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Sustainable Hop Production in the Great Lakes Region

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Introduction

Hops (*Humulus lupulus* L.) are an essential ingredient in beer production. The female flower "cones" of the hop plant contain lupulin glands with compounds important to the brewing process (Figure 1). These compounds — alpha acids, beta acids, and essential oils — contribute to beer's bitterness and aroma. Recent hop shortages, the growing appeal of specialty beers, and the desire for organic and locally sourced agricultural products have resulted in increasing interest in local hop production among farmers, brewers, and hobbyists. This bulletin is designed to provide an introduction to sustainable hop production in the Great Lakes region.

Fig. 1. Hop cone. *Photo: LuckyStarr/Wikimedia Commons.*

History

Over the past 5,000 years, hops have been used for medicinal purposes, as a fiber for paper, as a salad ingredient, in pillows as a sleep aid, and, of course, as a preservative and flavor agent in beer (Figure 2).

Pliny the Elder (61-113 A.D.) made one of the first known references to hops. The first documented reference to the cultivation of hops is in the eighth century in the Hallertau region of Germany. Hop production most likely began before the eighth century in eastern Europe and then spread to

Fig. 2. Early medicinal use of hops. *Source:* *www.antiquebottles.com/rl/tc/*.

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the rest of the continent.[1] The first description of the use of hops in beer was in 12th century Germany.

Though the British imported hopped Dutch beer in the early 1400s, commercial hop production did not begin in England before the early 1500s. European travelers transported the plant with them around the world, and the hop was brought to North America from England in 1629, though early settlers could harvest the native variety. Over time, most East Coast states became hop-growing regions. Hops weren't grown commercially until 1808 in New York. With the advent of the railroad and greater yield potential in California, hop production shifted west (Figure 3). As powdery and downy mildew decimated production in New York state, by the late 1920s hop production had moved to the Pacific Northwest. Today Washington, Oregon, and Idaho lead the nation in hop production.

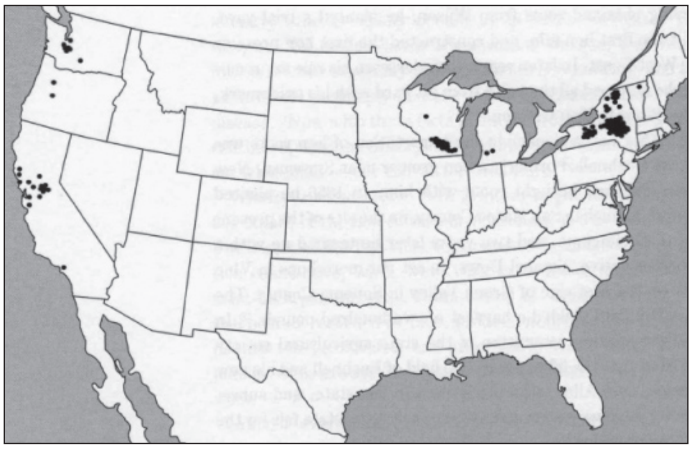


Fig. 3. Hop production in the United States circa 1879 (each dot represents 100,000 bales; 1 bale =200 pounds dried hops). *Source: Tinged with Gold: Hop Culture in the United States, Michael Tomlan, 1992.*

Natural History and Taxonomy

Humulus is a genus of herbaceous climbing plants that most likely originated in China but is indigenous to temperate areas of the northern hemisphere including Asia, Europe, and North America. *Humulus* is one of two genera in the Cannabinaceae family, the other being *Cannabis*. Though there are three distinct species — *H. lupulus, H. japonicus*, and *H. yunnanensis* — all commercial hops are of the *Humulus lupulus* (common hop) species.

Characteristics and Growth Habits

Hop plants are dioecious (male and female flowers occur on separate plants) perennial plants that produce annual bines from a crown and overwintering rhizome. With time, the perennial crown becomes woody and can produce an extensive root system. In the spring, shoots surface from rhizome buds, and, aided by trichomes or stout hairs, hop bines grow in a clockwise direction and have the potential to reach heights of 25 feet in a single growing season (4 to 10 inches per day). Hop leaves form off the main bine and lateral branches and are simple, heart-shaped to ovate and deeply lobed, with serrate margins. Around the summer solstice, lateral branches develop and flowers are produced in clusters at the terminal buds. Although hop plants produce both female and male inflorescence, only the female flower (cone or strobile) is desirable for use in beer production. In fact, most commercial operations take great lengths to discourage fertilization by removing all male plants and sources of hop pollen. Female flowers form 0.5- to 4-inch, light green, papery strobiles that contain lupilin glands, home to alpha and beta acids and essential oils (Figure 4).[2]

Hop Production and Growing Requirements

Environment and Climate

Though the diversity of hop cultivars rivals their varying climatic and environmental tolerances, hops require long day lengths to flower and produce adequate cone yields. For optimal growth, hops also have specific chilling requirements (winter temperatures below 40 degrees F for 1 to 2

Fig. 4. Lupulin glands inside hop cone. *Photo: Charlie Papazian.*

[1] Neve, R. 1991. Hops. Chapman and Hall, N.Y.

[2] www.examiner.com/x-241-Beer-Examiner~y2009m7d13-The-beer-lowdown-on-popular-American-dry-hop-varieties

months) that are rarely satisfied below 35 degrees latitude. Therefore, most commercial production worldwide occurs at latitudes from 35 to 50 degrees. Ideal conditions for hop growth also include sufficient spring moisture followed by significant periods of summer sun and heat to ensure ample growth and full development of chemical compounds.

Soils

In general, marketable yields of hops can be produced in well-drained, deep, sandy loam soils with a pH of 5.7 to 7.5. Heavy, poorly drained soils should be avoided. (See "Fertility and Irrigation" for amendment information.) Depending on prior land use, growers may want also to test for nematodes before planting. Michigan State University Diagnostic Services offers basic, foliar, and total community nematode analysis. Results may indicate the need for chemical fumigation to prepare soil for hop planting. Research has shown that several cover crop varieties may also provide sufficient control of pest nematodes.

Propagation

Because hop plants are dioecious, seed populations are extremely variable and will not produce offspring similar to a mother plant. Therefore, hop plants are most often propagated vegetatively from rhizomes (Figure 5) or softwood cuttings. Originating from the perennial hop crown, bud-bearing sections of lateral underground shoots or rhizomes are typically cut into 6- to 8-inch lengths and transplanted directly into hop yards or potted and placed in greenhouses. If not planted immediately, rhizomes should be stored in a cool place. Softwood cuttings are typically taken from the stem with one to two nodes and two leaves, and with 2 to 3.5 inches of wood beneath the node. Cuttings are usually planted and grown for one season before being transplanted into the hop yard the following year.

Fig. 5. Hop rhizomes. *Photo: www.growinghopsyourself.com*.

Agroecological Practices

Planting, thinning, training, stripping

Hops should be planted into recently tilled rows in early spring (late April to early May). Instead of tilling the entire field, many growers often leave alleys planted to ground cover to reduce the potential for soil erosion and to enhance beneficial insect habitat. The most typical planting scheme is 7 feet by 7 feet or 3.5 feet by 10 to 15 feet, with an average of 800 to1,000 plants per acre. Hops should be planted horizontally, bud side up, 1 to 2 inches beneath the soil surface. When bines reach 1.5 to 2 feet, four bines from each rhizome are selected to keep, and the remainder are removed (thinning). Two bines are then trained (training) up each of the two coconut fiber, jute, paper, or synthetic poly support strings in a clockwise direction. In the spring of the third year, after 2 to 3 weeks of growth, many growers will hand prune or mechanically prune the previous season's old growth and current season's new shoots to control hop maturation timing and yields, and to reduce disease incidence. Once bines reach approximately 6 feet in height, the lowest 3 feet of leaves and lateral branches are generally removed (stripping) to encourage airflow and reduce spread of downy and powdery mildew. Stripping can be accomplished manually, chemically, or even with livestock. The timing of both pruning and stripping are important in determining current and future-year hop yields.

Trellising

The vast majority of hops are trained on tall trellises (18 to 21 feet) to maximize yields. Growers should be advised that the trellis is an engineered structure subject to substantial loads, including the plant (approximately 35 pounds per plant) and wind (a 60 mph wind equates to roughly 10 pounds per square foot).[3] A trellis system consists of high-tensile (200 ksi), heavy-gauge wire or cable suspended between poles that are set 3.5 to 4 feet deep (below the frost line), and spaced every 30 to 60 feet. Wires are then tightened and connected to earth anchors at each row end. The main or horizontal wires can be set with a catenary shape[4] to enable them to carry both the plant and wind

[3] Sobkowski, S. Personal communication, 11/17/2009.

[4] The word "catenary" is derived from the Latin word for "chain"; it is the curve a hanging chain or cable assumes when supported at its ends and acted on only by its own weight.

loads efficiently. Strings are attached to the support wires, generally in a V shape so as to leave a tunnel through which farm implements can drive (Figure 6). This system results in the greatest yields. Because tall trellis systems require labor-intensive practices such as training and stringing, USDA Agricultural Research Service researchers have been working to identify shorter growth cultivars that would be well-suited to low (10-foot) trellis systems. Reducing installation and labor costs would provide growers with significant cost savings.

Fig. 6. Second-year hop growth at Old Mission Hops Exchange, Old Mission Peninsula, Mich. *Photo: Roger Dunlap.*

Fertility and Irrigation

The best way to determine hop nutrient needs is to take annual soil tests (Figure 7). Hop nutrient needs vary depending on soil quality, cultivars, and growing region. For nitrogen, it is useful to determine a budget and synchronize timing with plant uptake to estimate fertilizer timing and needs.[5] For example:

N fertilizer required = hop N needs – N from green manure, cover crops, compost

In general, it is necessary to replace the amount of nitrogen removed with the crop during harvest. In hop production, around 100 pounds of nitrogen per acre (lb N/acre) are removed on average during hop harvest.[6] Depending on soil quality, cover crop N fixation, and amount and quality of compost used, typical first-year N rates are 75 lb N/ acre (1.5 to 2 tons of compost/acre); in subsequent years, 100 to 150 lb N/acre (2 to 3 tons compost/acre).

Hops typically have low P requirements. Phosphorus needs are generally lower than N or potassium needs because the hop crop usually removes only 20 to 30 lb P/acre. Typical P recommendations thus range from 20 to 30 lb P_2O_5/acre. Increasingly, overapplication of P in agricultural and residential areas is leading to algal blooms in lakes and streams (eutrophication) and reductions in dissolved oxygen levels leading to "dead zones" such as that found in the Gulf of Mexico. Over the course of a season, hops typically take up 80 to 150 lb K/acre.[7] In northern Michigan's sandy soils, the optimal range for K is around 100 parts per million. At this level, potash (K_2O) is generally applied at 20 lb/acre to replace the K taken up by hops during the season.

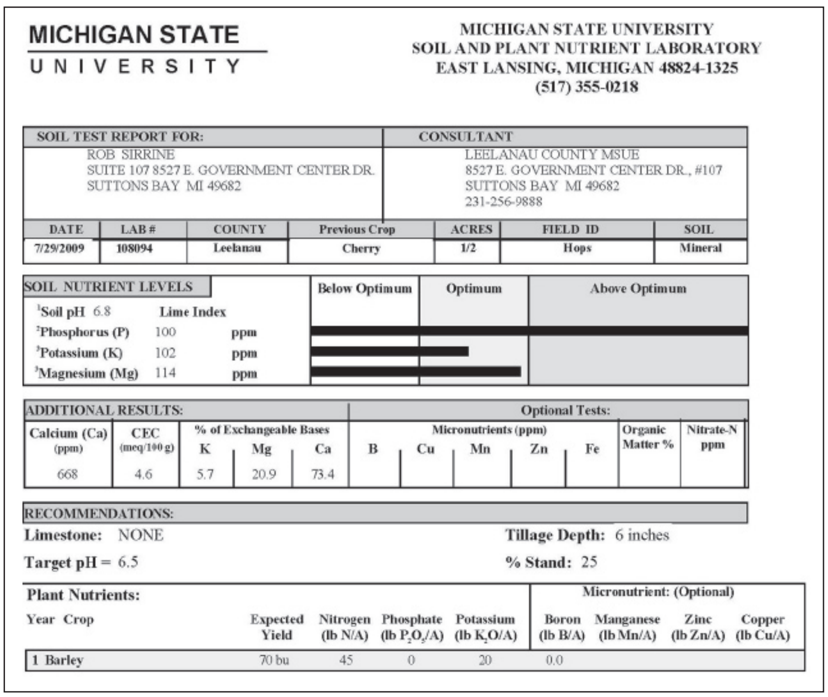
As the market for organic hops increases, the use of compost, cover crops, and other organic amendments will likely become more prevalent. As long ago as 1877, P.L. Simmonds underscored the importance of compost: "In preparing the soil for this plant, care should be taken to thoroughly destroy the weeds…well-rotted dung must be applied with a liberal hand."[8] Compost can be banded in the hop rows, where, in addition to providing N and other nutrients over an extended time frame, it may also provide weed control benefits. Depending on compost and initial soil quality, 2 to

[5] Gingrich et al. 2000. Hops. FG 79. Oregon State University.

[6] Carter et al. 1990. Hop. Alternative Field Crops Manual.

[7] Gingrich et al. 2000. Hops. FG 79. Oregon State University.

[8] Simmonds, P.L. 1877. Hops: Their Cultivation, Commerce, and Uses in Various Countries.



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MICHIGAN STATE UNIVERSITY
SOIL AND PLANT NUTRIENT LABORATORY
EAST LANSING, MICHIGAN 48824-1325
(517) 355-0218

SOIL TEST REPORT FOR:	CONSULTANT
ROB SIRRINE SUITE 107 8527 E. GOVERNMENT CENTER DR. SUTTONS BAY MI 49682	LEELANAU COUNTY MSUE 8527 E. GOVERNMENT CENTER DR., #107 SUTTONS BAY MI 49682 231-256-9888

DATE	LAB #	COUNTY	Previous Crop	ACRES	FIELD ID	SOIL
7/29/2009	108094	Leelanau	Cherry	1/2	Hops	Mineral

SOIL NUTRIENT LEVELS			Below Optimum	Optimum	Above Optimum
¹Soil pH 6.8	Lime Index				
²Phosphorus (P)	100	ppm			
³Potassium (K)	102	ppm			
³Magnesium (Mg)	114	ppm			

ADDITIONAL RESULTS:					Optional Tests:						
Calcium (Ca) (ppm)	CEC (meq/100 g)	% of Exchangeable Bases			Micronutrients (ppm)					Organic Matter %	Nitrate-N ppm
		K	Mg	Ca	B	Cu	Mn	Zn	Fe		
668	4.6	5.7	20.9	73.4							

RECOMMENDATIONS:

Limestone: NONE | Tillage Depth: 6 inches

Target pH = 6.5 | % Stand: 25

Plant Nutrients:					Micronutrient: (Optional)			
Year Crop	Expected Yield	Nitrogen (lb N/A)	Phosphate (lb P_2O_5/A)	Potassium (lb K_2O/A)	Boron (lb B/A)	Manganese (lb Mn/A)	Zinc (lb Zn/A)	Copper (lb Cu/A)
1 Barley	70 bu	45	0	20	0.0			

Fig. 7. Example of soil test result from MSU Soil and Plant Nutrient Lab.

3 tons/acre should satisfy nutrient needs in organic systems. The Michigan State University Soil and Plant Nutrient Lab can provide compost quality determinations.

Micronutrients and pH

Hop plants grow best in soils that are not overly acidic or basic. Application of ammonium fertilizers over a long time period leads to increasing soil acidity. As NH_3 is converted to nitrate (NO_2), the hydrogen anions that are released make the soil more acidic. As soil pH decreases below 5.7, manganese levels can become toxic in hop tissues. If soils are too acidic, lime ($CaCO_3$) may be applied to neutralize the acid (H+ ions) to form CO_2 and H_2O. Soils with high pH — above 7.5 — are often associated with zinc (Zn) deficiencies. If soils are too basic, ammonium sulfate fertilizer can be used. Hops have been shown to respond positively to boron (B) as well if test values are below 1.5 ppm.

Irrigation is generally needed in most areas of the United States to satisfy the water needs of hop plants. By the second year, hops need roughly 16 gallons per plant per week during the hottest parts of the summer.[9] Hop plants do not thrive in heavy, waterlogged soils, which can increase the incidence of many diseases. Drip irrigation that can deliver water directly to plants tends to be the most efficient watering system. Researchers at the Northwest Michigan Horticultural Research Station have successfully employed a computer-operated RAM tubing drip irrigation system with emitters every 2 feet and an output of .42 gallon per hour. In this soil-moisture-based system, underground sensors determine when water is needed and soil moisture levels are maintained at optimum levels. RAM tubing provides uniform output from each emitter, in spite of elevation changes or length of drip line. Though this type of system has higher initial costs, it is more efficient than other systems because it operates only when soil moisture levels are low.

Cover crops

Cover crops have been used as a major ground cover management tool in many agricultural systems.[10] Cover crops have proven particularly useful in perennial systems and offer several benefits (Figure 8). They have been shown to reduce fertilizer and pesticide costs, improve soil quality and crop yields, prevent soil erosion, conserve soil moisture, scavenge excess nitrogen, and provide beneficial insect habitat. If improperly managed, however, cover crops can compete with primary crops, provide habitat for pests and rodents, increase downy mildew concerns through restricted airflow, and increase frost damage.

Fig. 8. Cover crops planted in the alley at New Mission Organics hop yard, Omena, Mich. *Photo: Rob Sirrine.*

Insect Management

The most common pests in hop are hop aphids and spider mites, although less common pests such as cutworms and Japanese beetles can become problematic.[11]

Hop aphid *(Phorodon humuli)*

Hop aphids are small, pale green insect pests with two cornicles (upward-pointing tubes) protruding from the backside of the abdomen (Figure 9). Hop aphids overwinter on *Prunus* species (e.g., wild and cultivated cherry, plum, and apricots) and return to hop plants in the spring. Infestations develop more rapidly during cool weather.

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[9] Godin, R. 2009. Personal communication.

[10] Managing Cover Crops Profitably (3rd ed) (A. Clark, [ed.], 2009) is an outstanding text for practical information on cover crops.

[11] The Field Guide for Integrated Pest Management in Hops (Gent et al., 2009) is a comprehensive field guide for growers.

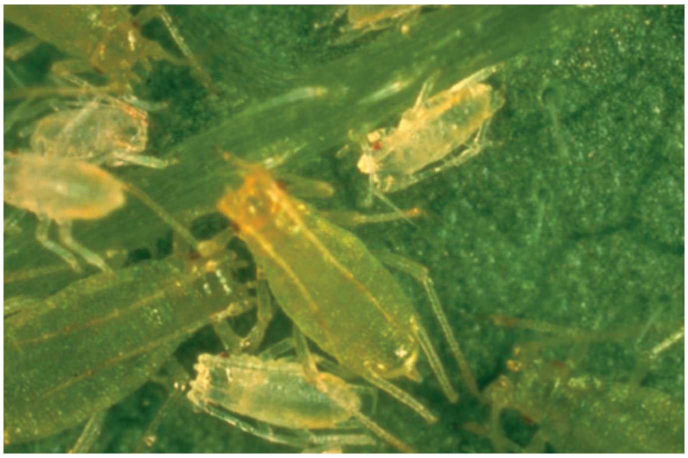

Fig. 9. Aphids. *Photo: www.inra.fr/hyppz/IMAGES/7012651.jpg.*

Hop aphids feed directly on hop plants by sucking plant juices. Once the aphids have entered the cones, they can secrete honeydew (plant cell sap) and cause sooty mold to grow in hop cones (Figure 10). Aphids weaken plants and reduce yields and should be controlled before or during flowering to prevent them from entering young cones. Scouting is recommended. Provisional threshold numbers are 8 to 10 aphids per leaf, though data suggest that plants can tolerate large populations, up to 100 per leaf or more, without direct yield loss.[12] Thresholds also vary depending on time of year. Threshold numbers often decline to zero when cones are present. Enhancing habitat to encourage beneficial predatory insects such as lacewings, lady beetles, and syrphid flies can reduce populations of aphids. Growers should also limit excessive nitrogen application because large quantities of new leaf growth favor aphid outbreaks.[13]

Spider mites *(Tetranychus urticae)*

Spider mites are serious pests of hops. They are pale yellow to reddish and often have a dark spot on each side of the body (Figure 11). Females emerge in the spring and begin feeding by piercing the lower leaf surfaces and ingesting plant sap, which causes leaves to become yellow, shrivel, and die (Figure 12). Damage on cones results in brownish, brittle cones — a condition that growers call "red hops". Spider mites most often present a problem during long stretches of dry, warm weather. Mite predators include the western predator mite and the small black lady beetle. Scouting is recommended. Though thresholds have not been empirically determined, the provisional threshold is 5 to 10 mites per leaf. Dust control and nitrogen management are important for mite control. Ground cover mixes that include red clover have been shown to host predatory mites that prey upon spider mites.

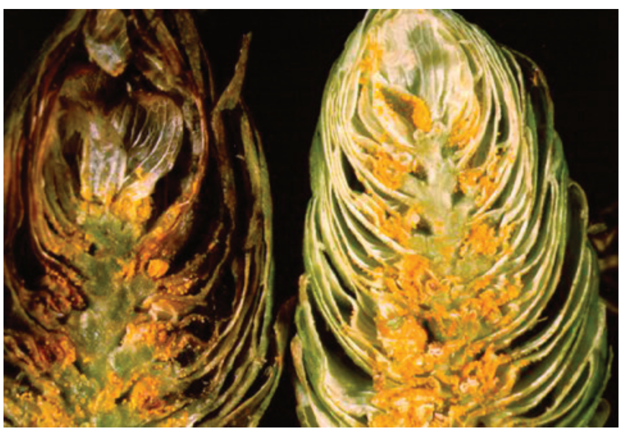

Fig. 10. Cross-section of hop cones with sooty mold (left) and without (right). *Photo: USDA.*

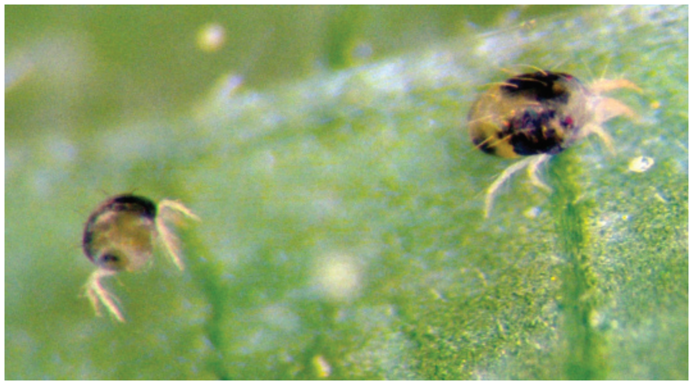

Fig. 11. Spider mites. *Photo: Frank Peairs.*

Fig. 12. Foliar symptoms of spider mite (*Tetranychus urticae*) infestation of common hop plants in Oregon. *Photo: David Gent.*

Weed Management

Weeds have the potential to compete with hops for moisture and nutrients. As in many agricultural systems, various weed control options have various tradeoffs. Mechanical cultivation (tillage), chemical control, and mulching are the most common methods of weed control in hop production. In mechanically cultivated systems, tillage

[12] Gent, D. Personal communication, 11/17/2009.

[13] Gent et al. 2009. The Field Guide for Integrated Pest Management in Hops.

(4 to 6 inches) should begin as weeds appear, followed by shallow cultivation (2 to 4 inches) until after lateral hop branches have developed. Over time, cultivation has been shown to decrease soil quality, and in hilly areas, it can lead to erosion problems. Many growers use no-till systems with herbicides to manage weeds. Only a few herbicides are labeled for hops, and growers must be careful with application timing and rates to prevent damage to hop plants. Mulch has been shown to suppress weeds in hop systems and over time can increase moisture retention and improve long-term soil quality (Figure 13).

Disease Management

Several diseases affect hops and are sure to be more prevalent and of more concern in the humid Great Lakes region than in the Pacific Northwest.[14] Major diseases include downy mildew (*Pseudoperonospora humuli*), powdery mildew (*Podosphaera macularis*), and Verticillium wilt *(V. albo-atrum or V. dahliae*). In fact, downy and powdery mildew were responsible for the decline of hop production in the eastern United States in the 1920s. The first step in disease management is selecting resistant or tolerant cultivars. The USDA ARS maintains a database of these cultivars.

Fig. 13. Innovative mulching system for weed control. New Mission Organics, Omena, Mich. *Photo: Rob Sirrine.*

Downy mildew *(Pseudoperonospora humuli)*

Downy mildew is a serious disease of hops in most hop-growing regions of the world and can threaten profitability if not controlled. Losses from downy mildew vary depending on cultivar susceptibility and climate. They are greatest in areas with heavy spring rainfall and favorable temperatures (60 to 70 degrees F). The fungus overwinters in infected crowns and results in a conspicuous stunted shoot or "spike" that typically has small, yellow, cupped leaves (Figure 14). Spike formation results in stunted growth and reduction in cone production. If bloom occurs in wet weather, cones are likely to become infected, resulting in blackened, unmarketable cones (Figure 15). Downy mildew management requires multiple practices including planting of resistant varieties, field sanitation, and fungicide application. Rhizomes should be disease-free, basal spikes should be promptly removed, and infected root crowns should be removed from the field as well. Pruning or

Fig 14. A spike resulting from downy mildew. *Photo: David Gent.*

[14] The Compendium of Hop Diseases and Pests (Mahaffee, Pethybridge, and Gent [eds.], 2009) offers a comprehensive overview of pest and disease management in hops.

Fig. 15. Downy mildew on hop strobiles. *Photo: David Gent.*

stripping the lowest leaves after training will help improve air flow and reduce inoculum density. The cultivar Cluster is extremely susceptible; moderately resistant cultivars include Cascade, Fuggle, Perle, Tettnanger, and Willamette.

Powdery mildew *(Podosphaera macularis)*

Powdery mildew is a serious disease of hop that requires control in most hop-producing regions. Symptoms include white, powder-like splotches on leaves or stems (Figure 16). Powdery mildew thrives in high-humidity, low-light areas with minimal air circulation. The fungus also favors young growth in overly fertile soils. Optimal temperature for growth and infection is 64 to 70 degrees F . In susceptible varieties, cones can become infected, resulting in stunting, cone-shatter, and reduced yields (Figure 17). As with downy mildew, control options include cultural and chemical.

Figure 16. A common hop leaf with foliar signs of powdery mildew infection caused by *Podosphaera macularis*. *Photo: David Gent.*

Figure 17. Common hop field with powdery mildew infection caused by *Podosphaera macularis*. *Photo: David Gent.*

Plants should be thinned and, after stringing, lower leaves should be stripped to improve airflow. Excessive fertilization should be avoided.

Verticillium wilt *(V. albo-atrum* or *V. dahliae)*

Verticillium wilt lives in the soil and infects hundreds of woody and herbaceous plants through their roots. Leaves of an infected plant will turn yellow and wilt from the base upward. Infected bines, when cut, will show a brown discoloration of the woody vascular tissue. The effect of the pathogen on hop varies depending on the virulence of the strain. Infected hop yards can demonstrate symptoms ranging from minor wilting and bine swelling with relatively minor economic damage to leaf and plant death. Cultural control measures include sanitation, planting of resistant cultivars (e.g., Cascade and Perle are less susceptible; Fuggle is susceptible), maintenance of adequate but not excessive fertilization and irrigation, employment of no-till, and long rotations (4 years minimum) of non-host plants.

Virus and Viroid Diseases

Several diseases in hops are caused by viruses and viroids. The best way to avoid virus issues is to start with certified virus-free rhizomes. If infected hop plants are found in small numbers, it may be economical for growers to remove them and nearby plants and then replant after ensuring that all volunteers are dead.

Carlavirus Complex

The three carlaviruses that infect hop plants are American hop latent virus, hop latent virus, and hop mosaic virus. Golding varieties or related cultivars are most likely to develop symptoms of hop mosaic virus, including yellow spots and weak growth. The carlaviruses can result in poor establishment and growth, and yield losses may be greater than 50 percent with extremely sensitive cultivars. The main modes of localized transmission of carlaviruses are mechanical and through aphid vectors.

Apple mosaic virus

In certain situations, apple mosaic virus can reduce cone yields by up to 50 percent. Symptoms are environment-dependent and include necrotic ringspots. As with the other viruses, using only virus-free rhizomes is the best way to limit apple mosaic virus. Limiting mechanical pruning and weed control may also reduce its spread locally.

Hop stunt viroid

Hop stunt viroid is of major concern for growers because it can severely reduce yields. Hop stunt viroid is spread through infected rhizomes and by mechanical means. Symptoms, which may take years for hop plants to express, include delayed early-season growth, stunting, small cones, and development of yellow-green leaves. Prevention and control measures include reducing or eliminating mechanical pruning, thorough disinfecting of tools and equipment, and removing infected bines by chemical means.

Harvesting, Picking, and Drying

Harvest timing is cultivar- and management-dependent, but in general, harvest occurs in mid- to late August through late September. Harvest date decisions depend on several factors, including cone moisture content, weather, and pest and disease issues. Proper timing is essential because hops are in prime harvest condition for only 7 to10 days. Premature harvest can result in losses in yield and flavor in the current season and potentially reduced yields in subsequent years. Harvesting after peak ripeness can result in reduced aroma and brewing quality, shattering, and discoloration due to oxidation.

All hops were once picked by hand. In most commercial operations today, at peak ripeness hop bines are cut at the base and transported to picking machines. Picking machines strip the cones from the bines and separate leaves and stems, which can then be composted for future use. Cones are subsequently cleaned to remove debris.

After harvest, the vast majority of hops are dried to reduce cone moisture from around 80 percent to 8 to 12 percent for storage. Drying reduces the potential for spoilage in storage. After drying, cones are allowed to cool and are then baled and pelletized. The hops are then bagged after a nitrogen purge and then frozen to minimize degradation with time. Preference among brewers for pelletized hops is nearly unanimous, though increasingly, many brewers are interested in small amounts of whole hops, whether fresh-wet or -dried, for seasonal and/or specialty brews.

Establishment Costs

Though establishment costs vary depending on current market conditions and choice of trellis systems, irrigation, and growing methods, costs generally range from $6,000 to $15,000 per acre. Tall trellis systems recently established in Michigan and Colorado averaged around $14,000 to $18,000 per acre (Table 1). In addition to growing costs, as mentioned above the hops have to be processed before marketing. Equipment for processing can be prohibitively expensive (six figures). To avoid this large upfront capital expense, many growers choose to enter into arrangements with local processors.

Economics, Markets, and Brewer Needs

In 2007, after years of oversupply and stagnant prices, there was a “perfect storm” of events that dramatically changed the hop industry. After over a decade of poor returns, many farmers had been pulling land out of production. In the United States, hops acreage had declined by over one-third since 1996 (Figure 18). When combined with a 2006 warehouse fire that destroyed 4 percent of U.S. production (50 percent of the total U.S. crop is exported on average) and poor yields globally in 2007, demand outpaced supply for the first time in years. Consequently, prices skyrocketed

Table 1. Standard tall hop trellis establishment costs/acre at the Northwest Michigan Horticultural Research Station, Leelanau County, Mich., 2009.

Item	Quantity/Price	Cost
Rhizomes	800 @ $4 each	$3,200
Poles (21 ft)	100 @ $32 each	$3,200
Crushed stone	4 yards	$550
Env. earth anchors	Manta Ray and Duckbill Anchors	$2,200
Drip irrigation	Materials	$800
3/16-inch wire	16,000 ft @ $.09/ft	$1,440
5/16-inch wire	2,000 ft @ $.21/ft	$420
Hop twine	Coconut fiber	$125
Compost	100 yards @ $10/yard delivered	$1,000
Misc. supplies	Wire clamps, staples, etc.	$250
Labor	Hole auger, pole setting, wire	$3,400
Equipment rental	Installing wire	$800
Total		**$17,385***

*Note: This figure may be reduced with less expensive products or if a grower chooses to install the hop yard with his/her own equipment and labor.

from $5 to $50 per pound in Michigan, and the needs of small-scale breweries took a backseat to those of large-scale beer producers, who hold long-term contracts for 80 percent of U.S. hop production. As prices increased, interest in hops production nationwide grew, and farmers in many Great Lakes states planted hops for the first time in more than 100 years. Washington state producers have responded by increasing acreage by more than 35 percent (Figure 19), which will greatly reduce prices nationally in the years ahead. Because of growing interest in the "buy local" movement and organic production, however, small-scale producers may have an opportunity to satisfy the needs of many Great Lakes microbreweries. A 2008 MSUE survey of brewers in Michigan found that 100 percent of brewers surveyed were interested in establishing a contract with a small local grower and/or processor. Seventy-five percent of brewers were either slightly or definitely concerned about the market security of hops. Eighty percent of brewers were slightly/definitely interested in purchasing organic hops. And 55 percent of brewers would pay a 1 to 10 percent premium for locally grown organic hops. It is recommended that growers have a solid marketing plan and contracts in place before planting significant acreage. With a diversified

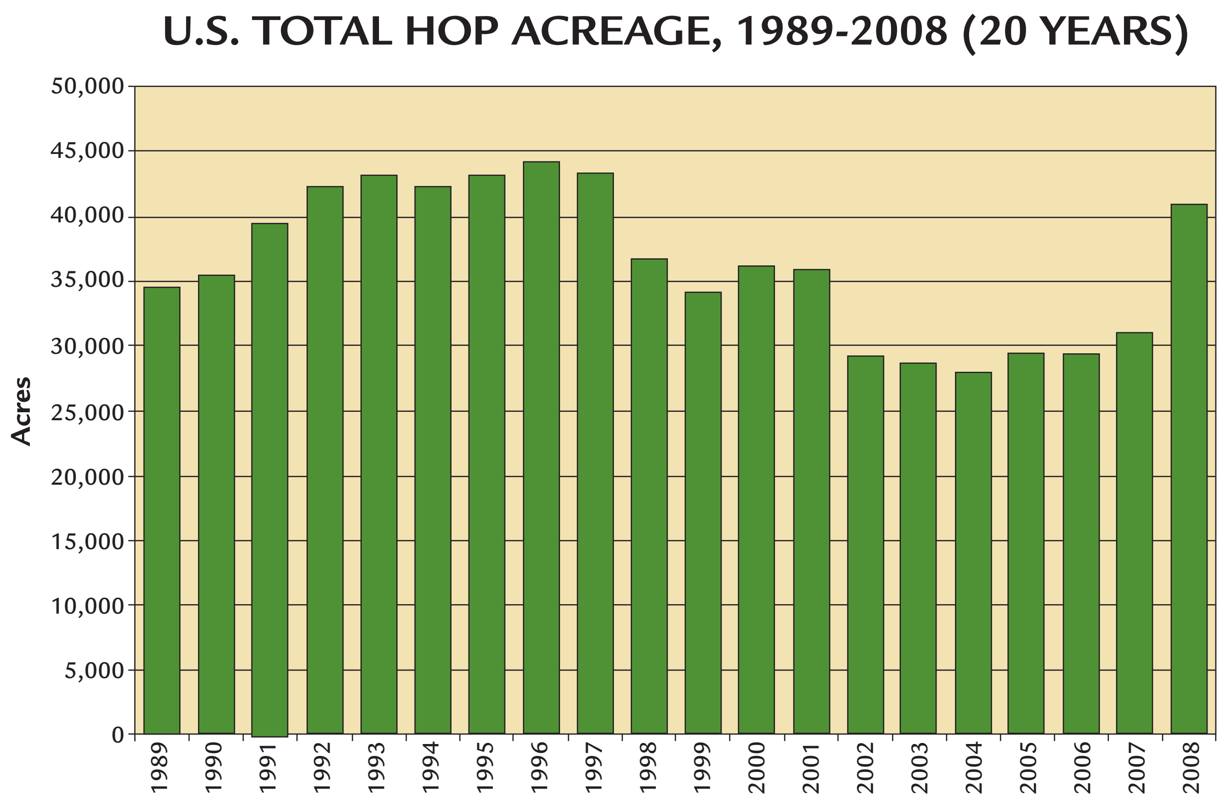

Fig. 18. Decline and recent rise in U.S. hop acreage (1989-2008). *Source: USDA NASS, prepared by HGA.*

U.S. HOP ACREAGE BY STATE, 1998-2008 (IN ACRES)

YEAR	WASHINGTON	OREGON	IDAHO	TOTAL
1998	26,573	6,161	3,909	36,643
1999	25,076	5,822	3,362	34,260
2000	26,980	5,819	3,321	36,120
2001	26,339	6,103	3,469	35,911
2002	20,333	5,577	3,399	29,309
2003	19,492	5,748	3,429	28,669
2004	19,382	5,107	3,253	27,742
2005	21,013	5,163	3,287	29,463
2006	21,532	5,036	2,797	29,365
2007	22,745	5,270	2,896	30,911
2008	30,595	6,370	3,933	40,898

Fig. 19. U.S. hop acreage by state, 1998-2008. Note increase in acreage in 2007-2008. *Source: USDA NASS, prepared by HGA.*

marketing strategy that includes medicinal, herbal, and home-brew markets, growers may be able to jump-start a regional hop industry.

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Oregon Crop profile, **www.ipmcenters.org/CropProfiles/docs/orhops.pdf**

Washington Crop profile, **www.tricity.wsu.edu/~cdaniels/profiles/Hops3PM.pdf**

Hop Growers of America, **www.usahops.org**

Resources *(continued)*

Processing and sales:

Michigan: Old Mission Hop Exchange, **www.oldmissionhops.com/**

Wisconsin: Gorst Valley Hops, **www.gorstvalleyhops.com/**

Registered chemicals for use on hop by state, **www.greenbook.net**

Rhizome sales:

Adventures in Home Brewing (Taylor, Mich.), **www.homebrewing.org/**

Ebrew, **www.Ebrew.com**

Fresh Hops, **www.freshops.com/**

HopTech, **www.hoptech.com/**

Hop Union, **www.hopunion.com/**

Midwest Supplies, **www.midwestsupplies.com**

Sandy Ridge Farms, Zeeland, Mich., (616) 218-2363

Thyme Garden, **www.thymegarden.com**

Statistical Reports, **www.usahops.org/index.cfm?fuseaction=stats&pageID=5**

USDA ARS National Clonal Germplasm Repository, **www.ars-grin.gov/cor/humulus/huminfo.html**

Weed control in hops, **www.uspest.org/pnw/weeds?15W_LEGL14.dat**