N	U	U	U	12h/28d
	Abamectin(6) + Bifenthrin(3)	Athena	U	U	U	U	12h/28d
	Azadirachtin + Pyrethrin(3)	Azera	U	U	U	U	12h/0d
Not classified/unknown	Bifenazate	Acramite 50WS	N	N	N	E	12h/14d
	Dicofol	Dicofol 4E Miticide	N	N	N	U	29d/7d

Pesticide efficacy is based on trials in fruit crops, as reported in the E154 Fruit Management Guide, Michigan State University Extension and South Carolina State University Extension, and UC Davis. 1. Pesticide efficacy ratings; E-excellent, G-good, F-fair, P-poor, U-unknown, N-pest not included on label. 2. PHI-preharvest interval, REI-restricted entry interval, expressed as h-hours or d-days.

* OMRI approved for organic production. ** Products containing these active ingredients are classified as a restricted use pesticides and require the applicator to retain a pesticide applicator license.

RELATIVE IMPACT OF PESTICIDES FOR USE ON HOP ON BENEFICIAL INSECTS

Fungicides		Beneficial arthropod IOBC rankings[1]			
Active Ingredient	Signal Word	Trade Name	Predatory mites	Lady beetles	Lacewing larvae
Bacillius 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
phosphorous acid	Caution	Fosphite & other formulations	ND	ND	ND
pyraclostrobin	Caution	Pristine	ND	ND	ND
quinoxyfen	Caution	Quintec	1	ND	ND
sulfur	Caution	Various formulations	2	ND	ND
tebuconazole	Caution	Folicur 3.6F	1	ND	ND
Herbicides					
2,4-D	Danger	Weedar 64 & other formulations	ND	ND	ND
carfentrazone	Caution	Aim EC	1	ND	ND
clethodim	Warning	Select Max	1	ND	ND
clopyralid	Caution	Stinger	1	ND	ND
flumioxazin	Caution	Chateau	OK[2]	OK[2]	ND
glyphosate	Caution	Roundup & other formulations	1	ND	ND
norflurazon	Caution	Solicam	ND	ND	ND
pelargonic acid	Warning	Scythe	ND	ND	ND
trifluralin	Caution	Treflan & other formulations	2	ND	ND

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

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

Pacific Northwest Hop Handbook 2010

RELATIVE IMPACT OF PESTICIDES FOR USE ON HOP ON BENEFICIAL INSECTS

Insecticides/Miticides		Beneficial	arthropod	IOBC	rankings[1]
Active Ingredient	**Signal word**	**Trade Name**	**Predatory mites**	**Lady beetles**	**Lacewing larvae**
abamectin	Warning	Agri-Mek & other formulations	3	3	ND
B. thuringiensis subsp. aizawal	Caution	Xentari & other formulations	1	2	ND
B. thuringiensis subsp. kurstaki	Caution	Dipel & other formulations	1	2	ND
beta-cyfluthrin	Warning	Baythroid XL	4	4	4
bifenazate	Caution	Acramite-50WS	1	2	ND
bifenthrin	Warning	Brigade & other formulations	4	4	4
cyfluthrin	Danger	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	Various formulations	1	3	3
malathion	Warning	Various formulations	2	4	3
naled	Danger	Dibrom	2	4	3
pymetrozine	Caution	Fulfill	1	1	1
pyrethrin	Caution	Pyganic & other formulations	2	2	2
spinosad	Caution	Success & other formulations	2	2	1
spirodiclofen	Caution	Envidor	2	2	1
spirotetramat	Caution	Movento	1	1	1
thiamethoxam	Caution	Platinum Insecticide	1	1	ND

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

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

Pacific Northwest Hop Handbook 2010

NITROGEN HOP FERTILITY

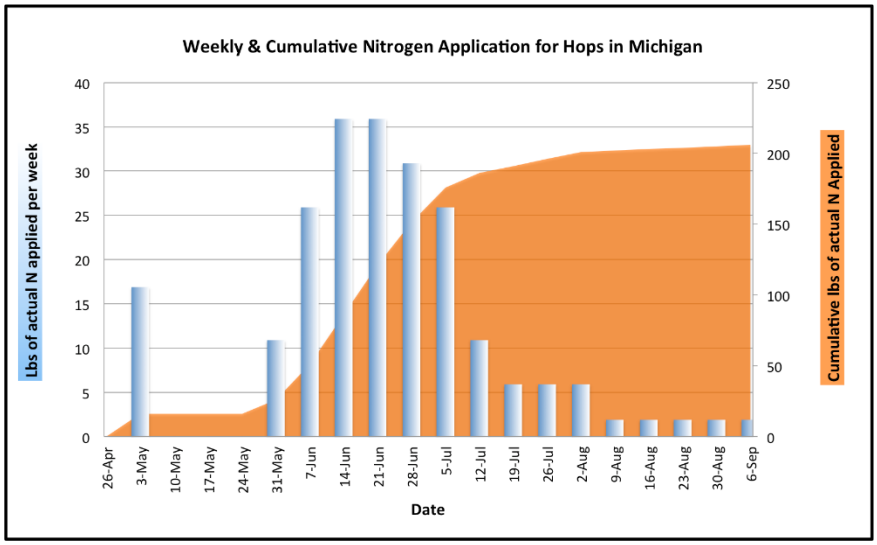


Figure 2. Weekly and cumulative nitrogen application in Michigan hops. Rob Sirrine, MSU

Nitrogen is an essential plant nutrient required for optimum cone production. The nitrogen replacement value, or the amount needed to replace what has been taken up by the plant biomass for fully-grown bines, is approximately 110 lbs./ac./year (cones-45 lbs./ac., crop residue-65 lbs./ac.). By the end of July, hops have generally accumulated 80-150 lbs. of N/ac. (Nitrogen Uptake and Utilization, Pacific Northwest Crops 513, Reprinted December 1999). Depending upon site-specific characteristics like soil quality and management practices (fertilizer type, application method, cultural practices, etc.), the nitrogen use efficiency (NUE) for hops is roughly 50 percent. This suggests that roughly half of the actual nitrogen applied is not taken up by the hop plant, but is instead lost to the environment; usually through leaching or volatilization. If the replacement value is 110 lbs./ac/yr. and only 50 percent is taken up by the hop plant, then producers should be applying 220lbs of actual N/ac./yr. However, this does not account for the method or timing of nitrogen application. Nitrogen that is banded into the hop rows in one spring application, prior to the optimum period of uptake, is likely lost at a higher rate than liquid nitrogen fertigated on a daily basis throughout the primary vegetative growth period from May-June.

Hop sites on sandy soils have low soil organic matter levels and may need to apply the higher rate of nitrogen to optimize growth. Based on average Michigan conditions, it is recommended that hop growers apply at least 200 lbs. of actual N/acre/yr. to mature hop plants. (See Figure). Near the end of June, internode length should measure around 8 inches in length. If length is less than 8 inches, growers need to increase N. If greater than 8 inches, growers should back off on N. At the same time. growers should calculate cumulative lbs. of actual N applied YTD. It should be at least 150 lbs. or more by the end of June when plants begin to transition from vegetative to reproductive growth. If the early summer has been overly wet and growers have not had the opportunity to fertigate this amount, granular N should be band applied and lightly tilled. For organic options growers can continue with composted manure and should account for this N when developing their seasonal N budgets, but should be diligent about not over applying Phosphorous. Other organic options include granular products like Nature safe 13-0-0, feather meal, and blood or bone meal that should be applied in early spring. Cover crops can also provide significant quantities of N, but cover crops must be tilled in for N to be released. For more information on cover crops please review, *Managing Cover Crops Profitably, 3rd ed.* Via the SARE (Sustainable Agriculture Research and Education) learning center at www.sare.org/Learning-Center.

Seasonal Primary Pest Occurrence in Michigan Hopyards

MICHIGAN STATE UNIVERSITY | Extension

Date	April					May					June				July				August					September			
	7	14	21	23	27	1	8	15	22	29	7	17	21	28	4	11	18	25	1	8	15	22	29	5	12	19	26
DD Base 50[1]	6	20	43	46	60	71	96	180	270	320	500	645	731	832	947	1099	1262	1459	1620	1790	1909	2024	2147	2276	2350	2400	2476
Growth stage[2]			Sprouting and leaf development									Bine elongation						Cone development and maturation									
	Dormant					Sidearm formation									Flowering							Harvest					

Pest	Pest lifestage	
Downy mildew	Systemic infection	Begin treatment at 6".
	Secondary infection	Continue treatments on a 7-14 day schedule up until harvest.
Two-spotted spider mite	Overwintering females	Monitor for activity as temps warm.
	Eggs and motiles	Monitor populations of eggs and motiles weekly, treat as needed.
Potato leafhopper	Arrive on spring storms	Scout carefully following spring storms.
	Eggs, nymphs and adults	First generation egg laying. / Eggs, nymphs and adults may be present at this time, treat as needed.
Rose chafer	Adult beetles	Beetles present, treat as needed.
Japanese beetle	Adult beetles	Beetles present, treat as needed.
Powdery mildew[3]	Initial infection	Flag shoots emerge, prune to remove.
	Secondary infection	Secondary disease cycle, favored by rapid plant growth, mild temperatures and high humidity. Treat with fungicide as needed.

1. Degree day accumulation based on 5-year average in central, lower Michigan.
2. Growth stage is highly dependent on location, annual weather fluctuations and cultivar, this table is meant as a guide to estimate pest activity, growers are encouraged to odify the table based on observations.
3. Powdery mildew is not a primary pest for growers in the midwest but is a critical pest in greenhouses and other production regions and so has been included in this table.

This material is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Agreement No. 2015-09785. *Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.*

MICHIGAN STATE UNIVERSITY | Extension