



Hops

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Introduction

Hop (*Humulus lupulus*) is a native herbaceous plant with a perennial crown and annual climbing stems (bines). Bines are similar to vines; however, bines wind around a support structure and lack the suckers or tendrils typical of vines. Hop crowns can survive for 25 years or more; however, the fast growing bines die back to the ground each winter. Bines can reach a height of 15 to 30 feet in a single growing season. Hops are valued for their female cones, which contain the resins and essential oils used to provide the distinctive flavor, aroma and bitterness to beer.

The University of Kentucky Robinson Center for Appalachian Resource Sustainability initiated a hop research project in 2011, and hop research plots at Murray State University were funded in 2018. Interested growers should contact the Horticulture Program at the Robinson Center for the latest research information. As with any new enterprise of this nature, prospective growers would be wise to proceed cautiously by starting small. Larger plantings should not be attempted until the crop has been evaluated over several seasons and the product has been test-marketed.

Marketing and Market Outlook

Hops have a limited, yet potentially profitable market in Kentucky. Major U.S. breweries generally purchase domestic hops from wholesale brokers. This market is usually available only to producers who can supply large quantities of hop cones. However, the increasing numbers of craft breweries and brewpubs in the U.S. has created market potential for small growers. Craft breweries are smaller breweries that produce less than 6 million barrels annually and typically sell their product off-premises.



Brewpubs, on the other hand, are small breweries that are connected with a restaurant and/or bar. Both generally produce specialty beers, often with regional appeal. Small-scale growers might provide these specialty breweries with desired cultivars of high quality, freshly harvested or processed hops not otherwise available to the small brewery. Direct sales to these

smaller breweries will generally require establishing an ongoing business relationship from production to harvest. Growers with small acreages could also market their product directly to home brew shops, hobby brewers, specialty



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stores, and specialty non-beer product markets.

Hop varieties are selected based on their essential oil content, alpha and beta acid contents, and aroma. Dried hops have traditionally been used in making beer; however, a recent trend in brewing with fresh hops has created a demand for non-processed cones. Processing and storage of at least some of the crop, however, can extend the market season for small-scale producers. Some innovative growers have developed other markets, besides breweries, for hops. Early in the growing season before bines become woody they can be harvested for pickling or cooking. Hop cones and extracts have also been used to make soap, condiments, and snacks that are sold on-line or at the hop yard. The reported mild sedative quality of hop cones has been exploited in making pillows and teas for the treatment of insomnia. After cone harvest, bines can be made into seasonal wreaths and sold to craftsmen, artisans, and craft stores. The bines have also been used for their fiber in paper and cloth production.

Production Considerations

Site selection and preparation

Planning a hop yard can be likened to that of planning an orchard because of the long-term nature of the enterprise. Careful thought and preparation needs to go into selecting and preparing a suitable site. Although hop plants may survive 25 years or more, growers often choose to replant after about 10 to 15 years as brewer demand changes.

Select a fertile, well-drained, sunny site with access to water for drip irrigation. Hops require plenty of water during the growing season, but it is critical to avoid wetting the plants themselves due to potentially devastating disease problems. While winds in the spring to mid-summer provide good air circulation and thus allow plant foliage to dry, winds later in the season can damage the ripening cones. Therefore, it is important to situate the planting with the prevailing winds to your advantage. If necessary, windbreaks can aid in preventing excessive cone injury.

Fields should be well-prepared the year prior to planting the yard. Have a soil test conducted and add lime, phosphorus and potassium as needed. Control perennial weeds. Have the soil tested for nematodes. Raised beds should be constructed if needed. The trellis system can also be set up at this time.



Trellis

Hops must be grown on a trellis system to obtain high yields. Bines growing vertically produce more flowers than those growing horizontally; thus, taller trellis systems result in more vertical plant growth and, therefore, more flowers. The overhead trellis system is most often used for commercial production, particularly in hop yards of more than one-half acre. This system can be constructed of metal, which will require fewer poles than a wooden system. Another advantage of the metal system is that the materials can be recycled when the yard is finally removed. Metal trellis systems also are lighter than wooden poles and easier to erect. A wooden pole system can also be used, and this elaborate 16- to 18-foot-high system consists of a number of wooden poles buried 3 to 4 feet into the ground approximately every five plants. Cedar poles are most frequently used; however, fir or pine poles treated with a preservative are also common. Because organic growers cannot use treated poles, the end buried in the ground is charred prior to installation to retard decay. The poles are connected by overhead wire cables that run both down and across the rows, although some growers just run the wires down the rows. Edge poles, which are generally thicker than interior poles, are installed at a 60- to 65-degree angle outward. Guy wires attached to edge poles are securely fastened to deep-set anchors in the ground. Approximately 55 wooden poles are required per acre.

Horizontal trellising involves the use of relatively short (8- to 9-foot) poles that are set in each planting hill. The hop bines grow vertically up each pole and then horizontally along the twine that connects the

tops of the poles. However, since hop cones are mainly produced on the vertically growing portion of the plant, lower yields can be expected with this trellising method.



A single pole trellising system that has been used with some success for backyard production and small hop yards is the tent training system. It consists of a central pole around which several hops are planted in a circle. Supporting twine attached to the top of the pole extends down to each crown, thus giving the appearance of a teepee. A dense clumping of cones is produced at the peak of the ‘teepee’ with this method.

Research into the production of hops on lower trellises is underway in several states. These systems require varieties that have been bred for their shorter bine growth. Several dwarf cultivars have been developed in Europe; however, there are currently few American dwarf varieties available for commercial production. Breeding programs in the Pacific Northwest are expected to result in additional varieties suitable for low trellis production.

Setting up the trellis system, which is quite time consuming, should be accomplished prior to planting. The poles can be installed with a hand or motorized auger. It is critical to place the poles deep enough to avoid trellis collapse. Wooden poles will need to be replaced approximately every five to eight years.

Cultivar selection

The research trial at the Robinson Center is evaluating yield, disease resistance, and other characteristics of several cultivars (Wye Viking, Willamette, Northern Brewer, Glana, Nugget, Columbus, Ultra, Cascade) in the current planting; Chinook, Cascade, Mt. Hood, Nugget and Newport were evaluated in an earlier trial. Cascade has produced the most cones in both trials; however, it is usually one of the least valuable varieties to the brewer, not due to poor brewing traits but because of the large volume of Cascade available on the market. Cultivars that have reportedly been grown successfully in backyard plantings in Kentucky include Willamette and Centennial. Summit is a dwarf hop bred for U.S. production; however, its perfor-

mance in Kentucky is unknown. Observations from local home growers, as well as research from neighboring states, may reveal additional cultivars suitable for trial plantings here. When selecting varieties, consider winter hardiness, disease resistance, and the

hop qualities required by the buyer. Choosing cultivars with high disease resistance to downy mildew and powdery mildew should be the first consideration for most producers, and particularly for organic producers. Growers should note that organic production of hops would be extremely difficult and unlikely to result in profitable yields in Kentucky, because of humid conditions and the limited availability of organic fungicides.

Propagation and planting

Hops are vegetatively propagated using rhizomes produced by the crown. Because only female flowers are used in brewing, only rhizomes from female plants are propagated and planted. Rhizomes may be purchased from a reputable supplier or removed from an established planting. New plants are started from 6- to 8-inch rhizome pieces bearing buds. Rhizomes can be potted-up in a greenhouse or hoop house prior to planting in the field. Some growers initially plant rhizomes in a nursery bed, then transplant them to the field the following year, but this is not as easy or successful as pots. Organic growers report difficulty in locating organic planting stock in the varieties they require.

Fields should be well-tilled and weed-free prior to planting. Hop rhizomes are planted in hills as early in the spring as possible. Some growers ditch the area between the rows instead of planting in hills; however, hilling is often easier. It is important to remove any possibility of standing water because hops are susceptible to root rots. Plant spacing preferences vary; however, yards are generally planted with approximately 900 plants per acre. Composted material should be added to each planting hole and plants watered well. Organic mulch surrounding the crowns can be used to control weeds and conserve soil moisture. Landscape fabric can also be used for weed control the first two to three years, but it will need to be removed after that as

the rhizomes need to be cut back yearly at that point.

In the overhead trellis system, two to four lengths of biodegradable twine are attached from the overhead cable to each crown as a support for the growing bines. Coir (made from coconut fiber) must be used for mechanical harvest because the harvester is adjusted to the tensile strength of the coir, and untreated sisal twine has also been used when hand-harvested. Once shoots have reached a height of 2 feet, several of the most vigorous shoots are selected for trellising and the remainder removed. Two bines will be trained to wind clockwise up each of the twine supports.

Crop management

Spring maintenance in an established hop yard consists of root pruning crowns, pruning out the diseased and less vigorous shoots, securing new twine to the cables, and training the selected bines. Spring is also the time when rhizomes can be divided to start additional plantings. In addition, the trellis itself could require annual maintenance, such as tightening cables.

Summer activities include scouting the yard regularly for pests and diseases, continually pruning out new shoots, managing weeds, and irrigating.

After harvest, all bines should be removed from plants prior to winter. A portion of uncut bines can remain intact for a while after harvest, which will allow time for additional photosynthesis until frost. The harvested bines can be shredded for mulch or composted; however, diseased bines should be destroyed.

Pest management

Mycosphaerella leaf spot has been diagnosed at the Robinson Center and Japanese beetles have been a serious pest for growers. Mites can be serious in hot, dry years.

The biggest threats are downy mildew and powdery mildew. Downy mildew and powdery mildew have a

history of causing serious damage in all the hops growing regions of the U.S. Variety selection combined with cultural practices, such as sanitation, avoiding heavy nitrogen fertilization, improving air circulation, and the use of fungicides may also aid management of these diseases. Fields with a history of the soil-borne



Verticillium wilt disease occurring on brambles, eggplant, potatoes, tomatoes or strawberry should be avoided. Other potential disease problems include Sclerotinia wilt and Cercospora leaf spot.

Hop plants and cones are attractive to a number of insect pests including aphids, spider mites, wireworms, root weevils, corn earworms, Japanese beetles, potato leafhoppers, and cutworms. Scouting to monitor populations can help the grower determine when and how often insecticides should be applied. The hop yard should be as weed-free as possible prior to

planting, and weeds need to be kept under control with mulch and/or regular cultivation.

Harvest, packaging, and storage

It normally takes three years for hops to come into full production. Large acreages of hops are mechanically harvested with specialized equipment. Small acreages are generally hand-harvested by removing individual cones as they mature. A ladder or cherry picker can be used when picking cones from trellised bines. Alternately, bines can be cut for a once-over harvest. UK researchers found that cutting the bines at shoulder height and pulling them down at harvest was quicker and easier than using a lift. Alternately, bines can be cut at the ground, which also entails removing hanging bines from the overhead wires. Cut bines are then carted to the harvest area where cones are removed.

Hop harvest season begins in August and ends in September, depending on the variety and location. Determining when the cones are ripe involves cone appearance, feel and smell. Hops are harvested when they are most aromatic and the cones are just beginning to feel dry. Color can be another indicator of ripeness:

hops fade in color from a bright green to a paler green as they mature. Sunburn, wind injury, and disease can cause the cones to become discolored or streaky; these cones are unacceptable. Ripe hop cones have a harvest window of approximately five to 10 days. Larger growers may want to use moisture analysis to help determine optimum harvest time. This also allows growers to provide oil and resin analysis to brewers buying their hops. Most growers aim for harvest when hops reach 20 to 25 percent dry matter.

Hop cones need to be dried for markets requiring a processed product and/or for storage. Curing is accomplished using good airflow, and occasionally an even supply of heat is needed. When heat is applied for drying, be mindful that high drying temperatures can damage hop quality. Screen racks placed in a dark room with box fans for circulation is one possible set-up for drying cones. Once dry, cones are cooled for packing/processing. To prevent the rapid deterioration that can occur in the presence of light, oxygen and warm temperatures, dried cones may be vacuum-packed in opaque bags and stored in a cooler (below 40° F). Larger breweries prefer baled or pelleted hops, which will require further processing.

Labor requirements

Hop production is very labor intensive. Labor is required for planting, root pruning, digging rhizomes, stringing bines, weed management, spraying for disease, insect management, and harvest. Many aspects of this enterprise, such as harvest, require skilled labor.

Labor needs per acre are approximately 30 hours for production, 70 to 150 hours for harvest, and 50 to 100 hours for packing/grading. Labor needs depend on the extent to which mechanization is used in harvest.

Economic Considerations

Hop production can be both profitable and risky. Much of the financial risk is linked to the trellising costs, including labor costs. The largest investments include the purchase and set-up of the trellis system, as well as the purchase of plant material. Other start-up costs include land preparation and installation of an irrigation system.

A 2012 North Carolina budget provided detailed production costs for small-scale (1/4-acre) hop production. This budget was updated for Kentucky using 2019 cost assumptions. The total initial investment for

1/4-acre was estimated at \$7,200 with annual production costs estimated at \$4,100. For a 1/4-acre hop yard, according to this estimate, a producer would need to obtain a price of about \$35 per pound for 400 pounds of wet hops to cover the annual cost of production and recoup all the establishment costs in the first harvest year. A link to this detailed production cost spreadsheet is included in the Selected Resources section below. Kentucky producers considering hop production on this scale can adjust this spreadsheet to reflect their expected costs, to determine whether hop production could be profitable.

Potential annual returns for 400 pounds of wet hops produced from 1/4-acre, by price:

\$5 per pound \$(2,104)*	\$15 per pound \$1,896	\$30 per pound \$7,896
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(Calculated from N.C. State 2012 budget, for 2019 Kentucky production; includes an annual charge of \$900 for hop yard establishment)

Michigan State University and the University of Vermont released detailed hop production budget estimates in 2016. These estimated establishment costs per acre at \$13,668 and production costs per acre at \$11,000 to \$15,500 per year, depending on yields. Net revenues from selling pelleted hops at \$12 to \$14 per pound would equal \$5,495 annually in the fifth year of production.

Selected Resources

- Robinson Center for Appalachian Resource Sustainability <http://www2.ca.uky.edu/rcars/>
- Hops 101 Webinar, with University of Kentucky researcher Dr. Shawn Wright <http://www.uky.edu/ccd/training/webinars/hops>
- Enterprise Budget: Small-Scale Commercial Hops Production in North Carolina (North Carolina State University, 2012) <https://www.ces.ncsu.edu/fletcher/programs/nchops/budget.html>
- Kentucky Hop Growers Alliance <https://www.kyhops.org/> and <https://www.facebook.com/kyhops>
- North Carolina Hops (North Carolina State University) <https://newcropsorganics.ces.ncsu.edu/specialty-crops/nc-hops/>
- Estimated Cost of Producing Hops in Michigan http://msue.anr.msu.edu/uploads/234/71501/MI_Hops_cost_of_production_Bulletin-E3236.pdf
- Hop Scouting Pocket Guide (Michigan State University, 2017)

https://www.canr.msu.edu/news/hop_scouting_flip_guide_now_available

- Post-harvest hopyard management (Michigan State University, 2017) https://www.canr.msu.edu/news/post_harvest_hop_yard_management
- The art and science of hop harvest (Michigan State University, 2015) https://www.canr.msu.edu/news/harvest_time_approaching_for_hop_growers_1
- Hop Cultivar Descriptions (USDA-ARS) <https://www.ars.usda.gov/pacific-west-area/corvallis-or/forage-seed-and-cereal-research/people/john-henning/cultindex/>
- Hops Trellis Construction (The Ohio State University, 2014) <http://southcenters.osu.edu/sites/southc/files/site-library/site-images/Hort/specialties/hops/Hops%20Trellis%20Construction%20FactSheet%202014.pdf>
- Hops (The Ohio State University) <https://southcenters.osu.edu/horticulture/other-specialties/hops>
- Purdue Hops Program <https://www.purdue.edu/dffs/hops/>
- Hops (Virginia Cooperative Extension) <http://www.ext.vt.edu/topics/agriculture/commercial-horticulture/hops/index.html>

- Hop Farm Management and Trellis Construction (Michigan State University) presentation https://www.canr.msu.edu/uploads/234/78941/Hop_Intro_-_2_Hopyard_Preplant_Preparation_and_Setup_-_Dan_Wiesen.pdf
- Oregon Hop Commission <http://oregonhops.org/index.html>
- Hops: Organic Production (ATTRA, 2005) <https://attra.ncat.org/attra-pub/summaries/summary.php?pub=87>
- Starting Up Small-Scale Hops Production (eX-tension, 2011) video <http://www.extension.org/pages/60945/starting-up-small-scale-organic-hops-production>

Commercial websites listed in the resources are provided for information purposes only and their inclusion does not represent an endorsement of the company or its products by the University of Kentucky.

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