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Hops Production in Arkansas

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Overview:

The hop (*Humulus lupulus*) plant is a member of the family Cannabaceae, and the flowers (cones) of the plant are used to add aromatic and bittering flavors to beer. The plant is a vigorously climbing herbaceous perennial with an overwintering rhizome and annual bines (Miller, 1958). Three to five bines per plant may grow more than 1 foot per day and reach a height of more than 20 feet during the summer. Bines are different from vines in that the stems grow by wrapping themselves on a supporting structure, whereas a vine has tendrils to anchor the plant as it climbs. The bines can be trained up twine on a trellis system or any supporting structure in a hopyard (Perry, 2008; Getty, et al. 2015; Sirrine, 2017; Hiller, et al. 2019). The stems and leaves of hops have hooked hairs, called trichomes, that help them attach as they climb.

Hops plants are dioecious, meaning they have separate male and female plants. The female flowers (cones) are used for brewing beer and contain lupulin glands that consist of alpha and beta acids and essential oils. Only female hops plants are grown commercially. The flowers of male plants produce pollen which, through wind pollination, fertilize the female flower, resulting in seeds in the harvested hop cone. Seeds reduce hop cone quality, and lipids associated with seeds can impart off-flavors in beer production (Boultron, 2013). For this reason, all male plants should be removed from commercial hopyards. Flowers develop into a mature hop cone ready for harvest in about 30-50 days.

The flowers are produced at the ends of side lateral branches that form off the bines. These lateral branches form near the summer solstice. To flower the plant needs short daylengths (less than 15 hours). In northern areas long days in mid-summer allow the bines to grow very tall before the days shorten and the plants start to flower. Hops are primarily produced between the 35th and 55th parallel due to their daylength requirements (Hiller, 2019). Commercial hops production in the United States is primarily in the Pacific Northwest. Arkansas lies between the 36th and 33rd parallels, which likely limits the yield potential for hops cultivars typically grown in the United States. Additionally, Arkansas has a higher incidence of disease than the dry northwest region. Hops do not have a winter dormancy requirement; however, plants may require a six-week period of winter temperatures below 40°F to achieve optimum yields (Bauerle, 2019).

Despite geographic and climatic limitations, hops can be successfully grown in Arkansas and may command a good price by brewers interested in selling locally derived products in the expanding craft brewing industry. The production cycle for hops in Arkansas (Figure 1) and basic production practices will be described in this fact sheet.

Site Selection and Preparation:

Hops grow best in well-drained fertile, sandy loam soils with a pH between 6.0-7.0. The hopyard should be situated in an area with good air circulation to reduce the incidence of disease. However,

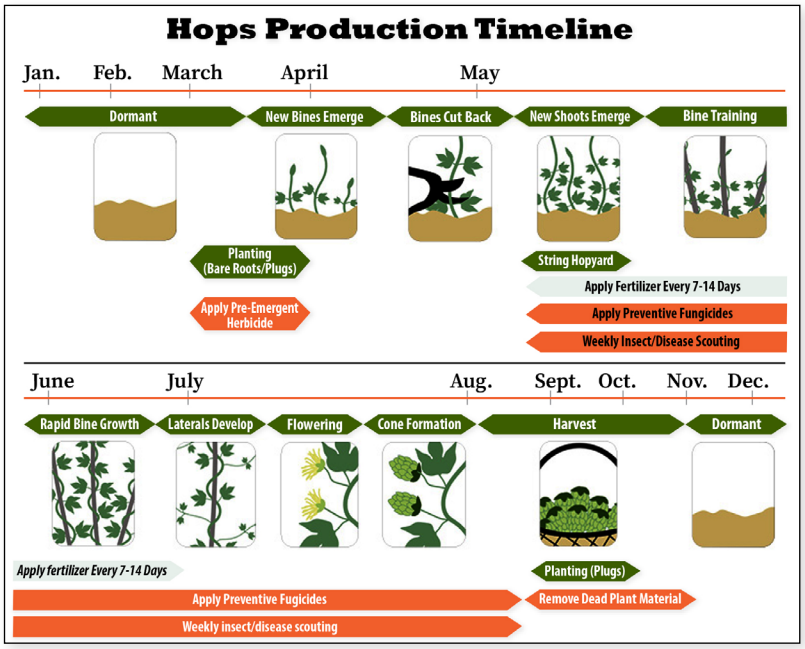

Figure 1. Hops plant growth and cone production timeline in Arkansas.

due to the height of the trellis, protection from strong winds should be a consideration to reduce damage to the plants, cones, and trellis. The hopyard should be at least 100 feet from the nearest tree line to reduce shading from the trees on hop plants. Rows should ideally be oriented north and south, and land with steep slopes should be avoided.

The area chosen for establishment of the hopyard should be tilled to loosen the soil, perennial weeds should be eliminated, and the soil pH should be amended. Site preparation should begin at least six months prior to trellis construction and establishment of the planting. Grade the field to ensure good drainage across the field.

Irrigation

Hops require a consistent supply of water during the growing season to support their rapid growth, but the plants cannot withstand flooding (Bamka, 2017). Plants may need several gallons of water per day during the height of summer. Drip irrigation is the best option for irrigating hops to maintain moisture in the shallow root zone and ensure foliage remains dry to reduce disease potential. One line of hard-sided tubing per row is common, and recommendations suggest in-line emitters spaced at 2 feet with an output per emitter of around 0.42 gallon per hour (GPH).

Trellis

A trellis is used to train the long bines upward to improve airflow through and sunlight penetration into the plant canopy. The trellis should be installed prior to planting and should be designed to last 20-30 years. The most common trellis type for hops is a V-trellis or an I-trellis. The V-trellis is commonly used in commercial, large-scale production of hops and generally requires a 3-foot plant spacing. The I-trellis, also known as an In-line V, is more suitable for a small-scale production, and plant spacing should be 2 to 4 feet. Rows should be placed at a distance of 10 to 15 feet. The I-trellis is made of single rows of tall wooden poles with one or two heavy-gauge metal wires suspended between the top of the poles. These wires should be anchored at the end of the rows to the ground with earth anchors (Sirrine, et al. 2010). Coconut fiber, jute, bailing cord, or poly support twine is hung from the top wire to the ground in the late spring upon which the bines will be trained upwards. A strong twine or cord should be used as the plants at full maturity will be heavy (up to 35 lbs. per plant). In major regions of commercial production, the recommended minimum height of the trellis is 16 to 20 feet. Due to labor intensive practices and costs associated with typical trellis heights, shorter trellis heights can be used but may impact cone production. In Arkansas, we modified an existing grape trellis, which was already designed to support plant weight and withstand high winds, for hops production. Modification of a grape trellis involved increasing the height of existing trellis poles from 6 feet to 12 feet or more.

Cultivar Selection

Public breeding programs have released hops cultivars that are publicly available and can be purchased at a nursery and grown by anyone. Private breeding programs have released cultivars that are widely used in craft brewing (examples: Citra®, Mosaic®, and Simco®) but are not available to most growers and require a license to grow. Choosing hop cultivars with aroma and bittering characteristics that are in demand by brewers will be key to the success of a commercial hopyard. A marketing plan and grower-buyer contacts should be established before planting hops, as brewers are usually looking for certain cultivars or hops with specific qualities. Hops can be added during or after the brewing process, but are generally divided into two broad categories based on their uses during brewing:

- Aromatic hop - impart aroma and flavor to beer, but typically have a low bittering content
- Bittering hop - have high levels of acids that impart a bitter flavor to beer

This fact sheet will discuss only publicly available cultivars. Growers should conduct small trials of cultivars before committing to a large operation to determine the best-performing cultivars for their climate, soil type, and day lengths. The cultivars listed here are what we have evaluated in Arkansas (Table 1).

Planting

Hops can be planted as dormant rhizomes in late winter or early spring or as live plug plants (Figure 2) in the fall and spring. Rhizomes should be placed at a depth of 1-2 inches from the soil surface with the buds facing upward. Plug plants vary in size, and small transplants will require extra care to ensure good establishment. Live plug plants should be planted after the last date of frost in the spring and at least six weeks before the first frost in the fall.

Plant spacing should be 2 to 5 feet between plants. The ideal spacing depends on the cultivar and trellis system. The goal for plant spacing is to maximize air and light penetration into the canopy and hopyard (Dodds, 2017). Cultivars like Willamette and Chinook are large-plant cultivars planted at a minimum of 45 inches apart. Cascade and Centennial are usually spaced 36 inches between plants because these cultivars produce shorter laterals (Great Lakes Hops, 2019).

Figure 2. Hops plug plants in a tray prior to planting.

After planting, the plants or rhizomes should be watered thoroughly to soak the soil and establish the roots. Young plug plants are prone to drying out until their root system is established, but care should be taken to prevent flooding the hopyard.

Cultural Practices

In the spring, early bines that emerge may be weak, hollow stemmed, or infected with disease (downy

Table 1. Cultivars of hops evaluated at the University of Arkansas System Division of Agriculture Fruit Research Station, Clarksville, AR (2019-2021)

Cultivar	Typical alpha and beta acid content	Characteristics
Cascade	**Alpha acids=4.5-7.0% Beta acids=4.8-7.0%**	Used as an aroma hop. Medium strength aroma profile with citrus, grapefruit, floral, and spicy notes. Has potential for well-balanced bittering. One of the most popular hops used in U.S. craft brewing and widely grown. Medium to low alpha acid levels. This cultivar has performed well in our trials in Arkansas for both yield and plant growth.
Cashmere	**Alpha acids=7.7-9.1% Beta acids=3.3-7.1%**	Used as an aroma or bittering hop. Complex and intense fruit profile of citrus, peach, and melon. Has secondary notes of coconut, pineapple, and herbs. Medium alpha acid levels. This cultivar has yielded moderately well in our trials in Arkansas.
Canadian Red Vine	**Alpha acids=<5% Beta acids=5.0-6.0%**	Mainly used as an aroma hop in combination with other hops. Can give a harsh aftertaste in beer production if used alone. Fruity and citrus aromas. Medium alpha and beta acid levels. Performed well in trials in the mid-Atlantic. The cultivar is currently being tested in Arkansas.
Centennial	**Alpha acids=9.5-11.5% Beta acids=3.5-4.5%**	Used as an aroma hop. Medium intensity aroma with citrus and floral profiles. One of the most popular hops used and grown in the US. Medium alpha acid levels. This cultivar has performed poorly in plant growth and yield in our trials in Arkansas.
Crystal	**Alpha acids=3.5-5.5% Beta acids-4.5-6.5%**	Used as a bittering hop, mostly in lager, wheat, and Belgian ales. Used some in craft brewing in IPA hop loads. Mild, sweet, and delicate aromas with flora, spice, and citrus profiles. Medium alpha and beta acid levels. This cultivar has yielded moderately well in our trials in Arkansas.
Nugget	**Alpha acids=11.5-14.0% Beta acids=3.0-5.8%**	Used mostly for its smooth and clean bitterness but can also be used as an aroma hop. Mild and sweet aroma with fruit and herb (ginger, rosemary, fresh oregano) profiles. High alpha acids and medium level beta acids. This cultivar has performed poorly in plant growth and yield in our trials in Arkansas.
Zeus (CTZ)	**Alpha acids=14.0-16.0% Beta Acids=4.0-5.0%**	Used as an aroma and bittering hop. Intense hoppy aroma with spicy herbal and floral aromas. High alpha acid levels and medium beta acid levels. This cultivar has performed well in our trials in Arkansas for both yield and plant growth.

Note: Alpha and beta acid ranges from Hieronymus, 2012.

mildew), so it is common to cut down all early emerged bines in mid to late April. This process is referred to as pruning. Bines should be cut back to the soil level with a sharp knife or hand pruners. The date of pruning and training impacts hops cone yield in the North and Northwestern United States, however recommendations for the Southeast have not been developed (Sirrine, 2017). Currently, we recommend pruning bines in Arkansas around May 1 – May 5.

Figure 3. Hops plant in mid-May with three bines trained up twine.

Bines that emerge after this pruning will be selected for training. Once the new bines have reached 2 feet in height, two to three of the most vigorous bines are each trained individually in a clockwise manner up a single strand of twine (Figure 3). Avoid breaking or damaging the tip of the bines as this will slow growth. The number of bines to train will depend on the trellis system used (Figure 4). As the bines reach a height of 4 to 6 feet, the bottom 24-36 inches of the plant should be carefully stripped of leaves and laterals. This removal allows for better air circulation in the hopyard, but also aids in the prevention of foliar diseases and management of the weeds.

Root pruning may be practiced on established plantings to keep rhizomes from competing with one another. Cutting around the main rhizome in March or April is sufficient to contain aggressive plants and can result in vegetative material that can be used for plant propagation. Crown cutting or scratching is another means of pruning the underground growth and may have an impact on reducing disease pressure and increasing crop vigor (Sirrine, 2018). Crown cutting and scratching involves scraping off the top of the crown in the early spring. We have not yet developed recommendations for root and crown pruning in Arkansas, but established hopyards should look into these practices as a way to control crop development and to potentially reduce disease pressure.

Fertilization

Nitrogen (N) is an essential plant nutrient required for proper leaf and hop cone production and development. Fertilizer should be applied in multiple applications from May through June to support plant growth.

Figure 4. Hops plants trained on a 12-foot-high modified grape trellis in Clarksville, Arkansas.

The period of rapid nitrogen uptake for hops is during mid-June to mid-July as leaf area and hop cone development is increasing. During this stage, N uptake occurs at a rate of three to four lbs. of N/acre/day (Sullivan, et al. 1999). Current recommendations suggest that a total of 100-150 lbs. of N should be applied in a split application each season. After early July, fertilizer application can be stopped. Phosphorus (P) demands are quite low on hops and only 20-30 lbs. of P are recommended per season. Potassium (K) needs are estimated at 80-150 lbs. per season. For small-scale hops growers, one tablespoon of 15-15-15 sprinkled every two weeks around the base of the plant from late April to early July should be sufficient.

Pests and Pest Management

The most common pests observed on hops in Arkansas have been caterpillar pests, two-spotted spider mites (*Tetranychus urticae*), downy mildew (fungal disease caused by *Pseudoperonospora humuli*), and weeds. The most common caterpillar pests observed were question mark caterpillars (*Polygonia interrogationis*) and yellow-striped armyworms (*Spodoptera ornithogalli*). Spider mites and caterpillar pests feed primarily on leaves and reduce the plant's ability to support hop cone production and development. Spider mites can become a problem during hot and dry periods and can directly damage cones when not controlled. Downy mildew can affect both the hop cones and plant leaves and is common during periods of wet weather. Summer and winter weeds that grow in the 3 feet around the base of the plant will compete directly with the hop rhizomes' water and nutrient uptake.

Mulching or herbicides should be used to keep a 2- to 3-foot-wide weed-free strip at the base of the plants. We do not currently recommend the use of black land-

scape fabric for weed control; in our trials in Arkansas it resulted in stunted plant development possibly due to excessively warm soil temperatures under the fabric. Plants should be scouted weekly for insect and arthropod pests. Insecticides should be utilized when pests are above threshold. Preventative fungicides should be used every seven to 10 days to deter downy mildew infection. Recommendations for approved pesticides, including organic options, can be found in the Southeastern U.S. Vegetable Crop Handbook (updated annually).

Harvest

Hops cone harvest occurs from early-August to mid-September depending on the cultivar and location in the United States. Hops cones will start out green in color and turn brown as they mature (Figure 5). For highest quality, cones should be harvested when they are still green, and the lupulins inside the cone have become a golden color (Figure 6). Cones are ready to harvest when they become light, are soft to the touch, feel dry and papery, and have a floral and hoppy aroma (Getty, et al. 2015).

Figure 5. Hop burr of a female flower.

A method used commercially to determine if hops are ready for harvest is to determine percent dry matter (Adams, 2018). A random sample of 100 to 150 cones from each cultivar are collected from the hopyard and weighed to get the wet weight. Then, the cones are placed in a food dehydrator and dried for eight to 10 hours and weighed again.

Percent dry matter is calculated by dividing the dry cone weight by the wet cone weight and multiplying by 100 to get the percent [(Dry cone weight ÷ Wet cone weight) x 100 = % Dry Matter] (Adams, 2018).

Figure 6. Mature hop cones on a hop plant.

The target dry weight to harvest hops cones is 20-25% dry matter (80-85% moisture). Dry weight can be converted to percent moisture by subtracting the percent dry matter from 100.

In Arkansas, we have found that after planting plug plants in the fall, hops can be produced on certain cultivars the following summer, but the quantity of hops is low. If cones are produced in the first year, the bines should not be cut back to the crown until the foliage begins to die back. Leaving the above-ground growth helps the plant store carbohydrates in the roots for the next year's growth (Getty, et al. 2015).

People harvesting the hops should wear gloves and long-sleeved shirts as the trichomes on the bines may cause skin irritations. Because of the height of the trellis, a grower may require tall ladders or apple-picking platforms to reach the top of the trellis. Harvesting hops by hand is a labor-intensive process; it can take a single person one hour to hand harvest one pound of hops. Harvest logistics should be carefully considered, especially the first year.

Small-acreage hops growers may decide to harvest the hops on a weekly basis as they mature, but in larger operations this is not economically feasible. As previously mentioned, once the plants are 2 to 3 years old, the bines can be cut from the trellis for harvest and hop cones can be removed by hand or by machine to increase efficiency. This allows for easier harvesting, but also helps remove any plant debris from the field to help with pest management. After harvesting the hops, it is important for the grower to properly dry, package, and freeze the hops to maintain quality for the brewing process.

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