MICHIGAN STATE UNIVERSITY | Extension

2021

# Michigan Hop Management Guide

USDA

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For more information on hop production in Michigan and upcoming programming, visit www.hops.msu.edu.

## Using the Hop Management Guide

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

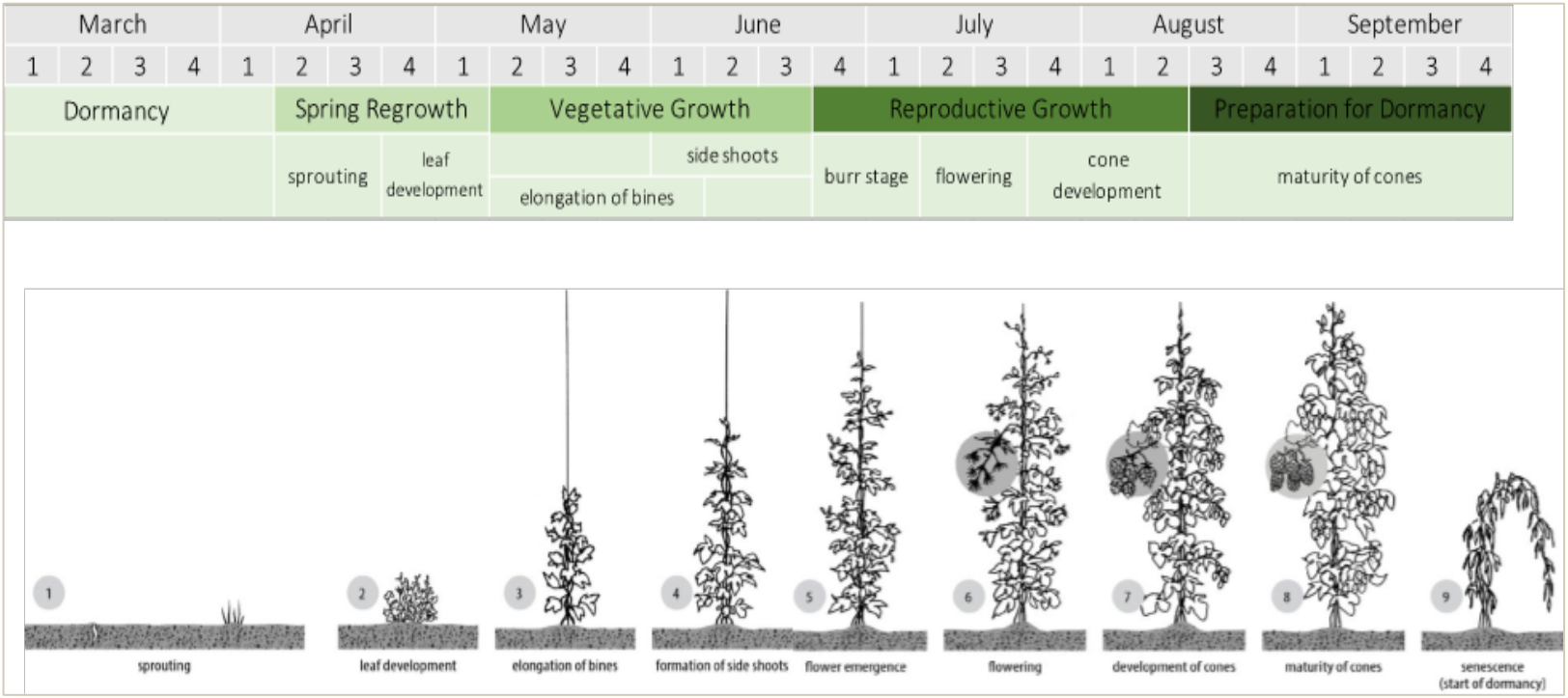
The efficacies of products listed have not been evaluated on hop in Michigan.Reference to commercial products or trade names does not imply endorsement by Michigan State University Extension or bias against those not mentioned.

## Hop Exporters

The US Hop Industry Plant Protection Committee has actively sought harmonization of pesticide regulatory standards (maximum residue levels or MRLs) in key customer countries for the past three decades. As US hops are exported worldwide, ensuring consistent regulatory standards between the US and export customers avoids trade issues and interruption of shipments. We also collaborate with other hop producing countries through participation in the International Hop Growers Convention and the European Union Commodity Expert Group for Hops.

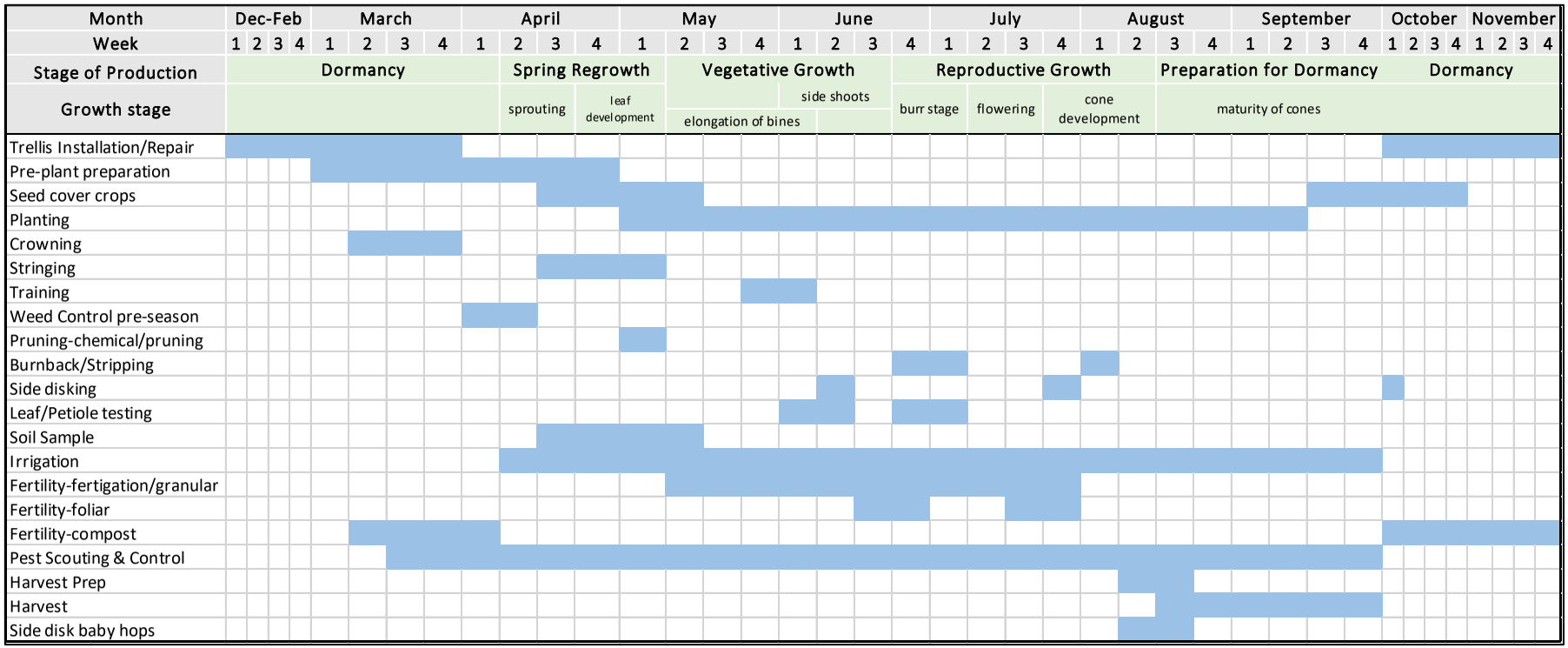
Some countries do not allow application of certain plant protection products or have lower MRLs than in the U.S. If you export hops you will need to comply with the relevant international MRLs. Export restrictions may apply to the pesticides included in this guide. Growers planning to export their hops should carefully review the Hop MRL Tracking Chart at https://www.usahops.org/growers/plant-protection.html.

# Average Michigan hop growth stages based on date.




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

# Timing of hop production management activities in northwest Michigan




Michigan State University Extension, 2021

## 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 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. Chemical weed management of baby hops is extremely limited.

### 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. Growers have also achieved some success controlling weeds with a side-mounted weed badger or “spin weeder” commonly used in orchards and vineyards.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.

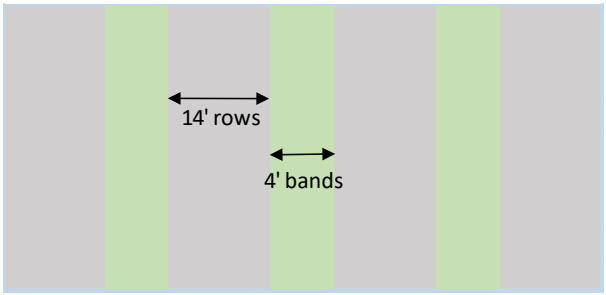
## APPLYING BANDED APPLICATIONS

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.

*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]) | Products labeled | REI/PHI[3] | Notes |
|---|---|---|---|---|---|
| Post- emergent | Both | glyphosate (9) | Abundit Extra, Abundit Edge, Buccaneer, Buccaneer Plus, Cornerstone Plus, Credit 41, Credit 41 Extra, Credit 5.4 Extra, Credit Xtreme, Duramax, Durango DMA, Envy, Envy Intense, Envy Six Max, Gly Star Original, Glyphogan, Gly Star Plus, Gly Star K Plus, Honcho K6 Herbicide, Makaze, Razor, Roundup PowerMAX, Roundup WeatherMAX, 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* | 4h/0d | Avoid spraying desirable plants. OMRI listed. |
| | Both | pelargonic acid (27) | Scythe | 12h/see label | Uses in directed vegetative burndown, prior to crop emergence, dormant or post harvest spray. |
| | Both | caprylic + capric acid | HomePlate 80L* | 24h/ | Burn down most green plants. Avoid contact with crop stem and foliage. OMRI listed for organic production. |
| | Broadleaf | pyraflufen-ethyl (14) | Venue[5] | 12h/30d | For the management of undesirable suckers and broadleaf weeds. Avoid contact with uncalloused or green desirable growth. |
| | Broadleaf | carfentrazone (14) | Aim EC[4] | 12h/7d | Use with shielded or hooded sprayers to control small broadleaf weeds and hop suckers and lower |
| | Broadleaf | dimethenamid-P (15) | Outlook Herbicide | 12h/60d | A selective residual herbicide that controlls annual broadleaf weeds and sedges as they germinate. |
| | Broadleaf | 2,4 D (4) | 2,4 D Amine 4, Clean Amine, Drexel De-Amine 4, Opti-Amine, Radar AM, Rugged, Shredder Amine 4, Tenkoz Amine, Weedar 64,WeeDestroy AM-40 Amine Salt, Weed RHAP A 4D | see label | Controls most annual and perennial broadleaf weeds. Ester* formulations restricted in certain townships in Berrien, Van Buren and Cass County- May 1-October 1. |
| | Broadleaf | clopyralid (4) | Spur | 12h/30d | Controls Canada thistle. Some activity on horsenettle at high rate. |
| | Grasses | clethodim (1) | Arrow 2EC, Avatar, Avatar S2, Cleanse, Cleanse 2EC, Clethodim 2E, Clethodim 2EC, Dakota, Intensity One, Intensity Post-Emergence, Omni Brand Clethodim 2 EC, Opti-Amine, Section Three, Select Max with Inside Technology, Select 2EC, Shadow, | see label | Controls annual and perennial grasses. |

**1**. Pre-emergent herbicides should 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 listed 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 the Michigan Department of Agriculture and Rural Development webpage. This label may not be available this season, check before purchasing. **5.** Supplemental label required.

***** OMRI approved for organic production.

# Registered Herbicides

| Application timing[1] | Broadleaf or grasses | Active ingredient (WSSA code[2]) | Products labeled | REI/PHI[3] | Notes |
|---|---|---|---|---|---|
| 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. |
| | Broadleaf | isoxaben (21) | Trellis SC[5] | 12h/ | Apply banded applictions to the ground on either side of the hop rows prior to emergence. Product is water activated. Supplemental label required. |
| | Both | flumioxazin (14) | Chateau SW, Flumi 51 WDG, Flumioxazin 51% WDG, Tuscany, Tuscany SC, Venue 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. |
| | Both | dimethenamid-P (15) | Outlook 6E | 12h/60d | New plantings and established hops. Apply in a band over the row preemergence or directed next to rows postemergence. Use low rates on light soil. |
| | 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]) | Products labeled | Diseases listed on label[2] | REI/PHI[3] |
|---|---|---|---|---|
| Single site | cyazofamid (21) | Ranman 400 SC | DM | 12h/3d |
| | cyflufenamid (U6) | Torino Fungicide | PM | 4h/6d |
| | cymoxanil (27) | Curzate 60 DF | DM | 12h/7d |
| | dimethomorph (40) | Forum | DM | 12h/7d |
| | fluopicolide (43) | Presidio[4] | DM | 12h/24d |
| | fluopyram (7) | Luna Privilege, Velum Prime | PM | 12h/7d |
| | flutianil (U13) | Gatten[4] | PM | 12h/7d |
| | flutriafol (3) | Rhyme | PM | 12h/14d |
| | mandipropamid (40) | Revus | DM | 4h/7d |
| | mefenoxam (4) | Ridomil Gold SL, Ultra Flourish | DM | see label |
| | metalaxyl (4) | MetaStar 2E, Metalaxyl 2E Ag, ReCon 4F | DM | see label |
| | metrafenone (50) | Vivando | PM | 12h/3d |
| | quinoxyfen (13) | Quintec | PM | 12h/21d |
| | tebuconazole (3) | Buzz Ultra DF, Monsoon, Onset 3.6 L, Orius 3.6 F, Tebu-Crop 3.6 F, Tebustar 3.6 L, Toledo 3.6 | PM | 12h/14d |
| | trifloxystrobin (11) | Flint, Flint Extra | 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, Mastercop* | DM | see label |
| | copper hydroxide (M1) | Champ DP Dry Prill, ChampION++, Champ Formula 2 Flowable, Champ WG*, Kentan DF, Kocide 2000, Kocide 2000-O, Kocide 3000-O, Nu-Cop HB, Nu-Cop 3L, Nu-Cop 50 DF*, Nu Cop 50 WP*, Nu-Cop 30 HB, Nu-Cop XLR, Previsto | DM | 48h/14d |
| | copper octanoate (M1) | Cueva* | Anthracnose, DM, PM | 4h/0d |
| | copper oxychloride (M1) | COC DF | | 48h/label |
| | copper oxychloride + copper hydroxide (M1) | Badge SC, Badge X2* | DM | 48h/14d |
| | folpet (M4) | Folpan 80 WDG | DM | 24h/14d |
| | sulfur (M2) | Auron DF*, Cosavet DF Edge*, Micro Sulf, Microfine, Microthiol Disperss, 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 applications of fungicides with the same FRAC code are not recommended. **2.** PM-powdery mildew, DM-downy mildew. **3.** PHI-preharvest interval, REI-restricted entry interval expressed as h-hours or d-days. **4.** Requires a supplemental label for use in hops.

***** OMRI approved for organic production.

# Registered Fungicides

| | Active ingredient (FRAC code[1]) | Products labeled | Diseases listed on label[2] | REI/PHI[3] |
|---|---|---|---|---|
| Premix | ametoctradin (45) + dimethomorph (40) | Zampro | DM | 12h/7d |
| | mandipropamid (40) + oxathiapiprolin (49) | Orodnis Ultra | DM | 4h/7d |
| | boscalid (7) + pyraclostrobin (11) | Pristine | DM, PM | 12h/14d |
| | famoxadone (11) + cymoxanil (27) | Tanos | DM | 12h/7d |
| | fluopyram (7) + tebuconazole (3) | Luna Experience | PM | 12h/14d |
| | fluopyram (7) + trifloxystrobin (11) | Luna Sensation | DM, PM | 12h/14d |
| | tebuconazole (3) + sulfur (M2) | Unicorn DF | PM | 12h/14d |
| 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 Systemic Fungicide Bactericide, OxiPhos, Phiticide, Phostrol, Reliant | DM | 4h/0d |
| | potassium phosphite (33) | Fosphite, Fungi-Phite, Helena Prophyt, 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 |
| | mineral oil | Damoil Dormant, 440 Superior Spray Oil, Omni Supreme Spray, PureSpray Green, SuffOil-X, Ultra-Pure Oil, and Summer Spray Oil | PM | see label |
| | paraffinic oil | Organic JMS Stylet oil*, JMS Stylet Oil | PM | 4h/0d |
| | potassium bicarbonate | Carb-O-Nator, Kaligreen*, Milstop*, Milstop SP* | PM, DM, anthracnose | see label |
| | *Reynoutria sachalinensis* extract (P5) | Regalia* | DM, PM | 4h/0d |
| | *Streptomyces lydicus* WYEC 108 | Actinovate AG*, Actinovate STP* | Verticillium wilt, DM, PM | 4h/0d |
| | tea tree oil (F7) | Timorex Gold | DM, PM | 12h/48h |

**1.** FRAC - Fungicide Resistance Action Committee (FRAC) codes are used to distinguish the fungicide groups for resistance management purposes. Consecutive applications of fungicides with the same FRAC code are not recommended. **2.** PM-powdery mildew, DM-downy mildew. **3.** PHI-preharvest interval, REI-restricted entry interval expressed as h-hours or d-days. **4.** Requires a supplemental label for use in hops.

***** OMRI approved for organic production.

## Hop Downy Mildew Management

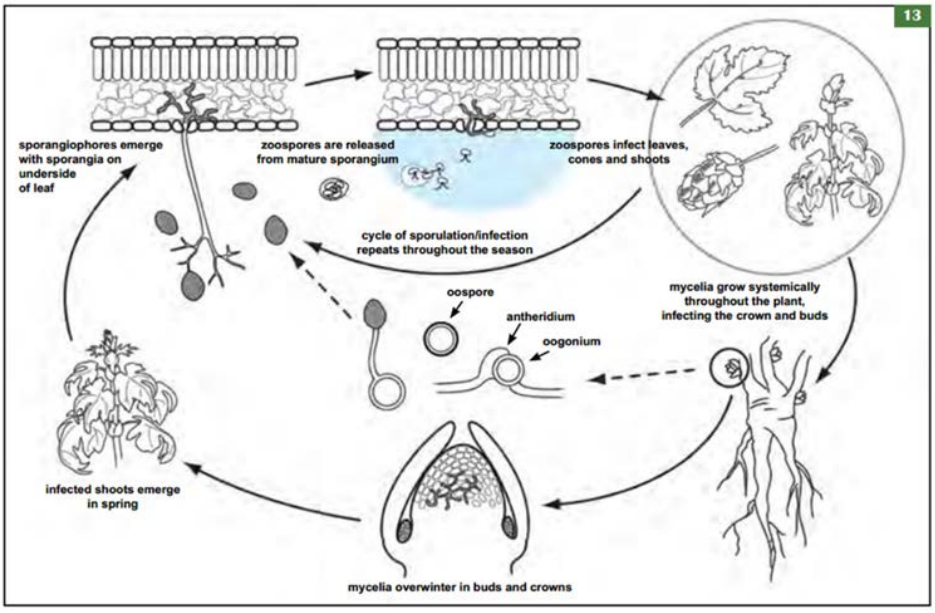
Downy mildew is caused by the fungal-like organism *Pseudoperonospora humuli* and is a significant disease of hop in Michigan, potentially causing substantial yield and quality losses. This disease affects cones, and foliage and can become systemic; in extreme cases the crown may die. Cool and damp weather during the spring provide ideal growth conditions for the pathogen. Disease severity is dependent on cultivar, environmental conditions, and management programs. Growers should focus on proactive management strategies, including 1) sourcing clean planting stock, 2) scouting regularly and 3) utilizing a preventative fungicide program.

*Disease cycle*

The causal agent of downy mildew, *Pseudoperonospora humuli*, overwinters in dormant buds or crowns and can emerge on infected shoots in early spring, resulting in basal spikes. Infected crowns can produce uninfected shoots as well, making downy detection difficult, particularly on potted baby hop plants that have been cut back. The pathogen produces copious spores on the underside of leaves formed on infected basal spikes that move via wind and rain onto health tissue and cause new infections. These new infections produce a second source of spores which can infect all parts of the plant and reproduce continuously over the season.

Infections that occur on the terminal growing point can become systemic, growing down through the plant toward the crown where the pathogen can persist in the root system for a prolonged period. Systemic infections contribute to the spread of disease through propagation and also allow for the pathogen to survive winter, contributing to disease pressure in subsequent seasons. The pathogen can also produce a resting spore and overwinter, but it is unclear how or if these resting spores contribute to infection and how readily they are produced under Michigan conditions.

Secondary infection is favored by mild to warm temperatures (60 to 70°F) when free moisture is present for at least 1.5 hours, although leaf infection can occur at temperatures as low as 41 °F when wetness persists for 24 hours or longer.

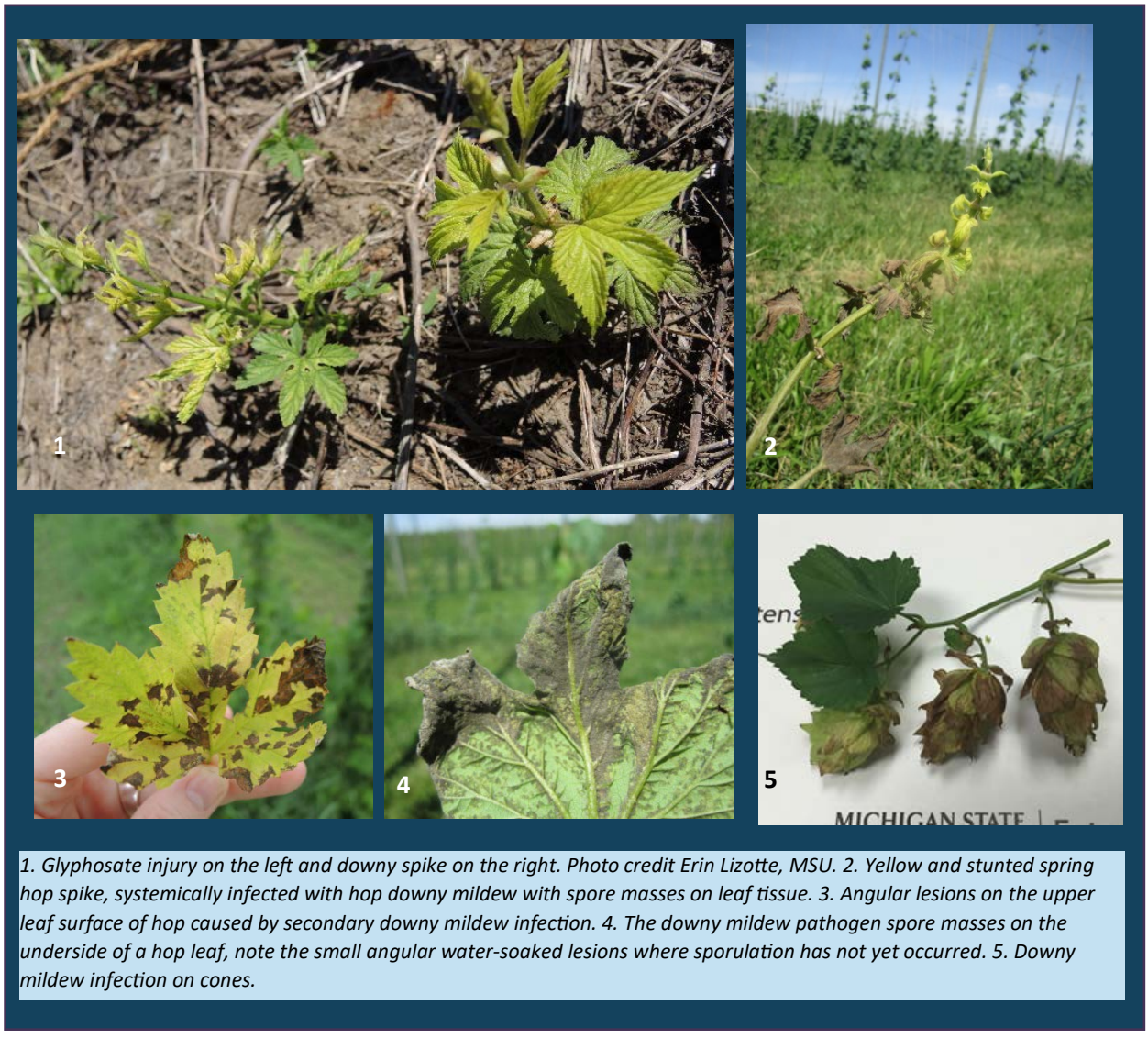



*Life cycle of Pseudoperonospora humuli on hop. Prepared by V. Brewster, Compendium of Hop Diseases and Pests.*

*Signs and Symptoms*

Primary downy mildew infections appear early in the season on emerging, infected shoots called basal spikes. Spikes are shoots growing from infected buds and appear distorted with shortened internodes that give the shoot a bushy appearance. It is easy to confuse some mild herbicide injury from glyphosate (e.g. Round Up) with downy mildew as they both produce stunted shoots. Glyphosate injury on the first flush of growth is very common, so it is important that growers recognize the difference. Herbicide injury will cause chlorosis that follows leaf venation and leaves will be misshapen and appear more "strappy". Downy infected shoots will develop spore masses on the underside of leaves that follow venation. Refer to the pictures below.

Secondary leaf infections form angular water soaked lesions that follow leaf venation. Eventually, the water-soaked lesions turn brown and necrotic with fuzzy and grey-black asexual spore masses developing on the underside of infected lesions. As bines continue to expand, new shoots become infected and brittle, falling off the string. Growers can attempt to retrain new shoots but will incur yield loss as a result of missing the ideal training timing. As the season progresses, symptoms may include stunted side-arm growth, tip die-back and cone discoloration. The fuzzy, visible growth of downy mildew is not always present and should not be relied upon as the sole indicator of whether infection is present.




*1. Glyphosate injury on the left and downy spike on the right. Photo credit Erin Lizotte, MSU. 2. Yellow and stunted spring hop spike, systemically infected with hop downy mildew with spore masses on leaf tissue. 3. Angular lesions on the upper leaf surface of hop caused by secondary downy mildew infection. 4. The downy mildew pathogen spore masses on the underside of a hop leaf, note the small angular water-soaked lesions where sporulation has not yet occurred. 5. Downy mildew infection on cones.*

*Scouting*

Scouting for downy mildew involves monitoring the crop for signs and symptoms of disease to evaluate the efficacy of the control program being utilized and gauge the level of disease pressure throughout the season. Growers should keep records of their scouting, including maps of their fields, a record of sampling and disease pressure, as well as the control measures utilized. Scouting should begin as soon as plants begin to grow and should continue until the crop is dormant.

To begin scouting, section your farm off into manageable portions based on location, yard size and variety and scout these areas separately. It is more practical to deal with blocks that are of the same variety, age and spacing. Walk diagonally across the yard and along an edge row to ensure you view plants from both the edge and inner portion of the block. Change the path you walk each time you scout to inspect new areas. Reexamine hotpots where you have historically encountered high mildew pressure. Weekly scouting is recommended at a minimum.

*Management*

Unfortunately, even when best management practices are followed, downy mildew can gain a foothold in Michigan yards due to high disease pressure, challenges with fungicide application timing, suboptimal spray coverage, fungicide wash-off, cultivar susceptibility or a combination of these factors. In addition, fungicide resistance and infected nursery plants may play a role in some disease control failures. Recent research indicates that fungicide resistance in hop downy mildew is not widespread in MI for popularly used fungicides with FRAC code 40 (Higgins et al., unpublished). See the list of recommended fungicides below for more information on FRAC code 40 fungicides.

Clean planting material should be used when establishing new hop yards, since many insect and disease pests are readily spread via nursery stock. Growers should consider purchasing a few plants from prospective nurseries and have them tested for diseases including mildews and viruses before committing to a large numbers of plants. Additionally, any other signs of poor handling at the propagator level may be used as an indicator of plant quality. Other signs of poor handling would include mite or aphid infestations, spray damage, or poor root development and would be grounds for rejecting a delivery of plants.

Growers should utilize a protectant fungicide management strategy to mitigate the risks of early and severe infections but can also utilize cultural practices to reduce disease. Keep in mind that varieties vary widely in their susceptibility to downy mildew and select the more tolerant varieties when possible (refer to Table 2 in the Field Guide for Integrated Pest Management in Hops).

On mature plants, removal of the first flush of growth can help suppress disease development if disease is already present in the yard from the previous season. The early growth should be completely removed using mechanical or chemical pruning. As bines develop (8-10’), the removal of superfluous basal foliage and lower leaves to promote air movement in the canopy and to reduce the duration of wetting periods is recommended. This is commonly achieved through multiple applications of Aim herbicide or concentrated nitrogen fertilizer solutions. Aim will also control smaller weeds within the row. The use of Aim, pruning, and/or crowning should NOT be performed on baby hop plants (less than 3 years old). If there is a cover crop, it should be mowed close to the ground. If yards have no cover crop, cultivation can help to dry the soil and minimize humidity. Keep nitrogen applications moderate. For more information on pruning, refer to the Michigan State University Extension article “Pruning hops for disease management and yield benefits”.

Apply fungicide treatments on a protectant basis as soon as bines reach 6" in the spring regardless of the presence or absence of visible symptoms of downy. If growers are planning to remove the first flush of growth by pruning, the first fungicide application should occur only after regrowth. Applications should continue season long on a 7-10 day reapplication interval. The time between applications may stretch longer when the disease pressure is low, particularly after cone closure. Several periods in the season are particularly critical for disease control: immediately before and after training; when lateral branches begin to develop; bloom; and when cones are closing up. Covering young, developing bracts before cones close up is critical to protecting against downy mildew when conditions for disease are favorable. Getting adequate coverage on undersides of bracts where infection occurs becomes increasingly difficult as cones mature.

Refer to the table on ther next page for a complete listing of known hop downy mildew fungicide efficacy. Ranman, Zampro, Forum, Presidio (supplemental label), metalaxyl products and Revus make up the backbone of effective downy mildew management programs in Michigan. These products should be rotated and potentially mixed with Curzate and Tanos to prevent resistance development. Copper-based fungicides may also be rotated in during periods of low disease pressure and as tank mix partners. Note that Revus, Forum and Zampro contain active ingredients with the same mode of action and should not be tank-mixed or rotated and Presidio is only available via a supplemental label that growers must have on hand for legal application.

Organic growers have fewer options and will need to focus on keeping tissue protected, selecting downy mildew tolerant varieties, and following cultural practices to limit downy infection. Copper-based products are the mainstay of downy mildew management in organic hop yards and offer 5-7 days of protection but no post-infection activity. Copper should be applied ahead of any wetting events as available. The pre-harvest intervals for copper formulations vary, refer to the label. Actinovate, Eco-mate, Armicarb-O and Sonata are additional products that list downy mildew on the label and are approved for organic use in hop. The pre-harvest interval for these products are 1 day or less, at this time we have no data on the efficacy of these products.

*Resistance Management*

The downy mildew pathogen is at high risk of developing fungicide resistance. Careful attention to resistance management is critical. To slow the development of resistance, growers should:

1. Keep inoculum low in your yard using various cultural practices, this keeps the population lower so shifts in resistance will happen more slowly.
2. Rotate fungicides diligently within a seasonal spray program. Use FRAC codes to help with determining rotations. These codes can be found in the upper right-hand corner of most conventional fungicide labels or refer to the current Michigan Hop Management Guide.
3. Spray on-time, at the full rate and follow appropriate intervals for the product and bine development.
4. Use cultural practices to improve spray coverage.
5. Utilize multisite fungicides as rotational products such as Cueva (FRAC Multisite 1).

| Hop Downy Mildew Fungicide Efficacy | | | |
|---|---|---|---|
| **Products labeled** | **Active ingredient (FRAC Code[1])** | **Efficacy[2]** | **REI/PHI[3]** |
| Forum | dimethomorph (40) | E | 12h/7d |
| MetaStar 2E, Metalaxyl 2E Ag, ReCon | metalaxyl (4) | E | See label |
| Orondis Ultra | mandipropamid (40), oxathiapiprolin (49) | E | 4h/7d |
| Presidio[5] | fluopicolide (43) | E | 12h/24d |
| Ranman 400 SC | cyazofamid (21) | E | 12h/3d |
| Revus | mandipropamid (40) | E | 4h/7d |
| Ridomil Gold SL, Ultra Flourish | mefenoxam (4)[4] | E | 48h/135d (drench) 48h/45d (foliar) |
| Zampro | ametoctradin (45) + dimethomorph (40) | E | 12h/7d |
| Curzate 60DF | cymoxanil (27) | G | 12h/7d |
| Tanos | famoxadone (11) + cymoxanil (27) | G | 12h/7d |
| Aliette WDG, Linebacker WDG | fosetyl-Al (33) | F | 12h/24d |
| Agristar Basic Copper 53*, C-O-C-S WDG, Cuprofix-Ultra 40 Disperss, Mastercop* | basic copper sulfate (M1) | P/F | see label |
| Cueva* | copper octanoate (M1) | P/F | 4h/0d |
| COC DF | copper oxychloride (M1) | P/F | 48h/See label |
| Champ DP Dry Prill, ChampION++, Champ Formula 2 Flowable, Champ WG*, Kentan DF, Kocide 2000-O, Kocide 3000-O, Nu-Cop 3L, Nu-Cop 50 DF*, Nu COP 50 WP*, Nu-Cop HB*, Nu-Cop XLR, Previsto | copper hydroxide (M1) | P/F | 48h/14d |
| Badge SC, Badge X2* | copper oxychloride + copper hydroxide (M1) | P/F | 48h/14d |
| Agri-Fos, Confine Extra, OxiPhos, Phiticide, Phostrol, Reliant | phosphorous acid, mono & di-potassium salts (33) | P/F | 4h/0d |
| Fosphite, Fungi-Phite, Prophyt, Rampart | potassium phosphite (33) | P/F | 4h/0d |
| Pristine | boscalid (7) + pyraclostrobin (11) | P | 12h/14d |
| Luna Sensation | fluopyram (7) + trifloxystrobin (11) | P | 12h/14d |
| Actinovate AG*, Actinovate STP* | *Streptomyces lydicus* WYEC 108 | 0 | |
| Folpan 80 WDG | folpet (M4) | U | 24h/14d |
| Sonata* | *Bacillus pumilus* strain QST 2808 (44) | U | 4h/0d |
| Trilogy* | extract of neem oil | U | 4h/0d |
| Oxidate 2.0, StorOx 2.0 | hydrogen dioxide/peroxyacetic acid | U | Until dry/5d |
| Carb-O-Nator, Kaligreen*, Milstop* | potassium bicarbonate | U | see label |
| Regalia* | *Reynoutria sachalinensis* extract (P5) | U | see label |
| 1. FRAC - Fungicide Resistance Action Committee (FRAC) codes are used to distinguish the fungicide groups for resistance | | | |
| 2. 0= not effective, P = poor, F= fair, G = good, E = excellent, U = unknown. Ratings are based on published information and | | | |
| 3. PHI-preharvest interval, REI-restricted entry interval expressed as h-hours or d-days. | | | |
| 4. Research in Michigan has shown that drench applications are more effective than foliar applications. | | | |
| 5. Requires a supplemental label for use in hops. | | | |
| * OMRI approved for organic production. | | | |

# Registered Insecticides

| Chemical Class (IRAC group[1]) | Active Ingredient | Products labeled | Pesticide Efficacy[2] | | | | REI/PHI[3] |
|---|---|---|---|---|---|---|---|
| | | | 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 EC, Abba Ultra, Abamex, Agri-Mek SC, Averland FC, Reaper 0.15 EC, Reaper Clearform, Reaper Advance, Willowood Abamectin 0.15 EC or LV | U | G | N | E | see label/28d |
| Biopesticides | *Bacillus thuringiensis* (11A) | Biobit HP, BT Now, Crymax Bioinsecticide, Deliver, Dipel DF*, Dipel ES, Javelin WG, Leptrotec, 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 CG*, 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, 440 Superior Spray Oil | N | N | N | U | 4h/0d |
| | Oils, petroleum based | Biocover MLT, Glacial Spray Fluid, JMS Stylet Oil, Omni Supreme Spray, Organic JMS Style Oil*, Purespray Spray Oil 10E, 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, 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 | Portal XLO | G | N | N | G | see label |
| Multisite, Organophosphates (1B) | Malathion | Fyfanon 57% EC, 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.** Insecticide Resistance Action Committee (IRAC) codes are used to distinguish the insecticide modes of action for resistance management purposes. **2.** Pesticide efficacy is based on trials in fruit crops, as reported by Michigan State University Extension, 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. **3.** 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[1]) | Active Ingredient | Products labeled | Pesticide Efficacy[2] | | | | REI/PHI[3] |
|---|---|---|---|---|---|---|---|
| | | | Potato leafhopper | Rose chafer | Japanese beetle | Two-spotted spider mite | |
| Neonicitinoids (4A) | Imidacloprid(4A) | Admire Pro, Advise Four, Alsias 4F, Imidashot DF, 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 Insecticide, Nuprid 2F, Nuprid 2SC, Nuprid 4.6F Pro, Nuprid 4F Max, 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 |
| Pyrethroids (3) | Bifenthrin** | Athena, Avenger S3, Bi-Dash 2E, Bifen 2AG Gold, Bifender FC, Bifenthrin 2EC, Bifenture 10DF, Bifenture EC, Brigade WSB, Brigade 2EC, Discipline 2EC, Fanfare ES, Fanfare EC, Reveal, Reveal Endurx, Sniper, Sniper Helios, Tundra EC | G | U | E | U | see label, many are 12h/14d |
| | Cyfluthrin** | Tombstone, Tombstone Helios | U | N | U | N | 12h/7d |
| | Pyrethrins | EverGreen Crop Protection EC 60-6, Pyganic EC 1.4 II*, Pyganic EC 5.0 II*, Tersus | U | F | F | U | 12h/0d |
| | Beta-cyfluthrin** | Baythroid XL, Sultrus | 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, Acramite 4 SC, Banter WDG, Bizate 4 SC, Bizate 50 WDG, Vigilant 4 SC, Willowood Bifenezate 50WDG | N | N | N | E | 12h/14d |

**1.** Insecticide Resistance Action Committee (IRAC) codes are used to distinguish the insecticide modes of action for resistance management purposes. **2.** Pesticide efficacy is based on trials in fruit crops, as reported by Michigan State University Extension, 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. **3.** 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 Miticides

| Products labeled (IRAC Code) | Active ingredient | Affected stage[1] | Considerations | Residual control[2] | Preharvest interval | Impact on predatory mites[3] |
|---|---|---|---|---|---|---|
| Savey or Onager (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 | see label | 1 |
| Abacus, Abacus V, Abba 0.15 EC, Abba Ultra, Abamex, Agri-Mek SC, Averland FC, Reaper 0.15 EC, Reaper Clearform, Reaper Advance, Willowood Abamectin 0.15 EC or LV (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 |
| Omite 6E, Endomite (12C) | propargite** | motiles | For basal treatments only to control early/beginning mite populations before they move into the canopy. | unknown | 14d | 1 |
| Portal (21) | fenpyroximate | Motiles | For best results, apply before mite populations exceed 5 mites/leaf. Not recommended when temperature exceed 90F. | 6-8 weeks | 15d | 1 |
| Acramite 50 WS, Vigilant 4 SC (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 | ** |

**1.** Motile forms include mite larvae, nymphs and adults.
**2.** 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.
**3.** 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.
****** Products containing these active ingredients are classified as a restricted use pesticides and require the applicator to retain a pesticide applicator license.

Modified from a table by John Wise, Larry Gut and Rufus Isaacs, Michigan State University, 2015.

# 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.

**2.** IOBC 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.

**2.** IOBC 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**

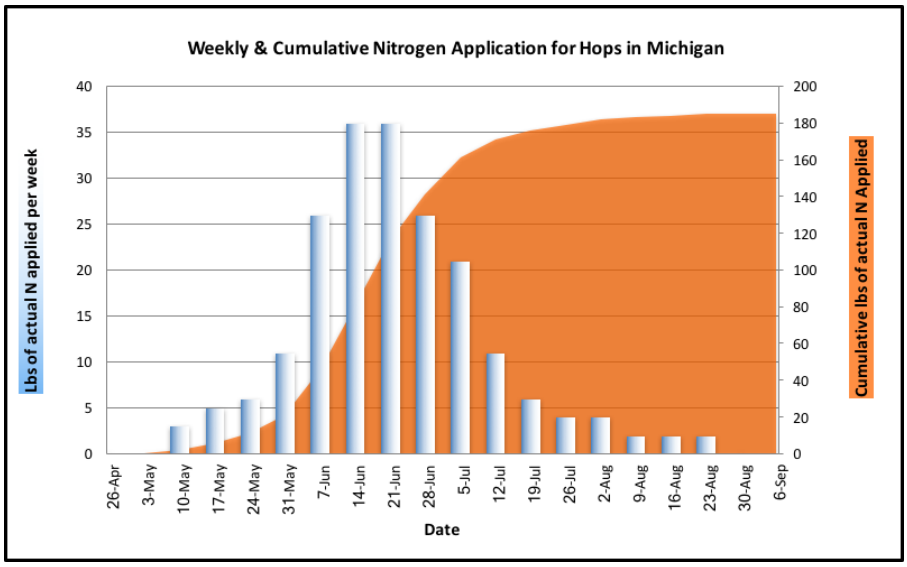
## Nutrient Management Considerations

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, or N-fixing leguminous cover crops, which should be added the the N budget, nor 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 late May- early July.




*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.

Sandy soils tend to have low soil organic matter levels and growers may need to apply a slightly higher rate of nitrogen to optimize growth. Based on average Michigan conditions, it is recommended that hop growers apply 150-185 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 3rd-4th week 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 130-150 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. In addition to soil and plant tissue testing, MSU also offers compost analysis, which may provide growers with useful information. 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. 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. Hop nutrient research results from the PNW suggest that (leaf+ petiole) K levels were often inadequate, even in hopyards with sufficient soil K levels. Inefficient plant uptake might be improved by adding a second fertigation line (Taberna, 2016)[5]. Plants deficient in K are more susceptible to environmental stress and disease. Excessive K levels can result in Mg deficiency.

**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

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

[5] Taberna, J. 2018. Hop nutrient needs for maximum production and quality. Western Labs Inc.

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 levels can often be inadequate mid-late season (Taberna, 2016). Boron soil test levels should be 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 plays 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. Growers may find foliar micronutrient applications that include Zinc to be beneficial.

**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 6-30 ppm. In addition to Potassium and Boron, Manganese was often inadequate in the soil solution in PNW research trials (Taberna, 2016).

**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.

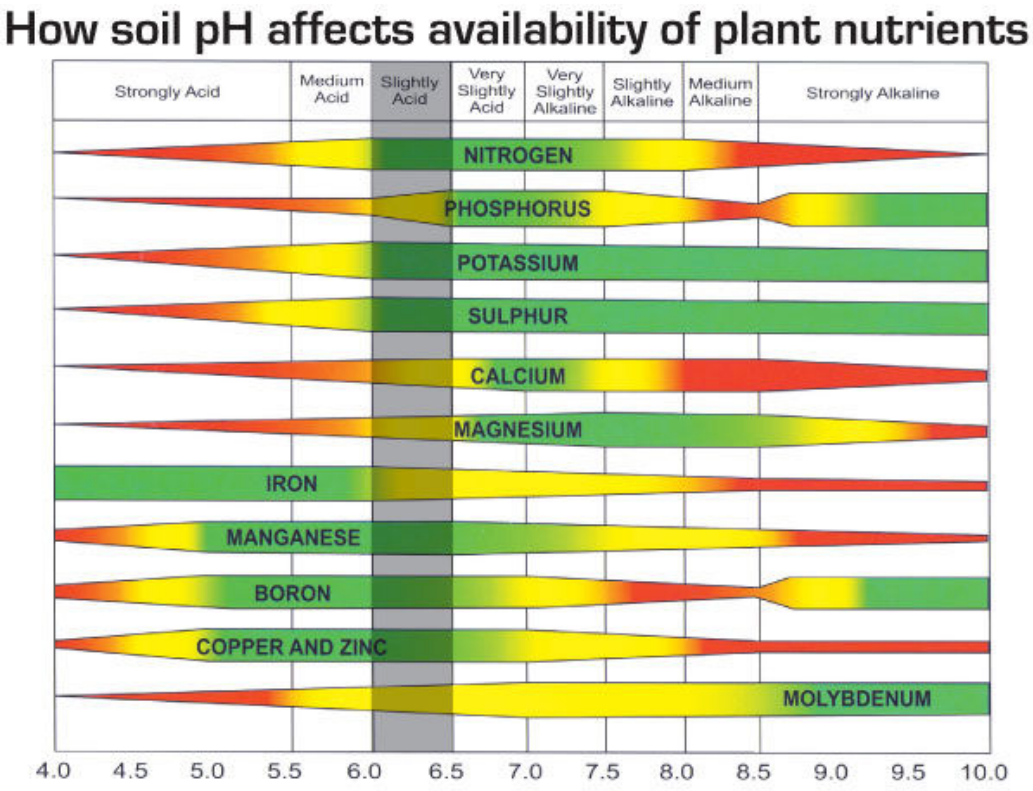
**Sodium (Na)**

Though non-essential, Sodium is important for metabolic processes and chlorphyll 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 soil acidity or alkalinity. Soil pH is determined by soil parent material, rainfall, and past fertilization practices. Soil pH affects nutrient availability (see figure)[6]. 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.




[6] 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 Nutrient Ranges**

| NUTRIENTS | JIH[1] | Plant Analysis Handbook IV[2] | | Western Labs[3] Leaf + Petiole | CSIRO Australia[4] (from Bergmann) Mid-season (YML) |
|---|---|---|---|---|---|
| | | Vegetative Stage-Pre-Bloom (YML)* | Reproductive stage & Full Bloom (YML) | | |
| Nitrogen (%) | | 3.2 - 5.6 | 2.13 - 3.93 | >4.5 | 2.5 to 3.5 |
| Phosphorous (%) | 0.29 - 0.6 | 0.27 - 0.54 | 0.18 - 0.43 | >0.33 | 0.35 to 0.60 |
| Potassium (%) | 1.49 - 2.5 | 1.6 - 3.4 | 0.97 - 2.55 | >2.8 | 2.8 to 3.5 |
| Calcium (%) | 0.79 - 1.2 | 1.03 - 2.57 | 3.09 - 6.05 | >0.6 | 1.0 to 2.5 |
| Magnesium (%) | 0.24 - 0.8 | 0.29 - 0.67 | 0.55 - 1.71 | >0.35 | 0.3 to 0.6 |
| Manganese (ppm) | 25 - 150 | 45 - 125 | 50 - 150 | >36 | 30 to 100 |
| Iron (ppm) | 30 - 60 | 44.3 - 97.9 | 35.4 - 151 | | |
| Copper (ppm) | 10 - 25 | 8 - 29 | 5.7 - 16.6 | >7 | 6 to 12 |
| Boron (ppm) | 24 - 75 | 17.6 - 63.2 | 48 - 150 | >18 | 25 to 70 |
| Zinc (ppm) | 24 - 50 | 23.2 - 108 | 19.4 - 57.1 | >25 | 35 to 80 |
| % Sulfur Sampled Basis | 0.16 - 0.32 | 0.2 - 0.34 | 0.18 - 0.30 | >0.23 | |
| % Sulfur Dry Matter Basis | 0.16 - 0.32 | 0.2 - 0.34 | 0.18 - 0.30 | | |
| Mo | | 0.5 - 3 | 1 - 5 | | 0.2 to 2.5 |
| Na | 0 - 1400 | | | | |
| NO3 ppm | 4000-12000 | | | | |

[1]Del Moro, S. 2014. Great Lakes Hop and Barley Conference. John I Haas.

[2]Plant Analysis Handbook IV. 2015. Bryson and Mills (eds). P. 301

[3]Taberna, J. 2017. Leaf + Petiole collected at 5.5' when plant is 8' and from 1' below wire when plant reaches wire

[4]CSIRO. Plant Analysis: An Interpretation Manual. 2nd Ed. Reuter, D.J. and & Robinson, J.B. (eds). 1997. p149

W. Bergmann, Ernährungsstörungen bei Kulturpflanzen, 3rd ed. Jena: Gustav Fischer Verlag, 1993, pp. 384–394.

*YML= Youngest Mature Leaf

## Guidelines for Safe Use of Pesticides

Karen Renner, Julianna Wilson, Meghan Milbrath

Pesticides are important tools for managing pests of orchard crops, but they need to be handled with care and responsibility. In this section we cover several important topics with respect to pesticide safety: worker safety, emergency preparedness, pesticide handling, storage and disposal, protecting water, protecting pollinators and other ben-eficial insects, and important legal considerations.

### Worker Safety

Agricultural operations that apply restricted-use pesticides are re-quired by Federal law to follow certain worker protection safety rules (for more information on WPS rules, visit your county MSU Extension office). It is good practice to protect workers from potential exposure to all pesticides being used – whether they are derived from synthetic or organic origins. Following are a basic set of good practices to protect workers from exposure:

- Provide employees with annual training in worker safety, if they are not already certified as pesticide applicators.
- Use a Central Notification Board to provide access to information about pesticide safety and the pesticides that are being used in the operation.
- Post pesticide safety posters to remind workers about how to be safe around pesticide use.
- Provide access to pesticide labels and MSDS sheets.
- Post what and where pesticide treatments were made and include when it is safe to enter the treated area based on the pesticide's restricted entry interval (REI).
- Protect workers from exposure to pesticides.
- Prohibit handlers from applying pesticides in any way that will expose workers or others. Monitor the health of handlers who apply highly toxic pesticides.
- Workers not applying pesticides must be excluded from areas being treated with pesticides and adhere to the REI on the pesticide label.
- Early-entry workers must be protected while they are doing permitted tasks in an area under REI and provided instruction for use of personal protective equipment.
- Mitigate exposure: Provide decontamination sites for washing up in the field.
- Provide emergency assistance to make transportation available to a medical facility in the event of a pesticide-related injury or illness.

### Emergency Preparedness

At the time that the pesticide is purchased, ask the chemical dealer for a complete specimen label of the product you bought. This label and labeling information packet is an exact duplicate of the label information that is affixed to and/or must accompany the pesticide container. Use the specimen label material as a reference during any pesticide emergency. Bring the label along with any person who has become poisoned and needs medical attention.

Closely follow all the warning statements outlined in the Precaution-ary Statements section of the pesticide label. Be certain that you use all protective clothing and equipment as specified by the label. Make certain all persons involved in the operation of the farm know and can carry out the information in the Statement of Practical Treatment. (See also the section on SARA Title III.).

### Pesticide Handling, Storage and Disposal

This section is not meant to be exhaustive or to take the place of labeled instructions for the product being used. ALWAYS READ AND FOLLOW THE LABEL for whatever product you are using.

**Transporting pesticides**

Have pesticides delivered by your dealer directly to your pesticide storage facility, if possible. Transporting pesticides, especially large quantities, can involve a high degree of assumed liability by the grower. Department of Transportation shipping rules must be followed for transporting large quantities of pesticides, including proper placarding of the vehicle, liability insurance, special handling require-ments, etc.

**Storing pesticides**

Pesticides must be stored in a facility that will protect them from tem-perature extremes, high humidity and direct sunlight. The storage fa-cility should be heated, dry and well-ventilated. It should be designed for easy containment and cleanup of pesticide spills and made of materials that will not absorb any pesticide material that leaks out of a container. Store only pesticides in such a facility, and always store them in their original containers.

Do not store any feed, seed, food or fertilizer with pesticides. Do not store any protective clothing or equipment in the pesticide storage facility. Store herbicides separately from insecticides and fungicides to avoid contamination of one material by another and accidental misuse.

Keep the facility locked at all times when not in use to prevent animals, children and irresponsible adults from entering and becom-ing poisoned. Post the facility as a Pesticide Storage Facility to warn others that the area is off-limits. Maintain an accurate inventory of the pesticides stored in the facility at all times in case of emergency.

Always read and follow the Storage and Disposal section of pesticide labels for specific storage and handling instructions. For additional in- formation on pesticide storage, refer to Midwest Plan Service bulletin 37, Designing Facilities for Pesticide and Fertilizer Containment, and MSU Bulletin E-2335, On-Farm Agrichemical Storage and Handling. Handling and mixing pesticides. Always wear protective clothing and equipment when handling, mixing and applying pesticides, and dur-ing cleanup of application equipment. Always wear what is required on the label.

**Handling and mixing pesticides**

Always wear protective clothing and equipment when handling, mixing and applying pesticides, and during cleanup of application equipment. Always wear what is required on the label.

Mix pesticides downwind and below eye level. Avoid excessive splashing and sloshing. If pesticides are spilled on you, wash them off immediately with lots of water and change clothing. Resume spraying only after cleaning up any spills. Try to use closed handling/mixing systems when appropriate.

Mix only what is required for the area to be sprayed according to label directions. Do not mix excessive amounts. Otherwise, hazardous waste will be created that is difficult and expensive to dispose of. Keep unauthorized persons out of the area when you handle pesticides.

**Applying pesticides**

Prior to any application, the equipment used must be thoroughly checked for sound operation and accurately calibrated. Poor main-tenance and calibration practices lead to excessive residues on the crop and could harm humans, animals, crops and other parts of the environment. Inspect the equipment

during use to prevent the unin-tentional misapplication of chemicals. If equipment needs repair, stop spraying and fix the problem immediately.

Do not spray when the wind is greater than 10 miles per hour and/or weather conditions (e.g., inversions) are conducive to pesticide drift away from the target area. Make every effort to AVOID PESTICIDES MOVING OFF TARGET!

**Handling and disposing of pesticide contain-ers**

Pesticide containers are considered hazardous waste unless they are triple rinsed or pressure rinsed and the rinsate is used as additional dilution in the spray mixture. After triple or pressure rinsing all emptied pesticide containers, perforate both ends so that the container can- not be reused. All metal and plastic triple-rinsed containers should be offered for recycling. If this option is not available, dispose of them in a state-licensed sanitary land ll. Dispose of all paper containers in a sanitary land fill or a municipal waste incinerator. Do not bury or burn any pesticide containers. Do not reuse any empty pesticide contain-ers for any purpose.

**Cleaning pesticide application equipment**

Follow all specific label directions for cleaning application equipment. If such instructions are not given on the pesticide label, then triple rinse the entire inside of the application equipment, spraying the rinsate on a labeled site not exceeding labeled rates. Wash off the outside of the equipment in the target area. Only after rinsing out the equipment with fresh water should you clean the spray system with an appropriate cleaning solution. Do not spray any cleaning solution onto any crop; dispose of the cleaning solution as you would any municipal waste. Follow the equipment manufacturer's guidelines for routine and year-end cleaning and maintenance.

Disposing of unused and unwanted pesticides Unused and unwanted pesticides are considered hazardous waste by both federal and state regulations. To be exempt from the strin-gent requirements for the disposal of hazardous pesticide waste, make every effort to purchase the exact amount of pesticides that will be needed during the growing season. Take extreme care in the calibration and application of any pesticide so that leftovers are not gen-erated at the end of the job. Use any pesticide-containing rinsates and unused pesticides exactly according to labeled use directions. Unused and unwanted pesticides can be disposed of at Michigan Clean Sweep sites located throughout the state. Contact the MDARD (800-292-3939) for the site nearest you.

If these procedures cannot be met, contact the Michigan Department of Environmental Quality Hazardous Waste Management Division for instructions on the legal disposal of pesticide waste.

**Protecting Water**

The key to preventing pesticides in groundwater and surface waters is identification of the source and route to the water. Point source contamination refers to situations where movement of a pesticide into water can be traced to a specific site. Nonpoint sources occur over a wide area, and most pesticides detected in groundwater and surface water are from nonpoint sources. This type of pollution generally results from land runoff, precipitation, acid rain or percolation rather than from a discharge at a specific, single location (such as a single pipe or well head).

**Fate and transport of pesticides**

Several processes determine the fate of pesticides and whether they will end up in ground or surface waters.

•Adsorption is the binding of chemicals to soil particles. The amount and persistence of pesticide adsorption vary with pesticide properties, soil moisture, soil pH and soil texture. Soils high in organic matter or clay are the most adsorptive; coarse, sandy soils are much less adsorptive. A soil-adsorbed pesticide is less likely to volatilize, leach or be degraded by microorganisms, but it is also less available for uptake by plants.

•Volatilization occurs when a solid or liquid turns into a gas. Pesticide volatilization increases with higher air temperature and air movement, higher temperature at the treated surface (soil, plant, etc.), and low relative humidity, and when spray droplets are small. Pesticides also volatilize more readily from coarse-textured soils and from medium- to fine-textured soils with high moisture content. A pesticide in a gaseous state is invisible and carried away from a treated area by air currents. The movement of pesticide vapors in the atmosphere is called vapor drift. Unlike the drift of sprays and dusts that can sometimes be seen during an application, vapor drift is invisible.

•Runoff is the movement of pesticides in water across the soil surface. It occurs as water moves over a sloping surface, carrying pesticides either mixed in the water or bound to eroding soil. The amount of pesticide runoff depends on the grade or slope of an area, the erodibility and texture of the soil, the soil moisture content, the amount and timing of irrigation or rainfall, and prop-erties of the pesticide. Pesticide losses from runoff are greatest when heavy rainfall occurs shortly after a pesticide application.

•Leaching also moves pesticides in water. In contrast to runoff, leaching occurs as water moves downward through the soil. Factors that influence leaching include whether the pesticide dissolves easily in water, soil structure and texture, and the amount and persistence of pesticide adsorption to soil particles.

•Absorption is the process by which chemicals are taken up by plants. Once absorbed, most pesticides are degraded within plants. However, some residues may persist inside the plant and be released back into the environment as the plant tissues decay.

•Crop removal can transfer pesticides. When treated crops are harvested, the pesticide residues are removed with them and transferred to a new location.

•Microbial degradation occurs when microorganisms such as fungi and bacteria use a pesticide as a food source. Condi-tions that favor microbial growth include warm temperatures, favorable pH levels, adequate soil moisture, aeration (oxygen) and fertility. Adsorbed pesticides are more slowly degraded because they are less available to some microorganisms.

•Chemical degradation is the breakdown of a pesticide by processes not involving a living organism. The adsorption of pesticides to the soil, soil pH levels, soil temperature and moisture all influence the rate and type of chemical reactions that occur. Many pesticides, especially the organophosphate insecticides, are susceptible to degeradation by hydrolysis in high pH (alkaline) soils or spray mixes.

•Photodegradation is the breakdown of pesticides by sun-light. A pesticide that is not volatilized, absorbed by plants, bound to soil or broken down can potentially move through the soil to groundwater. The movement of groundwater is often slow and difficult to predict. Substances that enter groundwater

in one location can turn up years later in other locations. A major difficulty in dealing with groundwater contaminants is that the sources of pollution are not easily recognizable. The problem is occurring underground, out of sight.

**Groundwater** is the water beneath the earth's surface occupying the saturated zone (the area where all the pores in the rock or soil are filled with water). It is stored in geological formations known as aquifers. Groundwater moves through aquifers and can be obtained at points of natural discharge such as springs or streams, or by drilling a well into the aquifer. The upper level of the saturated zone in the ground is called the water table. The water table depth below the soil surface fluctuates throughout the year, depending on the amount of water removed from the ground and the amount of water added by recharge and connected surface waters. Recharge is water that seeps through the soil from rain, melting snow or irrigation.

Many people who live in rural Michigan get their drinking water from wells. Well water is groundwater, so it is easy to see why you should be concerned about keeping pesticides out of groundwater. Surface waters are visible bodies of water such as lakes, rivers and oceans. Surface water contamination is a major concern associated with the runoff of pesticides from treated fields, mixing and rinsing sites, waste disposal areas and manufacturing facilities. In the 1988 inventory of water quality, pesticides were ranked sixth as river and stream pollutants, behind siltation, nutrients, pathogens, organic enrichment and metals.

Surface waters are home to many different organisms including fish and other wildlife. Fish can be harmed directly or indirectly from pesticides. Direct effects such as kills can result from water polluted by a pesticide (usually insecticides). Indirect effects include loss of food when aquatic insects that they eat are harmed or killed. Pesticides can enter water via drift, surface runoff, soil erosion and leaching. Take the precautions outlined below to protect surface waters.

**Keeping pesticides out of groundwater and surface water**

It is very difficult to clean contaminated groundwater or surface water. The best solution is to prevent contamination in the first place. The following pesticide use practices can reduce the potential for surface and groundwater contamination.

•Use integrated pest management programs – Keep pesticide use to a minimum by combining chemical control with other pest management practices.

•Reduce compaction – Surface water runoff increases when soils are compacted.

•Utilize conservation practices that reduce erosion and surface runoff – These practices include but are not limited to planting grassed waterways to retard soil and water runoff and keeping buffer strips to protect surface water bound-aries. These reduce pesticide runoff by trapping sediment and slowing water runoff so that pesticides can interact with the vegetation and soil.

•Consider the geology of your area – Be aware of the water table depth and the permeability of the geological layers between the surface soil and groundwater. Sinkholes can be especially troublesome because they allow surface water to quickly reach groundwater.

•Consider soil and field characteristics – Determine the susceptibility of the soil or field site to leaching or runoff. Soil texture and organic matter content influence chemical movement into groundwater and the slope of the field influences surface runoff. Surface grading, drainage ditches and dikes can help reduce the amount and control the movement of runoff waters.

•Select pesticides carefully – Pesticides that are highly soluble, relatively stable and not readily adsorbed to soil tend to be the most likely to leach. Read labels carefully and consult a specialist from MSU Extension office or your chemical dealer if necessary. The tables in this bulletin will also help you choose the best pesticide for your use.

•Follow label directions – The label carries crucial infor-mation about the proper rate, timing and placement of the pesticide.

•Calibrate accurately – Calibrate equipment carefully and often to avoid over- and underapplication.

•Measure accurately – Carefully measure concentrates before they are placed into the spray tank. Do not "add a little extra" to ensure that the pesticide will do a better job.

•Avoid back-siphoning – The end of the fill hose should remain above the water level in the spray tank at all times to prevent back-siphoning of chemical into the water supply. Use an anti-backflow device when siphoning water directly form a well, pond or stream.

•Consider weather and irrigation – If heavy rainfall is expected, delay applying pesticides. Control the quantity of ir-rigation to minimize potential pesticide leaching and runoff.

•Avoid spills – When spills do occur, contain and clean them up quickly with an absorbent material such as cat litter.

•Change the location of mixing areas – Mix and load pesticides on an impervious pad, if possible, where spills can be contained and cleaned up.

•Dispose of wastes properly – Obey laws regulating the disposal of pesticide wastes. Follow the label instructions for rinsing containers. Pour the rinsewater into the spray tank and use for treating the site or the crop.

•Store and mix pesticides away from water sources such as wells, ponds and springs – Locate pesticide mix-ing and storage sites a safe distance away to avoid contaminat-ing water sources through accidental spills and leaks.

•Dispose of post-harvest rinse water properly – After harvest, many agricultural commodities are washed or processed, and this can remove or degrade much of the remaining residue. However, the wash water may now be contaminated and should be disposed of as a potential contaminant.

**The Michigan Groundwater Stewardship Program**

The Michigan Groundwater Stewardship Program (MGSP) is a co-operative effort between the Michigan Department of Agriculture and Rural Development (MDARD), Michigan State University Extension, Conservation Districts and the USDA Natural Resources Conserva-tion Service. The program is funded through fees assessed on sales of pesticides and nitrogen fertilizers. MGSP-sponsored education, technical assistance and cost-share programs help individuals reduce the risk of groundwater contamination associated with pesticide and nitrogen fertilizer use.

Producers who complete the environmental risk assessments for their farmstead and cropping systems (Farm*A*Syst and Crop*A*Syst) will be able to determine what structural, management and record-keeping changes (if any) will be needed for their farming systems to be in conformance with Michigan Right-to-Farm guide- lines and state and federal environmental laws.

The Michigan Agriculture Environmental Assurance Program (MAEAP) is a voluntary program that assists growers in developing and implementing a plan to address the risks indicated by environmental assessments associated with farming practices. Many farms are becoming MAEAP-verified and as a result are eligible for various incentives. For more information about MAEAP and these incentives, contact MDARD.

**Protecting Bees and Other Beneficial Insects**

Pesticides can cause harm to pollinating bees and other non-pest insects. Be aware of how your pesticide use could potentially put these organisms at risk. The best thing you can do is to reduce potential exposure, since pesticide labels do not always reflect poten-tial hazards, and the health risks of all pesticides for every group of beneficial insects may not be well-studied. The following precautions may help reduce the chance of exposure:

- Avoid pesticide applications on flowers.
- If possible, do not apply pesticides if the site contains a crop or weeds in bloom.
- Pay attention to the orchard or vineyard floor and the spaces between rows: mow cover crops and weeds to remove blooms before spraying.
- Target your pest.
- Select pesticides that are most specific to the target pest.
- Apply only when models or scouting indicate the need.
- Reduce drift during application.
- Calibrate your sprayer early and often to ensure that the applica-tion is staying on target.
- Use drift control materials whenever possible – target nozzles where they are meant to spray; adapt or modify sprayers to recapture over-spray.
- Do not apply pesticides when wind speeds exceed 10 miles per hour.
- Time pesticide applications carefully.
- Bees are most active during midday – if possible, spray at dusk or at night.
- Honey bees are inactive when temperatures go below 55 F – if possible, spray when temperatures are below this threshold.
- Be aware of exposures through standing water.
- Do not let puddles of spray or rinsate accumulate on the ground, honey bees are attracted to standing water and use it to drink or bring back to cool the hive.
- If you rely on honey bee pollination, communication with your beekeeper is essential.
- Work with the beekeeper to choose a safe site for the hives; remember that honey bees can fly far and do not need to be directly in the crop to provide good pollination.
- Coordinate dates and times with the beekeeper for when hives will be delivered and then removed after bloom.
- Discuss your planned spray schedule and the materials you plan to use, so that the beekeeper can adjust if necessary.

**Important Legal Considerations**

**Pesticide Labels**

Always thoroughly read the label and the supplemental labeling material for any pesticide that you may consider using. Understand the label instructions and limitations. Use the pesticide only for the purposes listed and in the manner directed on the label. Select only pesticides labeled for the crop you wish to use them on and the pest(s) you wish to control. To do otherwise will cost you in effective and

economical product performance and may lead to an unaccept-able risk to humans, the crop and the surrounding environment, and later disposal problems of illegal material.

**Record Keeping**

The 1990 Farm Bill requires that all applicators who apply restricted use pesticides (RUP) keep records and maintain them for two years. The State of Michigan requires RUP records be kept and maintained for three years. Records to be kept include:

- Brand name or product name and the EPA registration number.
- Total amount of the product used.
- Size of the area treated.
- Crop, commodity, stored product or site to which the pesticide was applied.
- Location of the application.
- Month, day and year of the application.
- Name and certification number of the applicator or the applica-tor's supervisor.

The spray record sheet at the end of this publication or any re-cord form is acceptable as long as the required data are included. Penalties are up to $500 for the first violation and up to $1,000 for subsequent violations. Provisions for protecting the identity of the individual producers are included in the law. Commercial applicators must furnish a copy of the required records to the customer of the RUP application.

**Endangered Species Act**

To minimize the adverse impact of pesticides on endangered spe-cies, the EPA initiated the Endangered Species Act. The Michigan Department of Natural Resources (MDNR) administers the Michigan Endangered Species Act and maintains the federal and state endangered species lists in the state. Pesticide applications are a potential problem, particularly affecting birds, butterflies and moths. Alteration of the farm landscape can also negatively affect resident endangered species.

The Environmental Protection Agency (EPA) has determined threshold pesticide application rates that may affect listed species. This information is or will be included on pesticide labels. Counties with vulnerable endangered or threatened species will be identified on pesticide labels. Farmers must take the initiative and consult with the MDNR and the Fish and Wildlife Service (FWS) to be sure there are no endangered species in their area. The Nature Conservancy, a private land and habitat conservation organization, is working with the MDNR and the FWS and is conducting a landowner contact program to work with landowners who own property important for endangered species protection.

**SARA Title III Emergency Planning and Community Right-to-Know Act**

The Emergency Planning and Community Right-to-Know Law, under SARA Title Ill, requires farmers to notify the Michigan SARA Title III Program and the Local Emergency Planning Committee (LEPC) if they store extremely hazardous materials, along with the name and telephone number of the facility representative. Check Exten-sion bulletin E-2575 for a list of EPA-classified "extremely hazardous substances" and their threshold planning quantities. The LEPC may request maps of your storage facility and detailed lists of materials you store. This law also requires that, in the event of a spill, the state SARA Title III Program, the LEPC and the National Response Com-mission be notified.

**Right to Farm**

Farmers in Michigan are protected from nuisance lawsuits under the Right-to-Farm Act if they follow specific acceptable management practices. The generally accepted agricultural and management practices (GAAMPs) for pesticide utilization and pest control, nutrient utilization, irrigation and manure management have been completed and are revised annually. The current right-to-farm GAAMPs are posted on the MDARD website: www.michigan.gov/mdard.

**Federal Worker Protection Standard**

Changes to Federal worker protection rules for worker protection went into effect as of the 2018 field season. The Worker Protection Standard (WPS) covers pesticides that are used in the production of agricultural plants on farms and in forests, nurseries and greenhouses. Details for compliance with the Worker Protection Standard as well as other regulations affecting worker safety can be obtained at the county MSU Extension office.

# 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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