UF IFAS Extension UNIVERSITY of FLORIDA

UF/IFAS PEER REVIEWED HS1354

Hop Yard Establishment and Trellis Construction in Florida[1]

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Introduction

Hops (*Humulus lupulus* L.) are an essential ingredient in brewing that adds bitterness and flavor to beer. Driven by the recent craft beer movement, the US hop production volume and acreage increased by 62% and 78%, respectively, from 2000 to 2019 (US Department of Agriculture–NASS 2019a). The production acreage in 2019 (55,800 acres) was the highest on record since 1915 (US Department of Agriculture–NASS 2019a). The Pacific Northwest (i.e., Washington, Oregon, and Idaho) supplies nearly 90% of the hops produced in the United States (International Hop Growers' Convention (IHGC) 2018; US Department of Agriculture–NASS 2019b). Currently, hop production is expanding into nontraditional hop-producing states, including Colorado, California, Minnesota, Virginia, and North Carolina (Hop Growers of America 2019; Siegle 2020). In Florida, however, commercial hop production is almost nonexistent.

According to the Brewers Association (Brewers Association 2018), the number of craft breweries in Florida increased from 45 in 2011 to 285 in 2018, 95 of which are in the Tampa Bay area. The economic impact of Florida's craft beer industry is estimated at above $3 billion. The first research hop yard was built at the UF/IFAS Gulf Coast Research and Education Center (GCREC) in 2016 (Figure 1A) to study hops as an alternative crop in Florida. In 2019, the hop yard expanded from 0.8 to 2.2 acres (Figure 1B). An interdisciplinary team of more than 10 researchers specializing in plant genetics, plant physiology, plant pathology, entomology, nematology, and economics work on hops at GCREC. Based on our experience with the research hop yard, we prepared this article aiming to provide guidelines and considerations for building hop yards in Florida.

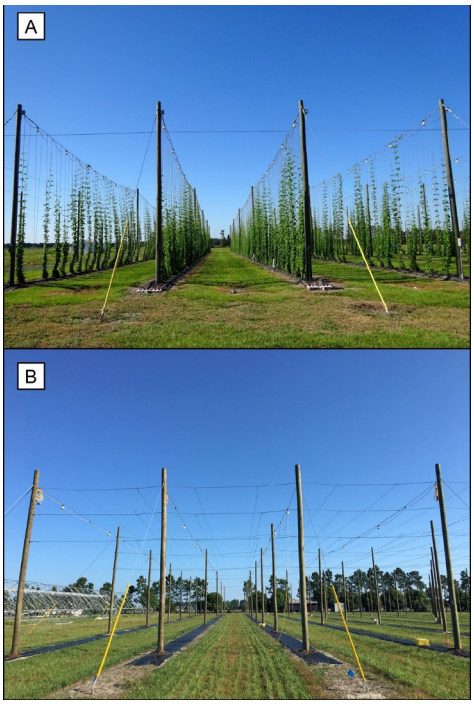

Figure 1. The UF/IFAS GCREC research hop yard: A) straight trellis, and B) V-trellis.
Credits: Shinsuke Agehara, UF/IFAS

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Growth Characteristics and Climatic Requirements

Hops are perennial, twining herbaceous plants in the Cannabaceae family. Hops are dioecious, meaning individual plants are either male or female. Male hop plants produce male flowers and pollen, whereas female hop plants produce female flowers, which develop into cones or strobiles. Hop cones are harvested from female plants and used in brewing beer.

Hop plants develop twining stems called bines. Unlike vines that climb using tendrils or other specialized tissues, bines twine up with the help of stiff hairs along their stems. Hop bines grow very rapidly, with a peak growth of up to 12 inches a day (Rebecca 2004). Because of these growth characteristics, commercially grown hop plants are trained to grow up on a high trellis, typically 12–18 ft tall (Dodds 2017). Commercial hops are harvested by cutting bines at the base. Crowns will remain in the ground and stay dormant during winter. New shoots will develop from the crown and rhizomes in early spring.

Flowering of hops is triggered by shortening day length (Thomas and Schwabe 1969). In the northern hemisphere, hop plants typically bloom in early to mid-July when day length becomes shorter than 16 hours (Iskra et al. 2019). Hop plants are most productive when day length ensures good vegetative bine growth before flowering is induced. Day length is a function of latitude, and the generally accepted latitude range for commercial hop production is 35° to 55° north or south of the equator (Dodds 2017). The world's two largest hop production regions are Hallertau in Germany and Yakima in the United States, located at 48.6°N and 46.6°N, respectively.

In Florida, the latitude is below 31°N, and the maximum day length does not reach 15 hours. Therefore, hop plants grown under Florida's natural day length tend to flower prematurely, limiting their bine growth (10–12 ft) and cone yields (Agehara 2018). Artificial lighting can be used to create long day conditions by either day length extension or night interruption. In our hop yard, we have demonstrated that day length extension using LED lamps is highly effective in inhibiting premature flowering.

Hop Yard Construction

Step 1. Site Selection

Site selection is one of the most important decisions determining the success or failure of hop yard management, considering the high establishment costs and the longevity of hop plants. In a well-managed commercial hop yard, hop plants may remain productive for up to 20 years (Michigan State University 2015). The ideal layout is a north-south row orientation with a south-facing slope. This orientation captures maximum sunlight and allows for even light distribution across the hop yard as the sun moves from east to west across the sky. A south-facing slope also maximizes the exposure to sunlight, thereby warming the soil faster and improving the drainage.

Soil testing is strongly recommended to determine the soil type, soil pH, and basic nutrient needs. Hops will grow in a variety of soils, but ideal soils are well-drained, deep, and sandy loam soils (Gent et al. 2019). Good drainage is critical for hops, especially in Florida, where heavy rains occur frequently during the summer. The optimum soil pH for hop production is 6 to 7 (Gent et al. 2019). In our hop yard, iron is the most common micronutrient deficiency observed, especially during the initial growth stage. Some hop cultivars are highly susceptible to root-knot nematodes, which are common in Florida's soils (Desaeger 2018). Therefore, nematode testing is also recommended to avoid a site with high nematode populations.

Strong winds can damage hop bines by twisting or sandblasting them. In our hop yard, we have observed mechanical damage on bines and cones following heavy winds and rain. The infection of several *Fusarium* species was also found, which was typically associated with mechanical damage on lateral branches. We recommend establishing a windbreak to minimize wind damage and the risk of disease infection. Other vital factors for site selection include marketing plans and availability of high-quality irrigation water, electricity for supplemental lighting, and labor.

Step 2. Field Preparation

Before bed preparation, soil pH should be adjusted between 6 and 7. See https://edis.ifas.ufl.edu/ss651 for lowering soil pH (Mylavarapu et al. 2019) or https://edis.ifas.ufl.edu/vh024 for increasing soil pH (Stephens and Liu 2019). For basic guidelines on soil test interpretations and fertilizer calculations, see https://edis.ifas.ufl.edu/hs1206 (DeValerio et al. 2018).

Typical row spacing in a hop yard ranges from 12 to 15 ft. Choose the row spacing based on the size of your farm equipment that will be used in your hop yard. If your soil is low in organic matter, we recommend incorporating compost into the soil. The soil at GCREC is Myakka fine sand, which typically has sand and organic matter contents

of >95% and <1.5%, respectively. We added about 2 inches (about 80 tons/acre) of compost primarily derived from yard waste (Southeast Hillsborough County Landfill, Lithia, FL) to one half of our hop yard, and plants grew much better with compost compared to those that were fertilized only via fertigation. Because hops develop extensive root systems with high water demands (Nakawuka et al. 2017; Evans 2003; George 2001), we recommend making shallow beds and installing two lines of drip tubing per row (Figure 2A). In our hop yard, we installed heavy-wall drip tubing (0.26 gph, 12" emitter spacing, 0.62" internal diameter, 0.045" wall thickness) that can typically last over 20 years. Making a gentle slope toward the middle of each aisle (between beds) is important for good drainage. For weed control, we recommend covering the ground with landscape fabric and establishing grasses in the row-middles (Figure 2B). Applying a fumigant before planting is a good preventative measure to ensure proper establishment of newly planted hops (Desaeger 2018).

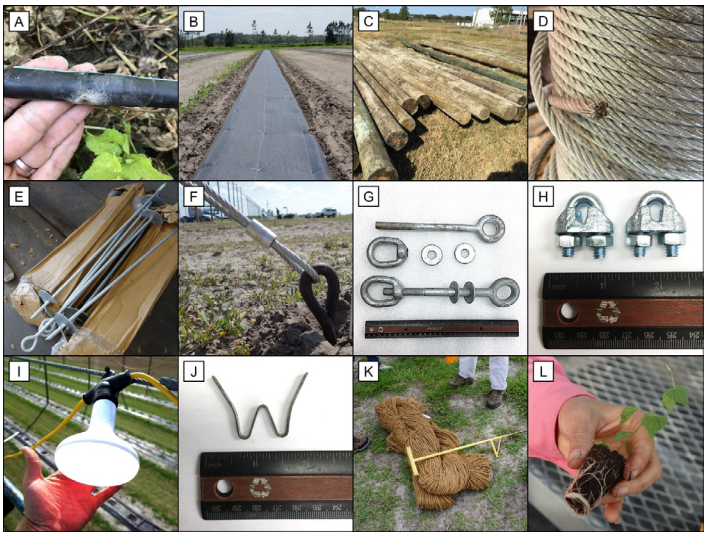

Figure 2. Materials used to establish a hop yard: A) drip tubing, B) landscape fabric, C) pressure-treated poles, D) 5/16" galvanized cables (7x19 strand type), E) anchors, F) an anchor cable secured by an aluminum sleeve, G) eye bolts and eye nuts, H) cable clamps for 3/16" cables, I) an LED light bulb installed on a 5/16" cable, J) a W-clip for twine installation, K) coconut coir twines and a W clip applicator for twine installation, and L) a tissue-cultured hop seedling.
Credits: Shinsuke Agehara and Aleyda Acosta-Rangel, UF/IFAS

Step 3. Trellis Construction

Constructing a durable trellis is essential to hop production. In Florida, the trellis design and materials used must withstand not only the weight of hop plants but also strong winds and heavy rainfall. Figure 2 shows the materials used to build our hop yard.

Figure 3 illustrates the two trellis designs installed in the GCREC hop yard: straight trellis and V-trellis. The straight trellis has only one cable per row, which is for installing both LED lamps and twines. By contrast, the V-trellis has three cables per row (Figure 3A): the middle cable is used to hang LED lamps, and the other two are used to install twines. The V-trellis also has cross-cables. Although the V-trellis requires higher material costs than the straight trellis (see the "Material Costs" section below), its "V" design makes maximum use of growing space (Figure 3B). Evaluation of hop plant growth and yields under the two trellis designs are in progress.

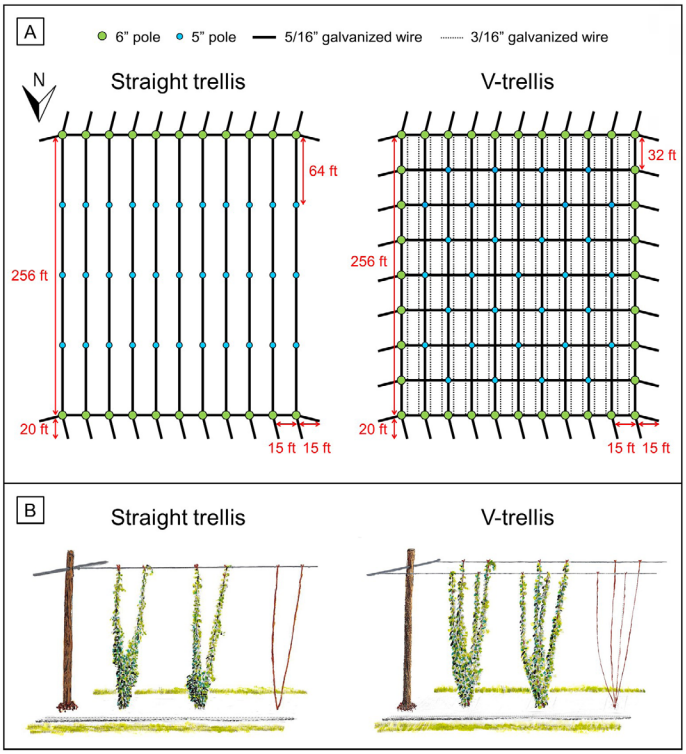

Figure 3. Straight trellis and V-trellis designs used for the GCREC hop yard: A) trellis layouts, and B) trellis diagrams.
Credits: Shinsuke Agehara and Aleyda Acosta-Rangel, UF/IFAS

Pressure-treated poles are recommended because they are more resistant to natural decay and last longer than untreated lumber. Our perimeter poles are 6 inches in diameter, and inner poles are 5 inches in diameter. All our poles are 25 feet in length and set 5 feet in the ground. In commercial hop yards, it is common to angle perimeter poles to increase the holding power (Arnett 2018). Although all our poles were installed perpendicular to the ground for making the future expansion easier (Figures 1 and 4C), no structural damage has been observed.

Common trellis cables used in commercial hop yards are galvanized steel cables with strand types of 1×7 (one strand with 7 wires) or 7×19 (7 strands with 19 wires in each strand) (Arnett 2018). The strength of a galvanized cable depends on its grade, diameter, and strand type. The galvanized cables used in our hop yard are 5⁄16" or 3⁄16" in

diameter with a strand type of 7×19 (Figure 2D). Cables with different diameters were used depending on the trellis design (Figure 3A). Trellis cables were strung through pre-drilled holes that were made using a ⅝" drill bit 2 feet from the top (Figure 4B). Cables were strung also from perimeter poles to ground anchors.

Figure 4. The hop yard establishment process at the UF/IFAS GCREC: A) installation of landscape fabric and drip tubing, B) drilling a hole on a 6" pole, C) pole installation using a crane, D) installation of an anchoring cable, E) installation of 5⁄16" cables, F) installation of 3⁄16" cables for a V-trellis, G) LED lamps installed on 5⁄16" cables, H) cutting a planting hole on landscape fabric, and I) a newly planted hop seedling.
Credits: Shinsuke Agehara and Aleyda Acosta-Rangel, UF/IFAS

Step 4. Installation of Supplemental Lighting

Using supplemental lighting to ensure good vegetative bine growth before flowering is critical to successful hop production in Florida. In the GCREC hop yard, we installed LED lamps (GreenPower LED flowering DR/W, Philips) on the main trellis cables (Figure 5A). Our current recommendations are to space LED lamps 20 feet apart in a staggered pattern (138 lamps per acre), and to operate them for 6 hours per night (>17 hours of day length) over 7–9 weeks or until plants develop sufficient bine growth. Plants normally begin developing flower buds within 5 days after lights are turned off.

We are currently evaluating the optimum number of LED lamps required to manipulate flowering. We spaced them 9 and 20 feet apart in 2018 and 2019, respectively, and it was proven that 20-foot spacing is as effective as 9-foot spacing.

Figure 5. Hop plants grown with supplemental lighting at the GCREC hop yard: A) hop plants illuminated by LED lamps at night, and B) hop plants reaching the top cable and producing many cones about one month after turning off LED lamps.
Credits: Shinsuke Agehara, UF/IFAS

Step 5. Planting

Establishing a hop yard with clean plant materials is essential for successful hop production. Florida does not have a historical record of typical hop pathogens like hop downy mildew (*Pseudoperonospora humuli*), hop powdery mildew (*Podosphaera macularis*), or hop latent virus, all of which are host specific (Vallad et al. 2019). Because Florida's climate is highly conducive to the spread of diseases, it is critical to avoid the possibility of introducing these pathogens into the state. For this reason, Florida growers are strongly encouraged to use tissue-cultured plants that are certified virus-free. We do not recommend using rhizomes, which may already be infected with fungal or viral pathogens. Our hop yard was established using tissue-cultured plants from a local nursery (Agri-Starts, Apopka, FL). We made 12"×12" planting holes on the landscape fabric and planted two seedlings per hill. Twines must be installed before or immediately after planting. Based on our cultivar trial, 'Cascade' is the most promising cultivar in terms of yields, cone quality, and nematode tolerance (Desaeger 2018).

Material Costs

Hop yard establishment costs depend on the trellis design, materials used, and resources that growers may have, such as farm equipment and infrastructure. Table 1 shows the

per-acre costs of materials used to build our hop yard with two different trellis designs. The total material cost for our hop yard establishment was $15,780 for a straight trellis and $18,687 for a V-trellis. Note that these costs include neither shipping fees, which may cost up to $1,000 per acre, nor labor costs. The main cost difference lies in the V-trellis requiring about 20% more poles and 370% more cables than the straight trellis. Most commercial hop growers in Washington use 18-foot tall V-trellises (Dodds 2017). The subtotal cost for trellis constriction materials for our V-trellis was $8,225 per acre, which was $1,230 higher than that for a similar trellis in the Pacific Northwest ($6,995) (Washington State University 2016). The major cost differences derived from the poles and cables. The total material cost for our hop yard establishment was relatively high because of some specific items required only in Florida. Among such items, the installation of supplemental lighting is the largest expense, totaling $5,398 per acre. The cost can increase significantly depending on the availability of farm electricity supply (e.g., transformers).

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Table 1. Material costs for establishing a 1-acre hop yard with a straight trellis or a V-trellis in Florida.[1]

Material	Unit price	Quantity		Total cost	
		Straight trellis	V-trellis	Straight trellis	V-trellis
Land preparation					
Drip tubing (1000 ft/roll)	$150.00	6	6	$900	$900
Fine pine bark mulch (2 cf/bag)	$2.50	44	44	$110	$110
Landscape fabric (300 ft/roll)	$69.19	11	11	$761	$761
Miscellaneous irrigation supplies				$500	$500
Subtotal				**$2,271**	**$2,271**
Trellis construction					
6″ pressure-treated poles	$76.50	22	36	$1,683	$2,754
5″ pressure-treated poles	$58.50	33	31	$1,931	$1,814
5/16″ galvanized cables (5,000 ft/roll)[2]	$0.36	3,900	5,300	$1,404	$1,908
3/16″ galvanized cables (5,000 ft/roll)[2]	$0.17	0	5,300	$0	$901
5/8″ eye bolts	$5.24	26	40	$136	$210
5/8″ eye nuts	$3.47	26	40	$90	$139
5/16″ aluminum oval sleeves	$0.40	78	120	$31	$48
3/16″ cable clamps	$1.10	0	44	$0	$48
5/8″ anchor rods	$7.59	26	40	$197	$304
Miscellaneous field supplies				$100	$100
Subtotal				**$5,573**	**$8,225**
Supplemental lightening					
LED lamps	$23.25	138	138	$3,209	$3,209
Light strands (100 ft)	$66.36	33	33	$2,190	$2,190
Subtotal				**$5,398**	**$5,398**
Planting					
Coconut coir twines (75 lb, 3,200 twines/bale)[3]	$0.12	1,848	3,696	$222	$444
W clips (1000 units/box)	$33.00	1	2	$33	$66
W clip applicator	$65.00	1	1	$65	$65
Tissue-cultured hops seedlings[4]	$1.20	1,848	1,848	$2,218	$2,218
Subtotal				**$2,538**	**$2,793**
GRAND TOTAL				**$15,780**	**$18,687**

[1] The hop yard layouts are illustrated in Figure 3.
[2] The unit price is per foot.
[3] The unit price is per twine.
[4] The number of seedlings per acre is 1848 (924 hills/acre × 2 seedlings/hill). Hills are spaced 3 feet apart within a row (84 hills in a 256 ft row).