2018 Cornell Integrated Hops Production Guide

Cornell Cooperative Extension

These guidelines are not a substitute for pesticide labeling. Always read and understand the product label before using any pesticide.

CHAPTER 7 – PESTICIDE INFORMATION *(continued)*

CHAPTER 8 – SPRAYER TECHNOLOGY *(continued)*

Chapter 3 – Hopyard Nutrient Management

3.1 Introduction

To produce a healthy crop, soluble nutrients must be available from the soil in amounts that meet the minimum requirements for the whole plant. The challenge is balancing soil fertility to supply the required plant nutrients at the correct time and at sufficient levels to support healthy plant growth.

3.2 Soils and Fertility

Healthy soil is the basis for any successful farming operation. Regular additions of organic matter in the form of cover crops, compost, or manure create a soil that is biologically active; with good structure and capacity to hold nutrients and water (For more information on the use of Manure and Produce Safety see section 3.9). Decomposing plant materials will support a diverse pool of microbes, including those that break down organic matter into plant-available nutrients as well as others that compete with plant pathogens in the soil and on the root surface. The practice of crop rotation to promote a healthy soil should be done in the one or two years prior to hopyard establishment or is limited to row middles in a perennial crop such as hops. Growers must attend to the connection between soil, nutrients, pests, and weeds to succeed. An excellent resource for additional information on soils and soil health is *Building Soils for Better Crops*, 3rd edition, by Fred Magdoff and Harold Van Es, 2010, available from SARE, Sustainable Agriculture Research and Education, Building-Soils-for-Better-Crops-3rd-Edition (www.sare.org/ Learning-Center/ Books/Building-Soils-for-Better-Crops-3rd-Edition). For more information, refer to the Cornell Soil Health website (soilhealth.cals.cornell.edu).

Fertility management is part of an overall soil management program that involves proper tillage practices, crop rotation, cover crops, water management (irrigation and drainage), liming, and weed management. Although it is important in obtaining maximum economic yields, fertilization alone will not overcome shortcomings in the areas mentioned above. Such problems should be corrected first so as to benefit fully from organic and inorganic fertilizer supplements and to sustain high yields and quality over the long term.

Regular soil testing and petiole testing will help monitor nutrient levels. It is recommended that regular petiole testing be incorporated into a fertility management program with soil testing to assist in determining the bines' nutrient status and to make sure that what is in the soil is making it into the bines in the proper amounts. It is recommended that soil and petiole tests be completed in each block/variety a minimum of every three years. Petiole testing is especially critical in getting the information needed to make management decision in problem areas of the hopyard and should be used on a more frequent basis if needed.

3.3 Soil Testing

Fertilizer requirements for best economic yield should approximate the difference between what hop plants take up from the soil for best growth and quality and what the soil can actually supply during the crop-growing period. The supply of essential nutrients in soil cannot be determined without conducting a soil test. Moreover, if pH is not in a desirable range, yields may be poor regardless of fertilizer added or already present in the soil.

Soils on which hops will be grown should be sampled at least once every three years. The pH of most hop soils can change with the removal of crop materials. Testing every year gives a more complete evaluation and is appropriate when significant changes have been made in the fertilizer program (e.g., applying less phosphorus or potassium when the previous year's test showed high levels). In general, when the Cornell-recommended rates of fertilizer are applied, low soil test values for phosphorus and potassium usually increase slowly and steadily in spite of crop removal. Medium soil test values tend to remain constant or increase slightly, whereas high values decrease gradually. The potassium level could decrease much more rapidly, however, if a light sandy soil with relatively low exchange capacity is coupled with a heavy potassium feeder such as hops. In such situations, yearly sampling is appropriate. The purpose of applying nutrients, however, is to benefit crop development, not to achieve a predetermined test result.

Growers interested in obtaining Cornell guidelines for crop management should submit samples to AgroOne (730 Warren Road, Ithaca NY, 14850; 1-800-344-2697) and request the Cornell Morgan test and Cornell guidelines. For New York samples submitted with the necessary field information, the soil test report will include results but for 2016 these will be forwarded for interpretation by Cornell's Hop Specialist. When submitting samples for hops, use the "F" form from the AgroOne website.

The soil test results provide soil pH, percent of organic matter, and level of phosphorus, potassium, magnesium, calcium, and zinc. Levels of aluminum, iron, and manganese are also listed to identify potential toxicities rather than deficiencies. Other nutrients can be tested for an additional fee. See the nitrogen, phosphorus, and potassium recommendations under each crop to design a fertility program for your farm.

Go to the Dairy One website (www.dairyone.com) to find out more about Agro-one soil testing services.

3.4 Soil pH

In general, hops grown on mineral soils will thrive at pH 6.0 to 6.8., the closer to 6.8 the better. Hops should not be grown on muck soils as they are prone to frost heaving.

Table 3.7.2. Estimated nutrient content of common animal manures

Type of Animal Manure	N	P_2O_5	K_2O	N_1[a]	N_2[b]	P_2O_5	K_2O
	Nutrient content lb/ton			*Available Nutrients lb/ton in first season*			
Dairy (with bedding)	9	4	10	6	2	3	9
Horse (with bedding)	14	4	14	6	3	3	13
Poultry (with litter)	56	45	34	45	46	36	31
Compost (from dairy manure)	12	12	26	3	2	10	23
Composted poultry manure	17	39	23	6	5	31	21
Pelleted poultry manure[c]	80	104	48	40	40	83	43
Swine (no bedding)	10	9	8	8	3	7	7
	Nutrient content lb/1000 gal			*Available Nutrients lb/1000 gal in first season*			
Swine finishing (liquid)	50	55	25	25*	20+	44	23
Dairy (liquid)	28	13	25	14*	11+	10	23

[a] N1 is the total N available for plant uptake when manure is incorporated within 12 Hours of application,
[b] N2 Is the total N available for plant uptake when manure is incorporated after 7 days.
[c] Pelletized Poultry manure compost. Available in New York From Kreher's.
*= injected
+ = incorporated
Adapted from *"Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops"* by Carl Rosen and Peter Bierman and Penn State Agronomy

3.8 Manure

Most hop operations do not have a ready source of manure, but it can be used when available. Once applied to soil, manure is decomposed by microorganisms, forming humus. Manure provides both major and minor nutrients. When used regularly, it contributes organic matter and helps to alleviate structural deterioration, an important consideration in maintaining the productivity of heavily worked hop soils. One drawback of using manure is that certain weed seeds maintain their viability after passage through animals, so a potential exists for adding a new weed species to a field. This is especially true of horse manure. This threat is more likely with fresh than with composted manure. An excellent, thorough discussion of manure use in crop production is provided in the Cornell Field Crops and Soils Handbook.

Manure contains two forms of nitrogen, the unstable form in the urine and the stable form in the feces. The unstable form may account for 50 percent or more of the total nitrogen in manure. This nitrogen decomposes rapidly to ammonium, which in turn converts quickly to extremely volatile ammonia that can be lost from the system. For this reason, much of manure's unstable nitrogen may never be taken up by crops unless measures are taken to conserve it during the process of collection, storage, and application to the field. In general, about 35 percent of the stable nitrogen becomes available during the year of application, about 12 percent the second year, about five percent the third year, and about two percent the fourth year. Thus, repeated application to the same field results in an accumulation of a slow-release source of manure nitrogen.

Most potassium in manure is available for plant growth during the year applied; whereas, some of the phosphorus is in organic form and must decompose before it becomes available. Moreover, because phosphorus is not very mobile in the soil, broadcasting manure is not an efficient way of applying this element for crop establishment.

A micronutrient deficiency in a field with a history of manuring is rare because manure contains small quantities of these elements. If a deficiency is observed on a nonmanured field, a commercial fertilizer should be added immediately because of the slower availability of micronutrients in manure. If soil pH is acceptable, manuring may eventually solve the problem.

3.9 Manure and Produce Safety

The use of improperly aged or treated manure can increase microbial risks and contribute to foodborne illness. The possibility that fecal matter may come into contact with produce or that water might splash pathogens from the manure onto field produce are both important concerns. Pathogens such as *E. coli* O157:H7, *Salmonella*, and *Campylobacter* can be present in manure slurry for up to 3 months or more, depending on temperatures and soil conditions. Troubling for growers is that *Listeria monocytogenes* can survive in the soil for much longer than 3 months. *Yersinia enterocolitica* may survive, but not grow, in soil for almost a year.

It is important that all farms using manure follow good agricultural practices to reduce any microbial risk that may exist. These include:

- Consider the source, storage, and type of manure
- Store manure as far away as practical from areas where fresh produce is being grown and handled. If manure is

Chapter 5 – Cover Crops

5.1 General

Cover crops are close-growing crops planted primarily for protecting and improving the soil. Integrating cover crops into hop production systems offers many benefits, but provides some challenges as well. Since hops are a perennial, cover crops are not used in the row. However, the following information can be useful for preparation in the year before the hops are planted or as an intercrop between the rows. For cover cropping to be successful, it is important to know the intended purposes, consider key management factors, and understand the characteristics of different cover crop species.

Cover crops offer a way to add organic matter to soils; improve soil tilth and remediate compaction; protect soil from wind and water erosion; add or recycle plant nutrients; increase the biological activity of soil; retain soil moisture; and in some cases, suppress weeds and may help control insects diseases and nematodes. No single cover crop can do all of these things. Matching the need and opportunity to the right cover crop requires information and planning.

5.2 Goals and Timing for Cover Crops

Cover crops play an important role in a hopyard, especially during the years prior to planting through improvement of soil organic matter, breaking up of compaction layers, erosion control and suppression or elimination of weeds. Goals should be established for choosing a cover crop; for example, the crop can add nitrogen, smother weeds, or increase equipment mobility. The cover crop might best achieve some of these goals if it is in place for an entire growing season prior to hopyard establishment.

Cover crops planted in late summer will suppress annual weed growth, improve soil texture, provide organic matter, and may increase soil nitrogen. The cover crop can be incorporated in late fall or in the spring before planting. Certain cover crops (marigold, sudangrass) will either suppress or resist nematode populations. These should be considered where fumigation is not an option. (See Tables 5.2.1 and 5.2.2.) In addition to producing large amounts of biomass that out-compete other plant species, some cover crops (annual rye, ryegrass) can inhibit weed growth through allelopathy, the chemical inhibition of one plant species by another. Rye provides allelopathic suppression of weeds when used as a cover crop, and when crop residues are retained as mulch. Rye residues retained on the soil surface release chemicals that inhibit germination and seedling growth of many grass and broadleaf weed species. Retention of residue on the soil surface can be accomplished by mowing after seed head formation.

Cover crops will perform best under good growing conditions, such as optimal temperatures, sufficient soil moisture, and adequate soil fertility. Practices, such as preparing an adequate seedbed; drilling seed or broadcasting and cultipacking; inoculating seed with the proper *Rhizobium* inoculant if using a legume; planting into sufficient soil moisture; correcting pH or soil fertility problems; and in some cases, controlling weeds with herbicides or mowing the cover crop in midseason, often further enhance cover crop performance. Access to appropriate equipment for incorporating the cover crop is also critical.

To be effective, cover crops should be treated as any other valuable crop on the farm, with their cultural requirements carefully considered including susceptibility, tolerance, or antagonism to root pathogens and other pests; life cycle; and mowing/incorporation methods. See Section 5.3 for more information on specific non-leguminous cover crops.

Use of cover crops in the row middles after hopyard establishment can have both beneficial and detrimental impacts so the choice of cover crop should be carefully considered. Care should be taken in the selection of a cover crop in established hopyards to minimize the competition for water and nutrients. In a four-year study in Western

Table 5.2.1. Non-leguminous cover crops: cultural requirements and crop benefits

Species	Planting Dates	Life Cycle	Cold hardi-ness zone	Tolerances[1]			pH Pref-erence	Soil Type Prefer-ence	Seeding Rate (lb/A)	Comments
				Heat	*Drought*	*Shade*				
Brassicas	April or late August to early September	Annual/ Biennial	6-8	4	6	NI	5.3-6.8	Loam to clay	5-12	• Good dual purpose cover & forage • Establishes quickly in cool weather • Biofumigant properties
Buckwheat	Late spring-summer	Summer annual	NFT	7-8	4	6	5.0-7.0	Most	35-134	• Rapid grower (warm season) • Good catch or smother crop • Good short-term soil improver for poor soils

Table continues on next page.

Chapter 7 – Pesticide Information

7.1 Pesticide Classification and Certification

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) created two classifications of pesticides – general-use and restricted-use. **General-use pesticides** may be purchased and used by anyone. **Restricted-use pesticides can** only be purchased by a certified applicator. Restricted-use pesticides must also be used by a certified applicator or someone under their supervision.

The same federal law that classifies pesticides divided applicators into two groups: private and commercial. **Private applicators** use or supervise the use of pesticides to produce agricultural commodities or forest crops on land owned or rented by the private applicator or their employer. A farmer must be certified as a private applicator in order to purchase and use restricted-use pesticides on agricultural commodities. (No certification is needed if a farmer does not use restricted-use pesticides.)

A **commercial applicator** uses or supervises the use of pesticides for any purpose or on any property not covered by the private applicator classification. In New York, a commercial applicator must be certified to purchase or use any pesticide whether it is general- or restricted-use.

Information about pesticide certification and classification is available from your Cornell Cooperative Extension office (cce.cornell.edu/localoffices), regional NYSDEC pesticide specialist (www.dec.ny.gov/about/ 558.html), the Pesticide Applicator Training Manuals (store.cornell.edu/c-876-manuals.aspx), or the Pesticide Management Education Program (PMEP) at Cornell University (psep.cce.cornell.edu).

7.2 Use Pesticides Safely

Using pesticides imparts a great responsibility on the user to protect their health and that of others and to protect the environment. Keep in mind there is more to "pesticide use" than the application. Pesticide use includes mixing, loading, transporting, storing, or handling pesticides after the manufacturer's seal is broken; cleaning pesticide application equipment; and preparing a container for disposal. These activities require thoughtful planning and preparation. They are also regulated by state and federal laws and regulations intended to protect the user, the community, and the environment from any adverse effects pesticides may cause.

7.2.1 Plan Ahead

Many safety precautions should be taken *before* you actually begin using pesticides. Too many pesticide applicators are dangerously and needlessly exposed to pesticides while they are preparing to apply them. Most pesticide accidents can be prevented with informed and careful practices. **Always read the label on the pesticide container before you begin to use the pesticide.** Make sure you understand and can follow all directions and precautions on the label. Be prepared to handle an emergency exposure or spill. Know the first aid procedures for the pesticides you use.

7.2.2 Move Pesticides Safely

Carelessness in transporting pesticides can result in broken containers, spills, and contamination of people and the environment. Once pesticides are in your possession, you are responsible for safely transporting them. Accidents can occur even when transporting materials a short distance. You are responsible for a pesticide accident so take every effort to transport pesticides safely. Be prepared for an emergency.

7.2.3 Personal Protective Equipment and Engineering Controls

Personal protective equipment needs depend on the pesticide being handled. ***Required personal protective equipment (PPE) are listed on pesticide labels.*** The required PPE are based on the pesticide's toxicity, route(s) of exposure, and formulation. Label required PPE are the minimum that must be worn during the pesticide's use. Pesticide users can always wear more protection than the label requires.

The type of protective equipment used depends on the type and duration of the activity, where pesticides are being used, and exposure of the handler. Mixing/loading procedures often require extra precautions. Studies show you are at a greater risk of accidental poisoning when handling pesticide concentrates. Pouring pesticide concentrates from one container to another is the most hazardous activity. More information on personal protective equipment can be found online at umes.edu/ NC170/Default.aspx?id= 7184.

Engineering controls are devices that help prevent accidents and reduce a pesticide user's exposure. One example is a closed mixing/loading system that reduces the risk of exposure when dispensing concentrated pesticides. More information on engineering controls can be found online at umes.edu/NC170/Default.aspx?id=7196.

7.2.4 Avoid Drift, Runoff, and Spills

Pesticides that move out of the target area can injure people, damage crops, and harm the environment. Choose weather conditions, pesticides, application equipment, pressure, droplet size, formulations, and adjuvants that minimize drift and runoff hazards. See product labels for specific application and equipment requirements.

7.2.5 Avoid Equipment Accidents

Properly maintained and carefully used equipment contribute to safe pesticide application. Use the following guidelines to prevent accidents:

- Be sure to turn off your machinery before making any adjustments.
- Do not allow children, pets, or unauthorized people near the pesticide equipment.
- Depressurize tanks or systems between jobs.
- Always return equipment to appropriate areas for cleaning and storage when the application is completed.

7.2.6 Pesticide Storage

Existing buildings or areas within existing buildings are often used to store pesticides. Whether you choose to build a new storage area or use existing buildings, consider several points:

- The site should be where flooding is unlikely.
- It should be downwind and downhill from sensitive areas like houses, ponds, and play areas.
- There should be no chance that runoff or drainage from the site could contaminate surface or groundwater.

Storage facility check list:

- ❑ Is the facility separated from:
  - o Offices, workshops, and livestock areas?
  - o Wells, streams, lakes, ponds, wildlife?
  - o Food and feed?
- ❑ Is the facility made of fire resistant building materials?
- ❑ Does the facility have:
  - o Impermeable flooring?
  - o Liquid spill containment (berms to hold 25% of liquid storage)?
- ❑ Can the doors be locked?
- ❑ Is the facility fenced in?
- ❑ Are warning signs posted?
- ❑ Is a spill kit readily available?
- ❑ Are fire extinguishers readily available?
- ❑ Is personal protective equipment readily available?

Additional guidance on pesticide storage is available online from the NYSDEC at www.dec.ny.gov/regulations/8871.html.

7.3 Pollinator Protection

Honey bees, wild bees, and other insects are important for proper pollination of many crops. Poor pollination results in small or odd-shaped fruit as well as low yields. Many factors affect pollinator health including lack of seasonal forage, parasites, predators, pathogens, lack of genetic diversity, and pesticide exposure.

To avoid harming bees, remember these general points:

- Before using a pesticide, always read the label for specific pollinator protection requirements;
- Do not spray or allow the pesticide to drift onto blooming crops or weeds;
- Mow blooming weeds before treatment or spray when the blossoms are closed;
- Avoid application during the time of day when bees are most numerous;
- Make applications in the early morning or evening; and
- Avoid making applications over or allowing drift onto hives or apiaries.

Labels on pesticides that are highly toxic to honey bees may carry warnings about hazards to bees and other pollinators. If pesticide sprays that are highly toxic to bees are used in strict accordance with label directions, little to no harm should be done to bees. Note that some pesticides with relatively low toxicity to honey bees can be made more toxic when mixed with other pesticides. Special care should be taken with tank mixes where pollinator safety may be unknown.

EPA has established bee labeling requirements for nitroguanidine neonicotinoid-containing pesticides (imidacloprid, dinotefuran, clothianidin, thiamethoxam) with outdoor foliar uses on their label. These labels have a bee icon and an advisory box with information on routes of exposure and spray drift precautions.

In 2017 the EPA adopted a risk-based pollinator protection policy. This policy describes EPA's approach to assessing those pesticide products and uses that may pose a risk to bees under contract pollination services. If the use poses a risk, language will be added to the product's label with directions on how to use the product for a given crop when contracted bees are present. More on EPA's policy can be found at https://www.epa.gov/pollinator-protection/policy-mitigating-acute-risk-bees-pesticide-products.

New York State has developed its own pollinator protection plan that discusses the status of pollinators in New York State and how they can be protected. To view the plan online, visit www.dec.ny.gov/docs/administration_ pdf/ nyspollinatorplan.pdf.

Additional information on pollinator protection can be found online at: www2.epa.gov/pollinator-protection and pesticidestewardship.org/PollinatorProtection/Pages/default.aspx.

7.4 New York State Pesticide Use Restrictions

7.4.1 Restricted-Use Pesticides

Pesticides that are highly toxic or that are persistent and accumulative are classified as restricted-use in New York State. The NYSDEC uses several criteria to classify pesticides as restricted-use including those:

– Having an active ingredient specifically listed in Part 326.2(a) of the state pesticide control regulations.

8.4.4 Boom Sprayer Calibration

-use clean water

Step 1. Check your tractor/sprayer speed

Formula: $\frac{\text{ft. traveled}}{\text{sec. traveled}} \times \frac{60}{88} = \text{MPH}$

Your tractor sprayer speed:

$$\text{MPH} = \frac{\text{ft. traveled}}{\text{sec. traveled}} \times \frac{60}{88} = \text{MPH}$$

Step 2. Record the inputs

	Your figures	Example
Nozzle type on your sprayer (all nozzles must be identical)	________	110 04 flat fan
Recommended application volume (from manufacturer's label)	________	20 GPA
Measured sprayer speed	________	4 mph
Nozzle spacing	________	20 inches

Step 3. Calculate the required nozzle output.

Formula: $\frac{\text{GPA X mph X nozzle spacing}}{\text{5940 (constant)}} = \text{GPM}$

Example: $\text{GPM} = \frac{20 \text{ X } 4 \text{ X } 20}{5940} = \frac{1600}{5940} = 0.27 \text{ GPM}$

Your figures: $\frac{\quad \text{X} \quad \text{X} \quad}{5940} = \frac{\qquad}{5940} = \_\_\_\_ \text{GPM}$

Step 4. Operate the sprayer

Set the correct pressure at the gauge using the pressure regulating valve.

Collect and measure the output of each nozzle for one minute. The output of each nozzle should be the approximately the same as calculated in Step 3 above.

Replace all nozzle tips that are more than 10% inaccurate.

8.5 Selecting Nozzles from the Nozzle Catalogue – Airblast Sprayers

We need to select hollow cone discs with a core or whirl plate.

Nozzle output is based upon gallons/acre required above.

$$\text{Gallons/minute} = \frac{\text{GPA X mph X row width in feet}}{495}$$

Where:
GPM = total sprayer output in gallons/minute

mph = travel speed in miles per hour

row width = width between rows of hops in feet

495 = a mathematical constant to correct units of measurement

Example 1

We wish to apply a 50 gallons/acre. We have an airblast sprayer with 5 nozzles each side and a comfortable forward speed for our ground conditions is 3.0 mph. **Rows are 12 feet apart.**

$$\text{Gallons/minute (GPM)} = \frac{\text{GPA X mph X row width in feet}}{495}$$

$$\text{Gallons/minute (GPM)} = \frac{50 \text{ X } 3.0 \text{ X } 12}{495} = \frac{1800}{495} = 3.64$$

$$\text{GPM} = \frac{3.64}{2} = 1.8 \text{ per side}$$

GPM per nozzle = 1.8 divided by 5 nozzles = 0.36

Using the hollow cone nozzle table in the Spraying Systems catalogues (Figure 8.5.1):

1. Read along the pressure row at the top of the table.
2. Read down the column for 150 psi until you read 0.34 GPM, look across to the left, you will see we can choose a D5 disc with a DC 23 whirl plate or core. Note we desire 0.36 GPM, so the same nozzles at 175 psi (midway between the 150 and 200 psi columns will give us our required amount.
3. Alternatively you may read down the column for 100 psi until you read 0.36 GPM, look across to the left and you will see we can choose a D3 disc with a DC45 whirl plate or core.

Example 2

We wish to apply a 100 gallons/acre. We have an airblast sprayer with 5 nozzles each side and a comfortable forward speed for our ground conditions is 3.0 mph. Rows are 12 feet apart.

$$\text{Gallons/minute (GPM)} = \frac{\text{GPA X mph X row width in feet}}{495}$$

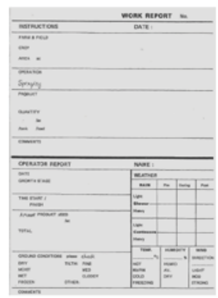
8.11 Going Spraying!

Mixing Procedures

Safety and the Law

- Always remain alert; pesticides are potentially dangerous to the operator and the environment.
- Tractors and sprayers are dangerous machines and care should be taken when operating them.
- Always follow Federal and State laws concerning licensing of operators and handling, application and disposal of pesticides.

Always read the label for detailed application information and keep a record.

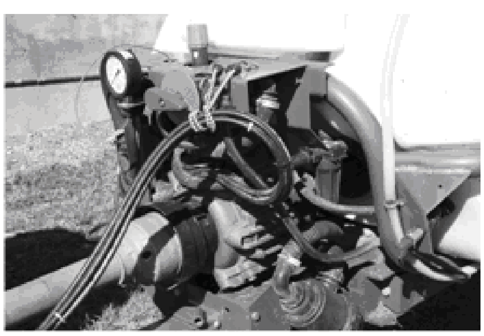


WORK REPORT

The seven P's of machinery management.

Proper prior planning prevents poor performance.

- Fill the tank on level ground per label instructions. If none are given, fill the tank half full with clean water.



- Prime the pump with water, if needed.

Chapter 9 – Hopyard IPM

9.1 Principles of Insect and Disease Management

While hop production may be severely limited by insect pests and plant diseases, an understanding of the factors involved in their development can aid greatly in effective management. The development of disease and insect damage is highly dependent on characteristics and conditions of the crop (host), the pathogen/pest population, and the environment. These factors all must be conducive before significant disease development or insect damage can occur.

Characteristics of the host that influence disease and pest susceptibility include the host's vigor, physiology, and variety (genetics). Aggressiveness or virulence, abundance, and physiology are characteristics of the pathogen or pest population that influence their ability to cause disease or damage. At the same time, environmental conditions such as temperature, moisture, light, and soil chemistry can affect both the host and pest and may promote or prevent disease. Moreover, the presence, abundance, and activity of natural enemies can play an important role in determining pest status. To complicate matters further, the most successful disease pathogens and insect pests have coevolved with crop hosts over many years to incite disease and damage at the most opportune times.

To successfully minimize disease and pest damage, the relevant aspects of the host, pathogen/pest, and environment must all be managed within specific timeframes. One of the purposes of this production is to eliminate some of the guesswork regarding management practices for diseases, insects, weeds and other pests.

Although individual insect pests and plant disease pathogens can be vastly different in their biology, they often have enough similarity in life history strategies to allow successful management under a single set of underlying principles. These principles include avoidance/exclusion, eradication/sanitation, and protection and are defined below.

Avoidance/exclusion: This principle focuses on prevention of pathogen introduction and minimizing factors that favor the establishment of pests and pathogens. Several practices that exclude or limit pathogen and pest presence include the following:

- Choose sites with good drainage. On heavy soils, tiling of plantings to remove excess water is necessary. Promote air circulation to dry leaves in hop plantings by selection of an open site, removal of dead or senescent plant material, and weed reduction.
- Plant only disease free planting stock.
- Practice weed management as weeds can be hosts for certain pests. Weeds also raise humidity that can increase downy mildew growth.

Eradication/sanitation: This principle is concerned with the destruction and/or minimization of pathogen/pest populations. Typically, complete eradication of a pest is not feasible and difficult to justify for economic reasons. A better goal is to use practices that reduce pest populations to manageable levels. Practices that can greatly reduce pathogen/pest populations include the following:

- Sanitation of plantings by removal and destruction of infected/infested plants or plant parts that will otherwise maintain, and increase, pest populations.
- Pheromone traps may reduce insect numbers, but are primarily used for scouting.
- Several biological products are available to suppress insect populations, including those based on formulated *Bacillus thuringiensis* and insectary-reared predatory mites. Currently, biological control products for disease management are designed to prevent infection at their particular sites of application.
- Applications of effective fungicides, insecticides, and miticides – whether chemical or biological –will (by definition) limit the reproduction of pathogen and pest populations and their resulting damage. It is MUCH easier to obtain and maintain desirable levels of control if such applications are made as soon as possible once the appropriate action threshold has been reached, rather than waiting to respond to an emergency. (See considerations regarding chemical application below).

Protection: This principle is founded on the protection of plants from pathogen infection and pest damage. Practices that protect plants by minimizing factors favoring infection and damage include the following:

- Plant hop varieties with significant resistance to important pests and diseases. *The selection of varieties with significant resistance is the cornerstone of an IPM program, and is the single most effective measure that can be taken to reduce losses. Decisions on what varieties to plant are especially critical for organic production, where disease suppression is extremely difficult on highly susceptible cultivars with the options available to organic growers.* Certain varieties have certain characteristics that make them far less susceptible to specific diseases or insect damage.
- Mating disruption using pheromones may protect crops by limiting reproduction and growth of insect populations.
- Avoid excessive nitrogen fertilization as many pathogens and insects thrive on succulent tissues.
- Applications of the appropriate fungicides, insecticides, or miticides at the correct timings protect susceptible tissues from pathogen infection and pest infestation.

Important considerations regarding chemical application for management of diseases, insects and weeds:

- Try to avoid chemical application except when anticipated crop damage or disease would exceed an

Common Name	Resistance Group No.	Trade Name	Formulation[a]	Days to Harvest (PHI)	Restricted-Entry Interval (REI)	EPA Registration Number
Potassium salts of fatty acids	N/A	M-Pede	L	0	12 hours	10163-324
Potassium silicate	N/A	Sil-Matrix	L	0	4 hours	82100-1
	N/A	Carbon Defense	L	0	4 hours	84846-1
Sulfur	N/A	Various trade names[c]	Various	0	24 hours	Multiple

[a]Formulation abbreviations: EC = emulsifiable concentrate; F = flowable; L = liquid; SC = suspension concentrate; WDG = water dispersible granule; WSP = water soluble packet

[b] Discontinue use at burr development. Newer labels for this product may not have this requirement. See label for details.

[c] See chapter 10 for sample trade names.

* Federal restricted-use pesticide. May be purchased and/or used by certified applicators.

*[NY] Restricted-use pesticide in New York State.

HOP APHIDS are an economically damaging pest of hops. Hop aphids are pear shaped and range from yellow to light green in color. These soft bodied insects are found on the underside of hop leaves. Immature individuals are wingless while adult females have wings. All hop aphid life stages are seen on hops. Hop aphids do not overwinter on hops but on an alternate host plant within the *Prunus* genus.

Hop aphids have piercing sucking mouthparts which are used to suck the phloem out of the plant. They secrete a sugary substance called "honey dew". This substance when secreted, especially in hop cones, provides the perfect habitat for sooty mold fungi to grow. Plant productivity is reduced by aphid feeding on foliage yet the greater yield and quality problem that hop aphids cause is sooty mold. Aesthetic cone damage and decreased cone quality from sooty mold will diminish cone marketability. Often, hop aphid populations can be managed by an assemblage of natural enemy arthropods.

Aphid populations will be most successful on plant parts highest in nitrogen and in hopyards with higher levels of nitrogen (Gent et al. 2009). However, all hop plants need adequate amendments of nitrogen for growth. The Pacific Northwest hop-growing region recommends an economic threshold of 8-10 hop aphid individuals per leaf. We do not yet have an economic threshold specific to the Northeastern region.

Management of hop aphid should include; 1) weekly scouting of the underside of leaves starting in early spring and continuing through preharvest, 2) judicious use of nitrogen fertilizer to avoid over fertilization, 3) management of high aphid populations before or during early burr development to avoid cone damage and 4) if sprays are necessary rotate modes of action to decrease the risk of resistance development.

There are many natural enemies of the hop aphid which will provide biological control without the use of insecticides. Use insecticides only when necessary, and when needed, try to use those which have been shown to have the least impact on natural enemies. Some of the natural enemies that you may find while scouting include lady beetles, lacewings, minute pirate bug, big-eyed bug and damsel bug.

Table 9.8.2. Hop aphid management options.

Management Strategy	*Guideline*
Scouting/Thresholds	Beginning in early spring, scouting of the undersides of leaves should be used to determine the presence of hop aphid. Scouting should be continued through the preharvest period. Note presence of predatory mites.
Resistant Varieties	none
Cultural Management	Encourage the development of natural enemies in the hopyard. Avoid over fertilization through judicious nitrogen use.
Chemical Treatment	See table on next page for options.

Common Name	Resistance Group No.	Trade Name	Formulation[a]	Days to Harvest (PHI)	Restricted-Entry Interval (REI)	EPA Registration Number
Azadirachtin + pyrethrins	3A	Azera Insecticide	EC	–	12 hours	1021-1872
Beta-cyfluthrin	3A	*Baythroid XL	EC	7	12 hours	264-840
Bifenthrin	3A	Various trade names[b]	Various	14	12 hours	Multiple
Bifenthrin + imidicloprid	3A, 4A	*Brigadier	F	28	12 hours	279-3332
	3A, 4A	*Swagger	L	28	12 hours	34704-1045

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Table 10.1. Fungicides labeled for use in hops.

Common Name	Resistance Group No.	Trade Name	Formulation[a]	Days to Harvest (PHI)	Restricted-Entry Interval (REI)	EPA Registration Number
Ametoctradin + dimethomorph	45, 40	*[NY]†Zampro	SC	7	12 hours	7969-302
***Bacillus amyloliquefaciens* strain D747**	44	Double Nickle 55	WDG	0	4 hours	70051-108
	44	Double Nickle LC	LC	0	4 hours	70051-107
***Bacillus subtilus* QST 713**	N/A	Serenade ASO	F	0	4 hours	264-1152
	N/A	Serenade Max	WP	0	4 hours	264--1151
***Bacillus pumilus* strain QST 2808**	N/A	Sonata	F	0	4 hours	264-1153
Boscalid + pyraclostrobin	7, 11	Pristine	DG	14	12 hours	7969-199
Basic copper sulfate	M1	Basic Copper 50W HB	D	0	48 hours	42750-168
	M1	Cuprofix Ultra 40 Disperss	DF	14	48 hours	70506-201
Copper hydroxide	M1	Champ DP Dry Prill	DG	14	48 hours	55146-57
	M1	Champ Formula 2 Flowable	L	14	48 hours	55146-64
	M1	Champ WG	G	14	48 hours	55146-1
	M1	Dupont Kocide 2000	DF	14	48 hours	352-656
	M1	Dupont Kocide 3000	DF	14	48 hours	352-662
	M1	Kentan DF	DF	14	48 hours	80289-2
	M1	Nu-Cop 3L	L	14	48 hours	42750-75
	M1	Nu-Cop 50DF	DF	14	48 hours	45002-4
	M1	Nu-Cop 50WP	WP	14	24 hours	45002-7
	M1	Nu-Cop HB	G	14	48 hours	42750-132
Copper octanoate	N/A	Cueva Fungicide Conc.	F	Up to day of harvest	4 hours	67702-2-70051
Copper oxychloride + copper hydroxide	M1	Badge SC	SC	14	48 hours	80289-3
Copper oxychloride + basic copper sulfate	M1	C-O-C-S WDG	G	0	48 hours	34704-326
Cuprous oxide	N/A	Nordox 75 WG	WG	14	12 hours	48142-4
Cyazofamid	21	Ranman	L	3	12 hours	71512-3-279
Cymoxanil	27	Curzate 60 DF	DF	7	12 hours	352-592
Dimethomorph	40	Forum	L	7	12 hours	241-427
Famoxadone + cymoxanil	11, 27	Dupont Tanos	DF	7	12 hours	352-604
Fosetyl al	33	Aliette	WDG	24	12 hours	264-516
Hydrogen dioxide+ Peroxyacetic acid	N/A	Oxidate	L	0	Until spray has dried	70299-12
Mandipropamid	40	Revus	L	7	4 hours	100-1254
Mefenoxam	4	Ridomil Gold SL	L	45	48 hours	100-1202
Metrafenone[c]	U8	Vivando	SC	3	12 hours	7969-284
Mineral oil	N/A	Drexel Damoil	oil	0[b]	4 hours	19713-123
	N/A	Biocover UL	oil	0[b]	4 hours	34704-806
	N/A	Glacial Spray Fluid	oil	0[b]	4 hours	34704-849
	N/A	Suffoil-X	EC	-	4 hours	48813-1-68539

Table continues on next page.