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Ohio Hop Disease Management Guide — 2018 —

Melanie L. Lewis Ivey, Rachel Medina and Brad Bergefurd
Fruit Pathology Program
Department of Plant Pathology
The Ohio State University-Wooster Campus
Wooster, OH

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Table of Contents

I. Introduction

The Ohio State University Hop Disease Management Guide is a resource for hop propagators and producers in Ohio and surrounding states. The guide provides integrated management tactics for the most important or more prevalent diseases that affect hops grown in Ohio.

Successful management of plant diseases requires a disease management program that integrates the use of available resistant varieties, good cultural practices, weed and insect control, biocontrol and chemical control. Disease management recommendations are based on research results of experiments conducted by The Ohio State University, other land-grant universities in the United States and the U.S. Department of Agriculture's Agricultural Research Service. Disease management recommendations within the guide are updated at annually.

References to commercial or trade names are made with the understanding that no discrimination is intended and endorsement of a particular product by The Ohio State University or Ohio Agricultural Research and Development Center is not implied. More information on available pesticides can be obtained at cdms.net or by contacting your local OSU Extension county office.

II. Abbreviations

Throughout this guide, units of measurement and time are abbreviated. The table below lists the units of measure or time and the corresponding abbreviations.

Term	Abbreviation
Day	d
Feet	ft
Fluid ounce	fl oz
Gallon	gal
Hour	hr
Inch	in
Minutes	min
Ounce	oz
Pre-harvest interval	PHI
Pint	pt
Pound	lb
Quart	qt
Reentry interval	REI
Square feet	ft^2
Year	yr

III. Pesticide Use and Safety

Pesticides are an important management tool in an integrated pest management program (IPM). Pesticides should be used in a manner that limits worker, domestic animal and wildlife exposure, runoff, drift and the buildup of pesticide resistant pathogens. Adequate training should be provided to all employees on how to use pesticides safely. More information on pesticide safety and a list of pesticide certification or recertification conferences for Ohio is available through the OSU Pesticide Safety and Education Program.

Pesticide Safety Education Program
256 Howlett Hall, 2001 Fyffe Ct
Columbus, OH 43210
614-292-4070
pested@osu.edu

Before applying a pesticide for disease control to a crop:

- Confirm that the problem is due to a pathogen.
- Have the disease identified by an authority on plant pathogens and diseases.
- Select a pesticide that is recommended for the disease.
- Confirm that the pesticide is registered in Ohio with the Environmental Protection Agency and labeled for the crop on which you intend to use it.
- Read the product label in its entirety. Pay particular attention to any application restrictions that may exist for the product.
- Check that your application equipment is functioning properly by testing it using water. Make all repairs prior to using a pesticide.
- Calibrate application equipment at the beginning of the season and at least twice throughout the season to ensure proper pesticide output.
- Confirm that your respirator fits properly and is clean and functioning.
- Check that gloves and protective clothing fit properly and are clean and free of holes. Always have extra clean clothes available in case of an emergency.

Application of pesticides:

- Always wear protective clothing and a respirator while spraying.
- Spray during calm weather to avoid pesticide drift.

Preparation, storage and disposal of pesticides:

- Always wear protective clothing when handling pesticides.
- Mix pesticides in a well-ventilated area with access to clean water, soap and single use towels (decontamination supplies).
- Product labels and material safety data sheets, as well as emergency contact information, should be available for quick reference.
- Only compatible pesticides should be tank-mixed. Read the label carefully to confirm pesticide compatibility.
- Do not prepare or store pesticides near food.
- Only prepare the amount of pesticide required to treat the crop.
- Store pesticides in a locked room at the recommended temperature.
- For proper (and legal) disposal of unused pesticides, contact your local solid waste management authority, environmental agency or health department. To identify a local authority, contact the Ohio Environmental Protection Agency-Division of Materials and Waste Management (epa.gov/hwgenerators/links-hazardous-waste-programs-and-us-state-environmental-agencies) or call 1-800-CLEANUP***.***

After applying a pesticide to a crop:

- Promptly post signs indicating the crop has been treated with a pesticide.
- Clean and decontaminate equipment according to the product label.
- Document the day, time, crop and type and amount of pesticide applied. **Careful record keeping is extremely important.**

In case of an emergency:

- In the case of direct human exposure that results in personal injury or ingestion of a pesticide, immediately dial 911 and/or contact your local physician.
- In the case of an environmental spill, contact your local environmental protection agency representative (https://www.epa.gov/smm/contact-information-regional-wastewise-representatives)

IV. Fungicide Resistance Management

Fungicides are important tools for managing many hop diseases. Fungicides are most effective when applied before fungal infections are established. Because protection by fungicides is temporary, they may need to be reapplied to protect new growth.

While many factors can contribute to the failure of a fungicide to protect a crop, the development of resistance by the fungal pathogen is the most difficult to overcome. Resistance is a heritable genetic trait that results in reduced sensitivity to a fungicide by a fungal pathogen. Fungicides that disrupt multiple cellular functions (multisite inhibiting fungicides) in the pathogen are less likely to result in resistant pathogen populations than those that target a single cellular function (single site-specific fungicides). Most new fungicides are single site-specific; however, because they have less of an effect on the environment, including non-target organisms.

Fungal pathogens that are resistant to one fungicide often are resistant to other fungicides that have a similar or same mode of action. This is called cross-resistance. For this reason, the Fungicide Resistance Action Committee (FRAC) developed fungicide group codes, referred to as FRAC codes, to facilitate resistance management. Fungicides with the same FRAC code have a similar mode of action and could exhibit cross-resistance. A full list of the codes for all fungicide common names (active ingredients), their modes of action and the risk level (low, medium or high) for fungicide resistance development can be found at frac.info/docs/default-source/publications/frac-code-list/frac-code-list-2017-final.pdf?sfvrsn=fab94a9a_2. FRAC codes are often listed on the front of a product label or in the resistance management section.

Fungicide resistance in a pathogen population becomes important when fungicide-resistant isolates outnumber fungicide-sensitive isolates. ***The buildup of resistant isolates is caused by repeated or incorrect use of a fungicide.*** Fungicide resistance within a population occurs at different rates and is affected by the mode of action of the fungicide, the genetics of the pathogen and cropping practices.

Strategies for managing fungicide resistance are aimed at slowing down the development of resistance. Therefore, resistance management plans must be implemented when at-risk fungicides become available for a particular use before resistance becomes a problem. The objective of a resistance management program is to minimize the use of at-risk fungicides without compromising disease control. While specific strategies vary depending on the fungicide FRAC code, the target pathogen and the crop, the general approach is similar. A resistance

management program should integrate resistant varieties, good cultural practices and thoughtful and judicious use of fungicides.

Resistant Varieties: Whenever feasible, resistant varieties should be selected. The use of resistant varieties lowers the potential for disease incidence and severity and thereby minimizes the need for fungicides.

Good Cultural Practices: Poorly drained soils, shady sites and poorly drained soils other can increase the susceptibility of plants to disease. Sites that get 6-8 hours of full sun per day and have well drained soils, as well as proper soil fertility, balanced foliar fertility and the use of high quality water can reduce disease incidence and severity. Good sanitation practices throughout the year can also reduce the incidence of disease.

Fungicide Use: Fungicides should only be used when alternatives are not available to avoid unnecessary selection of fungicide resistant populations. The following practices should be used when fungicides are necessary:

- Start fungicide applications early in disease development.
- Use low-risk (i.e. broad spectrum, FRAC No. M) fungicides when possible.
- Use optimal application methods to maximize spray coverage.
- Do not apply fungicides at rates below or above the range specified in the label.
- Do not apply high risk fungicides more than two times sequentially. Alternate (apply a fungicide at most twice and then switch) fungicides from different FRAC codes.
- Alternatively, tank-mix at-risk fungicides with a protectant fungicide. Refer to product labels to ensure fungicides are compatible or to confirm that the fungicide is not already a pre-mix.
- Refer to product labels for specific resistance management guidelines.
- Do not exceed the number of fungicide applications (or maximum use amount) recommended by the manufacturer.

Soil and Foliar Nutrient Testing

Soil and foliar nutrient assessments are essential to a disease management program, as nutrient imbalances can increase plant susceptibility to disease. However, specific hop fertility recommendations are beyond the scope of this guide. For specific fertility and testing facility recommendations consult your county Extension Educator or Specialist.

Soil nutrient analysis: Soil samples (topsoil and subsoil) should be taken prior to planting and annually thereafter. A complete analysis should be conducted that includes micro- and macronutrients, zinc, boron, nitrogen, percent organic matter and pH.

Foliar nutrient analysis: Foliar samples (petioles) should be taken around the first week of June and periodically throughout the season to track nutrient uptake. Analyses should include nitrogen, phosphorous, potassium, zinc and boron.

V. Hop Disease Diagnosis

Accurate and rapid diagnosis depends on the quality of the sample submitted for diagnosis. No one method of preparation for shipping of plant materials will guarantee their satisfactory arrival in the laboratory, but following the suggestions given below will ensure specimens will be received in good condition. Specimens completely desiccated or in advanced states of rot and those that arrive with little to no supporting information can't be diagnosed. To get the best possible results, follow these instructions:

General Guidelines for Submitting Hop Samples for Routine Diagnosis:

Please consult the following guidelines before collecting, packing and submitting the samples.

- Plan to collect and submit samples early in the week. Samples should be mailed Monday through Wednesday.
- Pack samples properly. (See "Sample Packaging and Mailing" below.)
- Collect specimens representing a range of symptoms.
- Collect all parts of the plant that show symptoms.
- Collect specimens before applying any pesticides. If pesticides were applied indicate which chemicals were applied and the date that they were applied.
- Submit a generous amount of plant material, including leaves, cones, rhizomes and roots.
- Include the following information with the sample: variety, when symptoms were first observed, recent pesticide applications and the number of plants affected.

Sample Packaging and Mailing:

1. Do not add water to samples.
2. Mail samples on the same day that they were collected.
3. Wrap leaves, roots, rhizomes or cones in dry paper towel(s) and place in plastic bags. Do not use paper bags.
4. For whole plant samples, place root ball (containing rhizomes, roots and some soil) and foliage in a plastic bag and tie with a twist tie or a rubber band. Do not cut the root ball off the above-ground plant parts.
5. Pack samples in a sturdy container. Whole plant samples should be enclosed in boxes or other crush-proof packaging.
6. Identify multiple samples by including a label on the outside of each bag.
7. Address package to:
   Melanie Lewis Ivey
   Fruit Pathology Laboratory
   1680 Madison Avenue
   Wooster, Ohio
   44691
8. Mail packages via overnight delivery to arrive Monday through Friday.

Remember that the better the specimen, the more accurate the diagnosis!

VI. Integrated Hop Disease Management

Many diseases (Table 1) occur on hops in Ohio. Damage from these diseases can result in reduced yield and diminished yield quality. Disease management depends largely on the care and attention that hops are given throughout their lifetime. For any given disease, or insect pest for that matter, multiple management tactics will be needed to successfully manage hops diseases throughout the season. In Ohio, downy mildew is the most economically important diseases of hops and drives the fungicide program. Starting with certified clean plant stock and planting resistant varieties are two of the best ways to reduce many disease problems. Use of good cultural and sanitation practices and fungicides are also important tactics to prevent or manage hop diseases.

Site selection and preparation: Selection of a suitable site is the first step toward producing healthy hop plants. Ideally a site should be selected at least a year ahead of planting in order to prepare and test the soil, adjust soil fertility and pH, install tile drainage, and implement weed management tactics. Because hops emerge very early in the season, hop yards should be placed on high ground or areas that are not prone to early and heavy frosts. Yards should also be established in areas that facilitate good air movement throughout the crop canopy. Avoid planting near fence lines, next to woods or windbreaks, or close to buildings that can obstruct airflow through the yard. Sites that are heavily infested with weeds such as sedge, nut sedge, quackgrass, Johnson grass or thistles should be avoided or treated prior to planting.

Soil type: Hop plants can grow in a wide range of soil types, from sandy to clay loams, but optimal yields will be obtained when they are grown in deep, fertile soil that is rich in organic matter.

Soil pH: The pH of soil influences many biological and chemical processes that can indirectly or directly impact the health of the soil and more importantly the hop plant. For example, acidic soils (low pH) can favor the growth of some fungal pathogens (i.e. Fusarium spp.) while suppressing others (i.e.*Verticillium* spp.). The opposite is true for alkaline soils (high pH). Therefore, a soil pH of 5.7 to 7.5 is ideal. Soil should be tested annually to determine the soil pH and tactics should be implemented to adjust the pH as needed.

Soil fertility: Hop plants require an intensive fertility program because they produce a lot of biomass (bines, cones, leaves) in a very short time, growing up to a foot per day. However, a fertility program must be well balanced as excess of some nutrients (i.e. nitrogen) can increase susceptibility to disease. Compost, applied in the fall, can be good source of fertility for the following year's crop and also acts as insulator protecting the crown from sub-zero freezing temperatures. Only use certified compost from a reputable supplier. Compost that is not properly heated can be a source of weed seeds, insects and pathogens. Petioles and leaves should be tested for nutrient levels throughout the season so that fertility programs can be adjusted as needed in a timely manner.

Soil moisture: Vigorous growth and high yields cannot be expected without adequate soil drainage during the entire year. The rhizomes and roots of hop plants cannot tolerate saturated soils for any length of time and saturated soils favor root rot pathogens such as *Phytophthora* spp. Prior to planting, the site should be leveled and systematic tile drainage systems, grassed waterways and drainage ditches should be installed. Raised beds that are eight inches high and two to three feet wide are recommended on sites with poorly drained soils and should be maintained over the life of the planting. Deep ripping between hop rows with a modified v-ripper or chisel plow can help to facilitate water drainage between the rows.

VII. Hop Clean Plant Network

Purchase virus-free certified planting stock: Several viruses and virus-like particles (viroids) infect hops. New plantings should be started using propagative material tested to be free of viruses and viroids. Currently there is not a certification program available for hop propagators. Therefore, it is important to purchase your rhizomes or starter plants from a reputable propagator or nursery that uses best propagation, sanitation and disease management strategies. Plants can also be purchased from the **Hop Clean Plant Network**, which is located at Washington State University in Prosser. The center offers 31 varieties of virus- and viroid-tested propagative material (shoots and tissue culture) to the industry. For more information on available varieties, the fee schedule and to place an order go to cpcnw.wsu.edu/current-plant-material-for-sale/.

***Plant resistant cultivars*:** In Ohio, downy mildew is the most widespread and destructive disease of hops. Selecting cultivars that are resistant or tolerant to downy mildew is recommended, especially in regions where cool and wet conditions persist. Disease susceptibility of hop varieties grown in the United States is provided in Tables 2 and 3.

Use good sanitation practices: Good sanitation should be used during crown topping, pruning, and leaf stripping. Caution should be taken to avoid damaging the crowns during pruning and cultivation. Destroying escaped hop bines near or in hop yards is an important practice to prevent the build-up of pathogens in the hop yard. Leaves should be stripped from bines soon after training (~4 ft height) to reduce the spread of downy mildew up the canopy. Stripped leaves should be removed from the yard immediately and destroyed. If cones were not harvested (i.e. first year hops), bines and leaves should be removed and destroyed after a hard frost. Disease tissue can be buried or burned. Composting diseased plant tissue is not recommended unless proper composting techniques are used. Flail chopping or mowing the plant material between the rows will not allow the material to completely decompose due to a lack of heat and the short time until new growth emerges in the early spring.

Ensure good spray coverage*:* Good spray coverage is essential for good disease control and to a lesser extent for insect control. However, spraying hop plants can be a challenge. Radial air blast sprayers are commonly used but may not allow for good coverage of fully grown bines.

Use registered chemicals: In Ohio, downy mildew is the most economically important disease of hops and drives the fungicide program. The potential for developing isolates of downy mildew that are resistant to fungicides is high in hop production. To slow the development of resistant pathogen populations 1) develop a spray program that uses fungicides with different modes of action; 2) avoid consecutive sprays with fungicides with the same or similar modes of action and 3) only use the labeled rates of recommended fungicides. More information of fungicide resistace management can be found in this guide.

Table 1. Symptoms, source of inoculum and management of diseases of hops

Disease	
Alternaria cone disorder (*Alternaria alternata*)	**Symptoms:** Brown discoloration first appears on the tips of bracteoles and eventually the cones turn dark brown and die. Symptoms are more pronounced on cones with mechanical injury. Symptoms are often confused with downy mildew or powdery mildew. **Source of Inoculum:** *Alternaria* is a weak pathogen that survives between seasons on decaying plant material. The pathogen primarily affects cones damaged by mechanical injury. **Management:** Accurate diagnosis is critical. Avoidance of mechanical injury from wind abrasion, insect pests and other pathogens will reduce disease significantly. Apply phosphorous acid based fungicides.
Apple mosaic virus (*Apple mosaic virus*)	**Symptoms:** Yellow rings or arcs on the leaves that eventually turn brown. The rings and arcs may come together giving an appearance of trails on the leaves. Symptoms are most severe when temperatures fluctuate from warm to hot in a short period of time. **Source of Inoculum:** Propagation is the primary mode of transmission. Root grafting and mechanical transmission can also occur and spread the virus from plant to plant. **Management:** Plant virus-free nursery stock. Clean and sanitize pruners before beginning to prune. Sanitize pruners between plants.
Black root rot (*Phytophthora citricola*)	**Symptoms:** Roots have a water-soaked and blackened appearance. Leaves may turn yellow. Bines wilt rapidly and leaves turn black. **Source of Inoculum:** Spores (oospores) of the pathogen overwinter in the soil for 18 months or longer. Spores (sporangia and zoospores) are dispersed in water. **Management:** Establish hop yard in areas with good water drainage and no previous history of black root rot disease. Plant resistant varieties (Table 3). Avoid damaging roots during cultivation. Apply phosphorous acid-based fungicides.
Carlavirus complex (*American hop latent virus, hop latent virus, hop mosaic virus*)	**Symptoms:** Only *Hop mosaic virus* causes symptoms and crop losses. Yellow spotting occurs between major leaf veins. Symptoms are more obvious on Golding type hops or hops with a Golding parentage. Weak bine growth and reduced yields. **Source of Inoculum:** Mechanical and aphid transmission. Propagation and distribution of virus-infected plants is the primary method of introducing the viruses into the hop yard. Pruning and root grafting is the primary method of spreading the viruses from plant to plant. **Management:** Plant virus-free nursery stock. Clean and sanitize pruners before beginning to prune. Sanitize pruners between plants.

Table 1. Symptoms, source of inoculum and management of diseases of hops

Disease	
Downy mildew (*Pseudoperonospora humuli*)	**Symptoms:** Stunted basal spikes with brittle, downward curled leaves. Leaf yellowing with browning. Purple to black colored spores form on the underside of the leaves. Leaf lesions are angular and form between the veins. Infected branches and burrs turn brown and quickly dry out. Bracts and bracteoles turn a reddish-brown color. **Source of Inoculum:** The pathogen overwinters in buds and crowns. Sporangia (spores) are wind dispersed. A second spore type (zoospores) are dispersed in water. **Management:** The use of resistant varieties is the most effective means for avoiding downy mildew (Table 2). Plant healthy rhizomes and softwood cuttings. Removal and destruction of leaves during spring pruning greatly reduces disease development later in the season. Timely fungicide applications are required for management when weather is favorable to the pathogen (high relative humidity and cool nighttime temperatures).
Gray mold (*Botrytis cinerea*)	**Symptoms:** Light to dark brown spots on the tips of bracts and bracteoles, which can enlarge with time and cause discoloration of entire cones. Gray, fuzzy fungal growth covers the spots during cool to warm, wet and humid conditions. During dry conditions, gray mold can be confused with Alternaria cone disorder. **Source of Inoculum:** The fungus can survive on organic material, in and on leaves, and in the soil as dormant resting structures called sclerotia. Spores are dispersed by the wind. **Management:** Increase air flow through the yard by increasing row and plant spacing. Manage overhead irrigation timing to minimize the amount of time that leaves and cones remain wet. Fungicide are effective, but only if the disease is correctly identified.
Hop stunt disease (*Hop stunt viroid*)	**Symptoms:** Symptoms may take 3-5 years to appear. Delayed growth of bines, stunting, inhibition of lateral bine growth. Reduced cone production and small cones. Yellow to pale green leaves at the base of the plant. **Source of Inoculum:** Propagation and mechanical transmission are the primary modes of transmission. **Management:** Plant viroid-free nursery stock. Confirm the disease and remove diseased plants and adjacent plants immediately. Clean and sanitize pruners before beginning to prune. Sanitize pruners between plants.
Powdery mildew (*Podosphaera macularis*)	**Symptoms:** Powdery white colonies form on leaves, buds, stems, and cones. Burr and young cone infections result in premature cone drop and distorted cone shape. As the disease develops, cones become reddish brown in color and may turn pale green or light brown after being dried. **Source of Inoculum:** The fungus survives overwinters in infected crown buds giving rise to infected shoots in the spring. Fungal spores

Table 1. Symptoms, source of inoculum and management of diseases of hops

Disease	
Powdery mildew (*Podosphaera macularis*)	are dispersed by wind. In some instances, overwintering structures called chasmothecia, form and survive in disease plant tissue. **Management:** Select resistant varieties (Table 2), remove and destroy plant tissue at the end of the season, and avoid excessive fertilization (especially nitrogen). Fungicides applied throughout the production season including during cone development.
Verticillium wilt (*Verticillium dahlia* or *V. nonalfalfae*)	**Symptoms:** Minor to severe wilting depending on the aggressiveness of the pathogen. Swollen bines and upward curling leaves may occur. Symptoms develop near flowering. **Source of Inoculum:** The fungus can survive in the soil for many years (3-15 years) and is spread during cultivation, on equipment and workers' boots, and on plant material. **Management:** Plant resistant varieties (Table 2) and use strict sanitation practices. Remove and destroy plant material. Clean and sanitize equipment and shoes or boots before entering the hop yard. Fungicides are not effective and not recommended.

Table 2. Disease susceptibility of primary public hop varieties grown in the United States.

Variety	Disease Susceptibility*		
	Downy Mildew	Powdery Mildew	Verticillium wilt
Brewer's Gold	S	S	MR
Bullion	S	S	R
Cascade	S	R/MS	MR
Centennial	S	MS	U
Chinook	S	S	R
Columbia	MR	MS	S
Cornet	S	R	R
Crystal	S	R	R
East Kent Golding	S	S	MR
Fuggle	MR	MR	S
Galena	S	S	R
Glacier	S	S	U
Hall Gold	R	MS	S
Hall Magnum	R	S	MR
Hall Mittelfruh	S	MS	S
Hall Tradition	R	MR	MR
Horizon	S	MS	MR
Late Cluster	S	S	R
Liberty	S	MS	U

Table 2. Disease susceptibility of primary public hop varieties grown in the United States.

Variety	Disease Susceptibility*		
	Downy Mildew	Powdery Mildew	Verticillium wilt
Mt. Hood	S	MS/R	S
New Port	R	MR/R	U
Norther Brewer	S	S	R
Nugget	S	S/MS/R	S
Olympic	MS	S	R
Perle	R	S	MR
Saazar	MS	S	S
Saazer 36	MS	S	S
Spalter	R	S	MR
Sterling	MR	S	U
Teamaker	MR	MR	S
Tolhurst	S	S	U
Triple Pearl	S	S/R	U
U.S. Tettnanger	MR	S	S
Vanguard	S	S	U
Wilamette	MR	S	S

*Resistant categories are as follows: R-resistant; MR-moderately resistant; MS-moderately susceptible; S-Susceptible. For powdery mildew, some cultivars have multiple susceptibility ratings that reflect their potential reaction based on region and whether virulent strains of the powdery mildew fungus occur.

Table 3. Black root rot susceptibility of hop varieties grown in the United States.

Variety	Black Root Rot Susceptibility*
Brewer's Gold	R
Bullion	R
Cascade	R
Columbia	R
Comet	R
Cluster E-2	S
Cluster L-1 (also called Yakima Cluster)	MR
Cluster L-8	S
Eroica	R
Fuggle	R
Galena	MR
Hallertau	R
Nugget	R
Olympic	R
Tettnanger	R
Willamette	R

*Resistant categories are as follows: R-resistant; MR-moderately resistant; MS-moderately susceptible; S-Susceptible.

Table 4. Fungicides registered for management of hop diseases in Ohio

Disease	Fungicide	FRAC Grouping	Rate/Acre	Spray Timing and Remarks
Before bine training				
Downy mildew	Metastar 2E	4	1 pt	Apply once when shoots are 6 in. long or less. Regalia must be tank mixed with another fungicide labeled for downy mildew control.
	Regalia	P5	1-2 qt	
	Ridomil Gold SL	4	0.5 pt	
	Ultra Flourish	4	1 pt	
From the beginning of bine training				
Downy mildew	Curzate 60DF	27	3.2 oz	There are many formulations Fosetyl-Al, Phosphorous acid and copper formulations; refer to Table 5 for a list of products and to the labels for the rate of the product. Regalia must be tank mixed with another fungicide labeled for downy mildew control. Metastar 2E, Ridomil Gold SL, Tanos, and Ultra Flourish must be tank mixed with another broad-spectrum fungicide active against downy mildew, such as copper. The addition of a spreading/penetrating adjuvant to Revus is recommended.
	Fixed copper*	M	see label	
	Flint	11	4 oz	
	Forum	40	6 fl oz	
	Fosetyl-Al*	33	see label	
	Metastar 2E	4	1 qt	
	Phosphorous acid*	33	see label	
	Pristine	11 + 7	14 oz/100 gal	
	Ranman	21	2.1-2.75 fl oz	
	Regalia	P5	1-4 qt	
	Revus	40	8 fl oz	
	Ridomil Gold SL	4	0.5 pt	
	Tanos	27 + 11	8 oz	
	Ultra Flourish	4	1 pt	
	Zampro	40 + 45	11-14 fl oz	
Powdery mildew	Fixed copper*	M1	See label	Applied at 10-14 day intervals. There are many formulations of potassium carbonate and copper products; refer to Table 5 for a list of products and to the labels for the rate of the product. Mineral and neem oil products can control powdery
	Flint	11	4 oz	
	Luna Experience	7 + 3	8-17 fl oz	
	Luna Privilege	7	3.2-6.84 fl oz	
	Luna Sensation	7 + 11	3-7.6 fl oz	
	Mineral oil, neem oil	NC	see label	
	Potassium bicarbonate*	NC	see label	
	Pristine	11 + 7	14 oz/100 gal	
	Procure 480SC	3	12 fl oz	
	Quintec	13	4-8.2 fl oz	

Table 4. Fungicides registered for management of hop diseases in Ohio

Disease	Fungicide	FRAC Grouping	Rate/Acre	Spray Timing and Remarks
Powdery mildew	Regalia	P5	2-4 qt (applied alone)	mildew; however, there is some evidence of plant injury with the use of oil. See the label for detailed instructions. Also, avoid using oil and sulfur within two weeks of each other because it may cause injury to the plants. The rate for sulfur is generally 2-3 lb/100 gal of water, but it can be increased to as high as 6 lb/100 gal. Severe disease pressure may warrant this, but beware of possible plant injury at higher rates.
	Tanos	27 + 11	8 oz	
	Tebuconazole*	3	2-8 fl oz	
	Vivando	U8	15.4 fl oz	
	Wettable sulfur*	M2	2-6 lb	
After burr development				
Gray mold	Luna Experience	7 + 3	8-17 fl oz	Pristine must be tank mixed with a broad spectrum fungicide such as copper.
	Luna Privilege	7	3.2-6.84 fl oz	
	Luna Sensation	7 + 11	3-7.6 fl oz	
	Pristine	11 + 7	14 oz/100 gal	
After harvest				
Downy mildew and powdery mildew	Fixed copper*	M1	See label	Applied once or twice after harvest.
	Fosetyl-Al*	33	See label	
	Phosphorous acid*	33	See label	
	Wettable sulfur*	M2	2-6 lb	

*Various formulations available. See Table 5.

Table 5. Chemical names, restricted entry interval (REI), and pre-harvest interval (PHI)

Chemical (product names or active ingredient)	REI (hours)	PHI (days)
Copper (various formulations: Champ WG, Cueva, Kocide, Nordox 75WG, etc.)	4-48 (see label)	0-14 (see label)
Curzate 60DF (cymoxanil)	12	7
Flint (trifloxystrobin)	12	14
Forum (dimethomorph)	12	7
Fosetyl-Al (aluminum tris; Aliette WDG, Linebacker WDG)	12	24
Luna Experience (fluopyram + tebuconazole)	12	14
Luna Privilege (fluopyram)	7	14
Luna Sensation (fluopyram + trifloxystrobin)	12	14
Metastar 2E and 2E Ag (metalaxyl)	48	45
Mineral oil (various formulations: Damoil, Omni oil, etc.)	4	0
Neem oil (various formulations: Trilogy, Green Light, etc.)	4	0
Phosphorous acid (phosphite; various formulations: AgriFos, Prophyt, Phostrol, etc.)	4	0
Potassium bicarbonate (various formulations: Armicarb, Kaligreen, etc.)	4	0-1 (see label)
Pristine (pyraclostrobin + boscalid)	12	14
Procure 480 SC (triflumizole)	12	7
Quintec (quinoxyfen)	12	21
Ranman (cyazofamid)	12	3
Regalia, Regalia PTO, and Regalia Rx (*Reynoutria sachalinensis*)	4	0
Revus (mandipropamid)	4	7
Ridomil Gold SL (Mefenoxam)	48	45

Table 5. Chemical names, restricted entry interval (REI), and pre-harvest interval (PHI)

Chemical (product names or active ingredient)	REI (hours)	PHI (days)
Sulfur (various formulations: Acoidal, Kumulus DF, Microthiol D, etc.)	24	0
Tanos (cymoxanil + famoxadone)	12	7
Tebuconazole (various formulations: AmTide, Tebu 3.6 F, Orius, etc.)	12	14
Ultra Flourish (mefenoxam)	48	45
Vivando2 (metrafenone)	12	3
Zampro (amedoctradin + dimethomorph)	12	7

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Contact Information

Dr. Melanie Lewis Ivey
Assistant Professor
State Fruit Pathology Specialist
State Fresh Produce Safety Specialist

The Ohio State University-Wooster Campus
1680 Madison Avenue
224 Selby Hall
Wooster, OH 44691

Office Phone: 330-263-3849
Email: Ivey.14@osu.edu
Website: u.osu.edu/fruitpathology/
Facebook: facebook.com/OhioGrapeIPM

Rachel Medina, MS
Research Associate, Dept. Plant Pathology

The Ohio State University-Wooster Campus
1680 Madison Avenue
229 Selby Hall
Wooster, OH 44691

Office Phone: 330-263-3846
E-mail: medina.72@osu.edu
Website: u.osu.edu/fruitpathology/

Brad Bergefurd
Ohio State University Extension Horticulture Specialist

Ohio State University South Centers
1864 Shyville Rd.
Piketon, OH 45661

Office Phone: 740-289-2071 ext. 136
E-mail: bergefurd.1@osu.edu