2018

Michigan Hop Management Guide

MICHIGAN STATE UNIVERSITY | Extension

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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. For current label and MSDS information, visit one of the following free online databases: greenbook.net, cdms.com, and agrian.com

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.

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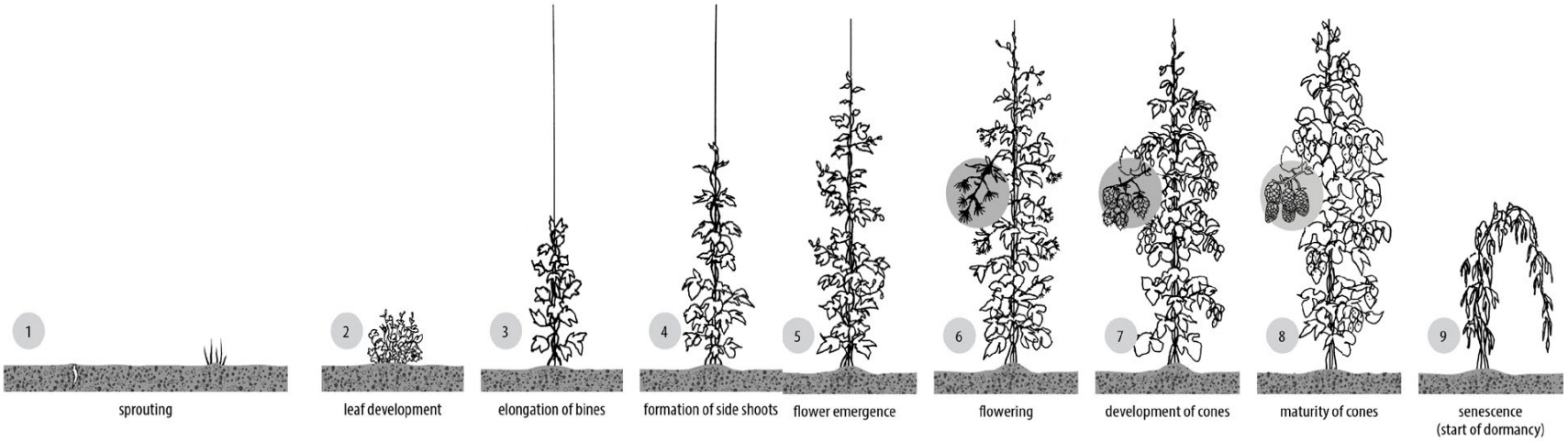


March			April				May				June				July				August				September				
2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
			6	43	46	60	71	96	180	270	500	645	731	832	947	1099	1262	1459	1620	1790	1909	2024	2276	2350	2400	2476	947
				Period of Vegetation																							
underground germination and growth				linear bine growth			establishment			shoots			catkins (burr) stage		inflorescence		cone formation		physiological ripening								
				sprouting		leaf development		elongation of bines			formation of side shoots			flowers	flowering		development of cones		maturity of cones								

Botanical drawings courtesy of Dodds, Kevin. 2017. Hops, a guide for new growers. NSW Department of Primary Industries.

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 inrow 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 with the precision required.

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, but more efficient methods of application should be considered for larger yards. In general, post-emergent herbicides provide the most effective control when applied to young weeds under 6 inches in height. Some products require crop oil concentrate or an added surfactant 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 and at the appropriate time to avoid injury.

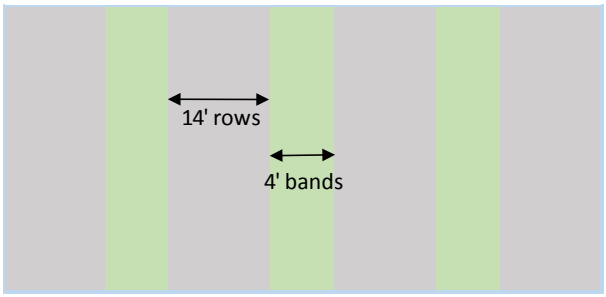
APPLYING BANDED APPLICATIONS

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 banded herbicide 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 Edge, Abundit Extra, Alecto 41-S, Buccaneer, Buccaneer Plus, Cornerstone Plus, Credit 41, Credit 41 Extra, Credit Xtreme, CropSmart Glyphosate 41 Plus, Duramax, Durango DMA, Envy, Envy Intense, Four Power Plus, Gly Star Original, Glyfos, Glyfos X-tra, Glyphogan, Gly Star 5 Extra, Gly Star Plus, Gly Star K Plus, Honcho, Honcho Plus, Honcho K6, Mad Dog Plus, Makaze, Roundup PowerMAX, Roundup WeatherMAX, Shar-Max Glyphosate 41% SL, Showdown, Touchdown HiTech	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*	4h/0d	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.
	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, Tenkoz Amine, 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. Some activity on hprsenettle at high rate.
	Grasses	clethodim (1)	Arrow 2EC, Avatar S2, Cleanse 2EC, Clethodim 2E, Clethodim 2EC, Dakota, Intensity, Intensity One, Intensity Post-Emergence, Opti-Amine, Section Three, Select Max, Select 2EC, Shadow, Shadow 3EC, Tapout, Vaquero, Volunteer, Wildwood Clethodim 2 EC	see label	Controls annual and perennial grasses.

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 must print and retain a copy of the 24C Special Local Need Label to apply Aim, available via MDARD. 5. Supplemental label that expires 7/20/20.

* 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 license.

Registered Herbicides

Application timing[1]	Broadleaf or grasses	Active ingredient (WSSA code[2])	Trade name	REI/PHI[3]	Notes
Pre- emergent	Annual grasses/ broadleaf	trifluralin (3)	Dintec Treflan 4D, Tenkoz Trifluralin 4EC, 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 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	indaziflam (29)	Alion[5]	12h/	Do not apply to baby hops or on sandy soils. Dormant application only.
	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.

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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)	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, Trionic 4SC	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 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
	folpet (M4)	Folpan 80 WDG	DM	24h28d
	metrafenone (U8)	Vivando	PM	12h/3d
	sulfur (M2)	Cosavet DF Edge*, Microfine Sulfur*, Sulfur DF*, Thiolux*	PM	see label

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]
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, OxiPhos, Phiticide, Phostrol, Reliant	DM	4h/0d
	potassium phosphite (33)	Fosphite, Fungi-Phite, Prophyt, Rampart	DM	4h/0d
Biopesticide	*Bacillus amyloliquefaciens* strain D747 (44)	Double Nickel 55*, Double Nickel LC*, Serifel*	PM	4h/0d
	Bacillus pumilus strain QST 2808 (44)	Sonata*	DM, PM	4h/0d
	Bacillus subtilis(44)	Serenade Max*, Serenade ASO*	PM	4h/0d
	extract of neem oil	Trilogy*	DM, PM	4h/0d
	hydrogen dioxide/peroxyacetic acid	Oxidate 2.0, StorOx 2.0	DM, PM	until dry/5d
	paraffinic oil	Organic JMS Stylet oil*, JMS Stylet Oil	PM	4h/0d
	potassium bicarbonate	Carb-O-Nator, Kaligreen*, Milstop*	PM, DM, anthracnose	see label
	Reynoutria sachalinensis extract (P5)	Regalia*	DM, PM	4h/0d
	sodium borate	Prev-Am Ultra	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, Tide Timectin 0.15EC AG, Willowood Abamectin 0.15 EC, Zoro	U	G	N	E	12h/28d
Biopesticides	*Bacillus thuringiensis* (11A)	Biobit HP, Crymax Bioinsecticide, Deliver, Dipel DF*, Dipel ES, Javelin WG, Xentari*	N,U	N,U	N,U	N,U	see label
	Burkholderia spp.	Venerate, 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]	Cocoon, 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, Sivanto Prime	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*, AzaGuard, Azatrol EC, Ecozin Plus 1.2% ME*, Molt-X, Neemix 4.5 Insect Growth Regulator, Trilogy	U	F	F	U	4h/0d
	Etoxazole	Zeal Miticide 1	N	N	N	E	12h/7d
	Hexythiazox(10A)	Savey 50 DF	N	N	N	R	12h/0d
METI (21A)	Fenpyroximate	Fujimite XLO, Fujimite SC, Portal, Portal XLO	G	N	N	G	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	24h/7d

1. Pesticide efficacy and beneficial insect toxicity 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. Pesticide efficacy ratings; E-excellent, G-good, F-fair, P-poor, U-unknown, N-pest not included on label. 2. Beneficial insect toxicity; S-safe, M-moderate, T-toxic, U-unknown. 3. PHI-preharvest interval, REI-restricted entry interval, expressed as h-hours or d-days

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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, Alsias 4F, 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, Willowood Imidacloprid 4 SC, 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, Bifender FC, 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	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	4h/1d
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)	Avenger S3, 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, Banter WDG, Enervate 4 SC, Willowood Bifenezate 50WDG	N	N	N	E	12h/14d
	Dicofol	Dicofol 4E Miticide	N	N	N	U	29d/7d

1. Pesticide efficacy and beneficial insect toxicity 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. Pesticide efficacy ratings; E-excellent, G-good, F-fair, P-poor, U-unknown, N-pest not included on label. 2. Beneficial insect toxicity; S-safe, M-moderate, T-toxic, U-unknown. 3. PHI-preharvest interval, REI-restricted entry interval, expressed as h-hours or d-days

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Registered Miticides

Compound (IRAC Code)	Active ingredient	Affected stage	Considerations	Residual control[1]	Preharvest interval	Impact on predatory mites[2]
Savey (10A)	hexythiazox	Egg/larvae	Apply before burr formation and before adult build up. Savey will not control adults. Use higher rate for moderate to heavy mite pressure, for large plants or longer residual control.	6-12 weeks	0d	1
Agri-Mek (6)	abamectin	Motiles*	Apply at threshold and with required adjuvant. Application rate is based on bine height.	6-12 weeks	28d	3
Zeal (10B)	etoxazole	Egg/larvae	For best results apply when mite populations are low, at or prior to threshold.	6-10 weeks	7d	2
Envidor (23)	spirodiclofen	Egg, motiles*	For best results, apply early in the infestation before threshold as soon mite activity begins. Low rates are adequate if plants are small and pressure is low. Use higher rate for moderate to heavy mite pressure, on large plants or for longer residual control.	6-10 weeks	17d	2
Portal or Fujimite (21)	fenpyroximate	Motiles*	For best results, apply before mite populations exceed 5 mites/leaf. Not recommended when temperature exceed 90F.	6-8 weeks	Portal 15d, Fujimite 14d	1
Acramite (20D)	bifenazate	Motiles*	Provides quick knockdown, good coverage is key. Best positioned as soon as mites become active. Use low rates at early infestation and increased rates under higher mite pressure.	6-8 weeks	14d	1
Magister SC (21)	fenazaquin	Motiles*	Provides quick knowdown. Has some activity against powdery mildew. One application per year.	3-5 weeks	7d	**

*Motile forms include mite larvae, nymph and adult stages.

** Harmless on most beneficials, but has moderate toxicity on honey bees and phytoseiid predacious mites.

1. Residual control is based on studies in tree fruit and is highly dependent on rate, coverage, weather and mite pressure at the time of application. 2. Rankings represent relative toxicity based on mortality data from studies conducted in tree fruit, hop, mint and grape following direct exposure. 1 = <30% mortality; 2 = 30-79% mortality; 3 = 79-99% mortality; and 4 = >99% mortality.

Relative impact of pesticides 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 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

Fertility

As hops reach technical maturity in August and September prior to dormancy, more carbohydrates are produced than are needed for growth; excess carbohydrates are directed toward the rootstock in preparation for the following growing season. As hops break dormancy, they rely solely on carbohydrate reserves until photosynthesis commences with the period of vegetation. For optimum production, supplemental nutrition is necessary at this time[1]. Because fertility requriements can be cultivar-specific and each growing season can vary, growers are encouraged to collect soil and petiole/leaf samples each year to optimize plant nutrition, growth, and yield.

Nitrogen (N)

While hops require macro and micro-nutrients, because of the rapid growth characteristics of the hop plant, effectively managing nitrogen fertility is particularly important. Nitrogen fertilizer is available in many different forms and growers should consult closely with their chosen soil testing lab to optimize N fertility.

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[2]. 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 65 percent[3]. This suggests that roughly thirty-five percent 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 65 percent is taken up by the hop plant, then producers should be applying ~170 lbs of actual N/ac/yr. This does not account for additional N inputs such as compost, plant residue, N-fixing leguminous cover crops, nor for the method or timing of nitrogen application. Nitrogen that is banded into the hop rows in one spring application,

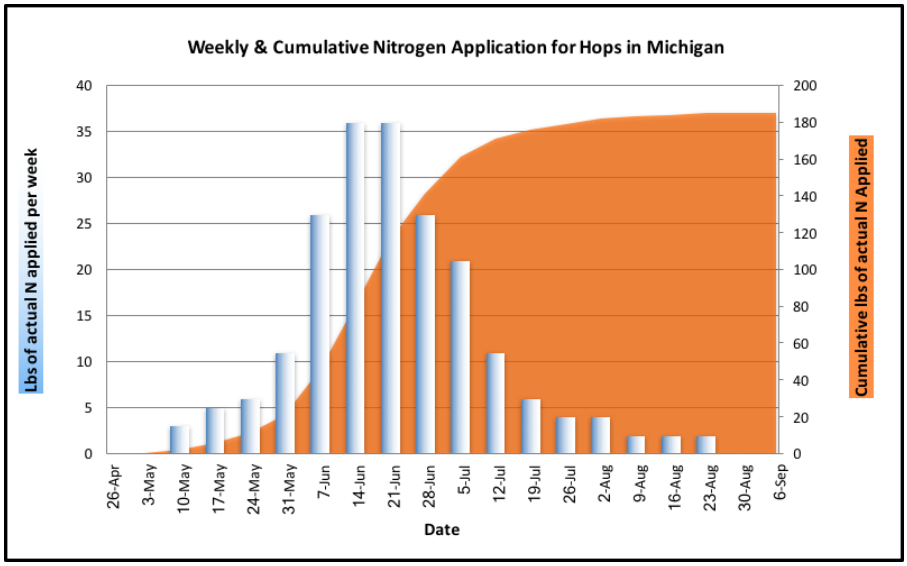


Figure 2. Weekly and cumulative nitrogen application in Michigan hops. Rob Sirrine, MSU

[1] Gingrich, G., J. Hart, and N. Christensen. 2000. Fertilizer Guide: Hops. FG 79. Oregon State University, Corvallis, OR.

[2] Sullivan, D.M., J.M. Hart, and N.W Christensen. 1999. Nitrogen Uptake and Utilization by Pacific Northwest Crops. P.10. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw513.pdf

[3] Neve. R.A. 1991. Hops. London: Chapman and Hall.

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 late May- early July.

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 150- 200 lbs of actual N/acre/yr to mature hop plants (See Figure 2, which shows 185 lbs/ac/yr). Baby hops require less Nitrogen ~ 75lbs/ac/yr. 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 around 150 lbs. 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. Nitrogen needs may differ depending upon cultivar vigor and disease susceptibility. Vigorous cultivars may need less N, while weaker cultivars may need more N over the course of the season. Verticillium wilt may be more severe with excessive N application.

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, feathermeal, 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.

Phosphorous (P)

Phosphorous is important for photosynthesis, the movement of materials across cell membranes, and cell division and growth. When P is limiting, root and fruit development are diminished. The hop plant P requirement is small when compared with the plant's need for N and potassium (K). Studies in Germany and Washington indicate a 9- to 10-bale/ac hop crop (1800-2000 lb/ac) removes an average of only 20 to 30 lb P/ac[4]. This corresponds to other studies, which have found that hops have a low phosphorus requirement and generally do not respond to fertilizer phosphorus applications. P should be incorporated into the soil in the hop row because it is less mobile than other nutrients. Ideal Phosphorous levels are 25-40 ppm.

Potassium (K)

Potassium is a key nutrient for plant regulation. It activates enzymes involved in plant cell division and growth, is necessary for formation and transport of carbohydrates, and regulates opening and closing of stomata. Hops take up 80–150 lbs K/ac/year on average. Plants deficient in K are more susceptible to environmental stress and disease. Potassium levels should be over 300 ppm. Excessive K levels can result in Mg deficiency.

[4] Gingrich, G., J. Hart, and N. Christensen. 2000. Fertilizer Guide: Hops. FG 79. Oregon State University, Corvallis, OR.

Sulfur (S)

Sulfur activates plant enzymes and helps form plant proteins and cholorphyll. Plant Nitrogen use can be limited when Sulfur levels are below optimum. Sulfur deficiency may resemble N deficiency, though plants deficient in S generally show symptoms on the newest leaves first. Optimum soil test levels are > 20ppm.

Calcium (Ca)

Calcium is responsible for cell wall structure and strength. Calcium deficiency is possible if Potassium, Magnesium, or Sodium levels are excessive. Ca soil test levels should be >1800 ppm.

Magnesium (Mg)

Magnesium is crucial for photosynthesis and activation of plant enzymes. Because Mg is mobile in plants, older leaves will develop signs of deficiency first. Magnesium soil test levels should be >250 ppm.

Copper (Cu)

Copper is responsible for plant metabolism and is important in the formation of chlorophyll. Copper is immobile; deficiency symptoms will develop first in younger leaves. Soil with high pH result in copper deficiency, whereas copper toxicity can occur in very acidic soils. Optimum levels of Copper in the soil are 0.8-2.5 ppm.

Boron (B)

Boron helps facilitate carbohydrate transport and metabolism and activates growth regulators. Boron is important in plant reproductive phases (fruit development). Boron deficiency can occur in acidic soils Boron soil test levels should be between 0.7-1.5 ppm.

Zinc (Zn)

Zinc is the most common micronutrient deficiency. Zinc is an enzyme activator and required for optimum growth. It also play a role in internode elongation. Zn deficiency is associated with high soil pH >7.5. Zinc levels in the soil should be 1.0-3.0 ppm.

Manganese (Mn)

Manganese is an enzyme activator, important for carbohydrate synthesis, and for photosynthesis. Calcareous soils and high pH soils often show signs of Manganese deficiency. Ideal soil levels of Manganese are between 6-30 ppm.

Iron (Fe)

Iron plays a role in metabolic processes and is required for many plant biological processes. While Iron is generally abundant in soils, in neutral-high pH and aerobic soils, it can be unavailable for plant uptake resulting in interveinal chlorosis. Soil Iron levels should be >7 ppm.

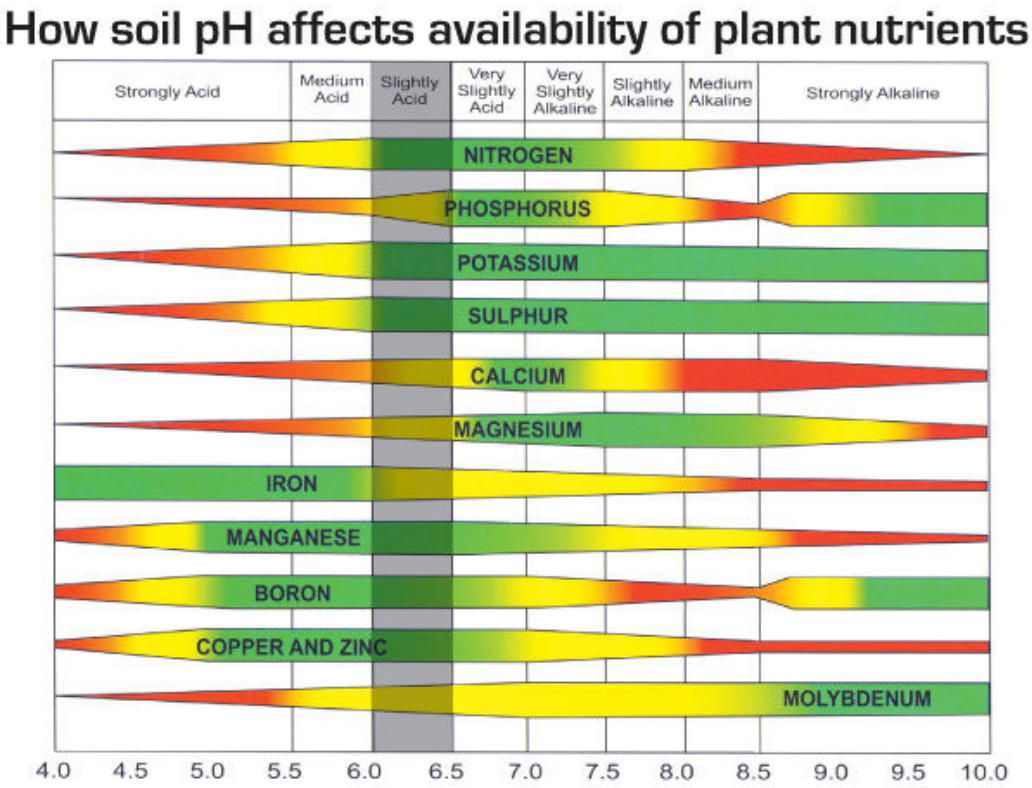
Sodium (Na)

Though non-essential, Sodium is important for metabolic processes and cholorphyll synthesis. Excessive Na can lead to toxicity generally demonstrated by leaf margin and tip necrosis. Soil Sodium levels should be <225 ppm**.**

*Ratios amongst certain nutrients can be very important and should be discussed with your soil test laboratory.

pH

Soil pH is a measure of the soils acidity or alkalinity. Soil pH is determined by soil parent material, rainfall, and past fertilization practices. Soil pH affects nutrient availability (see figure)[5]. A value of ”7” is considered neutral. Optimum plant growth and yield is achieved under appropriate soil pH levels; different plant species require different soil pH levels. Hops prefer slightly acidic soils ~6.5. Soil pH can be adjusted to optimize plant growth and yield. Ground limestone is generally recommended to increase soil pH if it is too acidic. Soil texture, crop, and type of lime should all be considered. Limestone contains calcium and Dolomitic limestone contains both calcium and magnesium. In general, lime should be applied in the fall and incorporated into the soil prior to planting. If soil pH is too alkaline, sulfur can be applied to reduce the soil pH. Certain fertilizers can also increase the acidity of the soil over time.



[5] https://www.superior.net.nz

Nutrients	Role	Deficiency Symptoms	Excess Symptoms
Nitrogen (N)	Facilitates plant growth, provides the "green" response in plant, necessary for photosynthesis, increases yields (up to point of diminishing returns)	Poor growth, stunting, yellow leaves, cones are small an undeveloped,	Internodes are too long, increased insect and disease issues
Phosphorous (P)	Photosynthesis, cell division, nucleus formation, stimulates root growth and energy transfer	downward curling of lower leaves, dull appearance	Can cause zinc deficiency in alkaline soils, water quality issues
Potassium (K)	Role in metabolic process, production and translocation of carbohydrates, water intake, respiration, positive effect on cone ripening, production of lupulin, and resin and essential oil content	Weak bine growth and reduced burr formation, bronzing between veins, reduced N use efficiency	Can induce Mg deficiency
Sulfur (S)	Activates plant enzymes	Stunted growth, spindly stems, yellow leaves, usually in coarse textured soils prone to leaching	
Calcium (CA)	Root and leaf growth, cell wall structure and strength, does not move in plant-deficiency develops on new leaves, counteracts the effects of alkali salts	Young tissue and growing points, yellowing and death of leaf margins	Can induce deficiencies in other + charged ions (ammonium, K, Mg)
Magnesium (Mg)	Essential for photosynthesis, helps activate plant enzymes needed for growth, role in the quality and quantity of hop cones, can increase lupulin levels,	Older leaves yellowing between veins, most common in acid soils	
Iron (Fe)	Mainly concentrated in the leaves, essential for synthesis of chlorophyll	Yellowing on young leaves between veins while veins remain green, most common in alkaline soils	
Manganese (Mn)	Activates plant enzymes, mainly concentrated in hop leaves	Becomes limited in high alkaline soils, yellowing of young leaves and white speckling	In low pH soils can interfere with iron uptake
Zinc (Zn)	Concentrated in apices and young organs such as leaves, enzyme activator, hops are very sensitive to zinc deficiency	Weak growth, short laterals, poor cone production. Leaves are small misshapen, yellow, curled upwards, common when pH is greater than 7.5	
Copper (Cu)	Functions as a catalyst in photosynthesis and respiration, is a constituent of several enzyme systems involved in building and converting amino acids to proteins		
Boron (B)	regulates metabolism of carbohydrates, cell wall component	Delayed shoot emergence, stunting, distortion and crinkling of young leaves. Most common in acid/sandy soils	
Molybdenum (Mo)	Used by enzymes, important for N metabolism, high sulfates can reduce plant uptake of Mo.	Young leaves become chlorotic with light brown spots, speckling around veins. Deficiencies have been reported in acidic soils (pH <5.8)	

Optimum Petiole Nutrient Ranges

		Plant Analysis Handbook III		
NUTRIENTS	JOHN I HAAS*	Vegetative Stage Pre-Bloom	Reproductive stage & Full Bloom	Western Laboratories^
Nitrogen (%)		3.2 - 5.6	2.13 - 3.93	4.0
Potassium (%)	1.49 - 2.5	1.6 - 3.4	0.97 - 2.55	3.0
Phosphorous (%)	0.29 - 0.6	0.27 - 0.54	0.18 - 0.43	0.4
Calcium (%)	0.79 - 1.2	1.03 - 2.57	3.09 - 6.05	2.5
Magnesium (%)	0.24 - 0.8	0.29 - 0.67	0.55 - 1.71	0.4
Manganese (ppm)	25 - 150	45 - 125	50 - 150	85
Iron (ppm)	30 - 60	44.3 - 97.9	35.4 - 151	
Copper (ppm)	10 - 25	8 - 29	5.7 - 16.6	10
Boron (ppm)	24 - 75	17.6 - 63.2	48 - 150	55
Zinc (ppm)	24 - 50	23.2 - 108	19.4 - 57.1	60
% Sulfur Sampled Basis	0.16 - 0.32	0.2 - 0.34	0.18 - 0.30	0.25
% Sulfur Dry Matter Basis	0.16 - 0.32	0.2 - 0.34	0.18 - 0.30	
Mo		0.5 - 3	1 - 5	
Na	0 - 1400			
NO3 ppm	4000-12000			

* Del Moro, S. 2014. Great Lakes Hop & Barley Conference

^ Taberna, J. 2017. American Hop Convention. Samples collected 5.5 ft above ground just prior to bines reaching the wire

Seasonal Primary Pest Occurrence in Michigan Hopyards

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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.

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Michigan State University Extension, 2018