

Hops on a Quarter-Acre

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Figure 1. Quarter-acre hop trellising with “V” style training of hop plants.

This publication presents information on how to develop a quarter-acre hop yard, suitably sized to explore the unique production methods associated with this specialty crop. Farmers interested in growing hops should gain knowledge about hop plant growth and development, its culture, common pests and diseases, and harvest considerations. Using information in this publication, farmers should be able to experiment with hop production and harvesting so that they can develop a measured vision for future production opportunities.

Introduction

Farmers are seeking ways to improve farm income through the production of high-value specialty crops. Hop



Figure 2. Quality trellis supplies will provide a long-lasting hop trellis system.

is one such crop that has received much attention through the media, given consumer interest in craft and home beer brewing. Experienced farmers, gardeners, and everyday “beer enthusiasts” want to grow hops as they see the potential for income. This crop is unique in its growth, cultivation, harvest, and ultimately its post-harvest handling. Interested growers should start by experimenting with a small number of hop plants, so they can better understand plant growth and cultivation before expanding to commercial production.

Trellising

Hop cultivars grown commercially are typically trained on a tall trellis system 18–20 feet above the ground. The trellis

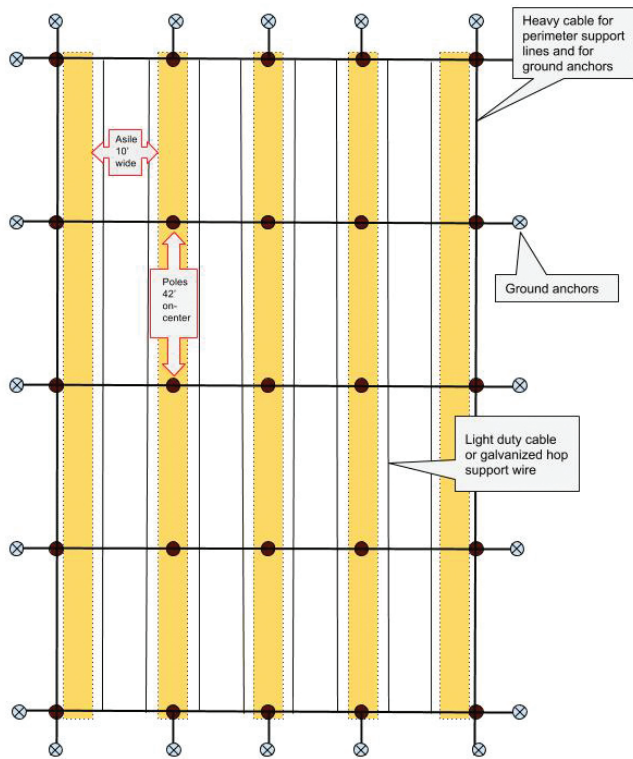


Figure 3. Quarter-acre trial plot showing planting beds, poles, anchor supports, main cable, and hop support wire placement.

comprises either a row of poles that suspends a heavy-gauge wire across the top with ropes hanging down to the individual plants or a collection of poles with cables and wires that create an overhead grid, which allows for a “V” training system for each hop row (Figure 1). In an effort to lower hop production costs, low trellis designs are being researched, but will not be discussed in this publication.

It is important to note that trellis construction is one of the most important aspects of developing a hops planting. The trellis design and materials used (Figure 2) must be durable enough to withstand the weight of the plants at maturity and the environmental forces working against it. Purchasing new poles is preferable as they are uniformly sized and durable. Used utility poles are oversized, difficult to handle, and often have creosote or other chemical preservatives that may affect crop production.

A quarter-acre trial planting would give potential growers a manageable first exposure to what is involved in the production of this unique crop. A 10,080-square-foot hop trellis design is illustrated in Figure 3. However, additional space is required for outside pole anchors and the turning radius of lifts, mowers, sprayers, and harvest equipment. In the example design, planting beds are 48 inches wide and 168 feet in length. Poles are positioned 42 feet on-center within rows and 14 feet on-center between rows. Plants are set at 42 inches on-

center within the row, having 12 plants positioned between each pole within rows and a total of 48 plants per row. When planted in this configuration, a total of 240 plants can be grown under this roughly quarter-acre planting design.

Heavy-duty cables are positioned across the rows and on the outer two lengthwise rows as the primary support grid. Each outer pole will also be cabled from pole top to ground anchors, located away from pole at approximately ½ pole height (a 20-foot pole would have anchors set 10 feet out). Heavy gauge 2-strand wire or light-duty cables are set from end to end of the planting row, positioned on either side of the plant bed. For the design illustrated, a total of eight would be needed (note: heavy-duty cable on outside perimeter used for plant support).

Trellis Materials List

- 25 each 22' x 5" Diameter poles (measured at top)
- 20 each Ground anchors w/6" base plate (5/8" x 48" x 6")
- 20 each, Turnbuckles (1/2" x 12")
- Cable staples (100 minimum)
- 710' Heavy-duty main cable (5/16" galvanized aircraft cable–7x19 strand)
- 80 each, Cable clamps for main cable (5/16", 4 per perimeter pole anchor)
- 1,376' Light duty cable for training support (3/16" galvanized aircraft cable 7x7 strand)
- 32 each Cable clamps for training support cables (3/16")
- 480 each 21' Coir twine strings

Trellis Construction Steps

1. Identify suitable growing site (see guidelines below)
2. Verify easements and setbacks with local governing body
3. Lay out hop yard row orientation
4. Prepare raised planting beds through subsoil ripping, surface tillage, and bed shaping
5. Identify pole locations and have belowground utility locations verified (call 811)
6. Dig support pole holes 48 inches deep and firmly set them by tamping
7. Set ground anchors
8. Attach turnbuckles to ground anchors
9. String heavy cables for across row mainlines, wrapping each pole at top and affixing in position using cable staples
10. String cables from intermediate end poles to ground anchors

11. Uniformly pull cables to moderately tighten and retain in position using a minimum of two (2) cable clamps per cable end
12. Tighten system as required using turnbuckles
13. String twisted hop wire or light-duty cables for support of training ropes (coir)
14. Install irrigation system, flush, and verify uniformity of distribution
15. Ready for planting

Supply Cost Estimate 2018

25 Poles @ \$115 each	=	\$2,875
20 Ground anchors	=	\$260
20 Turnbuckles	=	\$224
710' 5/16" Cable/\$0.67ft	=	\$478
1,376' 3/16" Cable/\$0.23ft	=	\$317
Clamps and staples	=	\$100
Coir	=	\$130
Total	=	\$4,384 plus taxes and shipping

Hop Yard Establishment

Careful production planning and hop culture is critical for the first year to establish a healthy and uniform crop in coming years. Cultivar selection is a personal decision, determined by the intended use of the crop and the potential buyer's needs. Purchase healthy and disease-free plant starts from reputable suppliers who have high standards in propagating clean and "true to type" stock. Plant starts can be ordered as either rhizome sections or rooted cuttings. Either can be used effectively; however, rhizome cuttings should only be purchased for spring planting and received as dormant cuttings. Rooted plant cuttings can be planted any time after danger of frost but must be planted before August 1 for best root establishment before winter.

Location

Hop can be grown in a wide range of soil types; however, locations that are well-drained are necessary for best production. Sites previously cultivated can easily have the planting beds marked out and then tilled after the trellis system has been installed. Topography should be considered for ease of trellis installation, plant cultivation, and harvest activities, given that level sites allow for greatest efficiency in all production activities. Trellising systems should typically be oriented in a north-south direction to optimize light infiltration into the plant canopy.



Figure 4. Short and frequent irrigation cycles and weed management are important in the new hop field planting.

Soil

Grower cultivation methods will need to consider the amount of clay present in the soils. Those in a silt-clay loam or clay-loam should mound the planting beds so the rhizomes and feeder roots have a well-drained growing environment. Additionally, clay-containing soils are susceptible to compaction and should not be walked or driven on in the planting beds. Soils containing sand (e.g., sandy-silt or sandy-silt loam) may not benefit from mounding, and mounding may be detrimental to the plants if erosion exposes the rhizomes and roots. One benefit to soils containing large amounts of sand is that stringing and harvesting operations can occur across the beds for greater efficiency without affecting the soil structure. It is important to have a professional soil analysis completed prior to planting the hop yard. Soil pH should be between 5.8 and 7.5, and optimally near 6.5 for balanced nutrient uptake. Any nutrient corrections should be made prior to hop planting (more information provided below).

Irrigation

Irrigation is the most important cultural aspect for the first-year plant, closely followed by weed management (Figure 4). Young plants have few roots and need consistent water availability. Drip irrigation that is laid near the plants is recommended. Drip tubes should have 1 gallon per hour (gph) output emitters that are spaced 12–18 inches apart. Irrigation initially should cycle twice daily for 30 minutes per period. As roots become established, the cycles should be reduced in frequency with a longer duration to encourage deep rooting. At no time should the plants be water stressed. Once the

Table 1. Commonly used chemical controls for weed control in hops

Common Name	Control Type	Weeds Controlled
2,4-D	Post (emergence)	Small broadleaf weeds only in established plantings
Carfentrazone	Post	Broadleaf
Clethodim*	Post	Annual and perennial grasses
Flumioxazin	Pre (emergence)	Annual broadleaf and annual grasses
Glyphosate	Post	Broadleaf and grass control. Careful application in young plantings

plants are established, irrigation can be reduced to once daily for 60 minutes or as needed.

A soil moisture measurement tool should be used to determine when watering is needed. Soils higher in clay will be irrigated less often than sandy soils, which will need more frequent and shorter irrigation cycles. It is important to note that this is general information and will vary greatly depending on soil type and environmental conditions at each location. Hop plants in cultivation typically need between 27 to 32 inches of moisture during their active growth period, provided either through natural rainfall or irrigation.

Weeds

Controlling weed pressure during the first and second years is essential to establish a uniform and vigorously growing hop yard. After the preplant soil bed preparation, annual weeds can be controlled simply by hand hoeing when needed on a weekly basis. Some growers attempted to use plastic mulch during the first year but struggled with winds lifting it, and root and rhizome diseases resulted from high moisture levels. Several herbicides are labeled for use on hop (*Table 1*), but should be properly labeled for use on hops and tested on a small scale before applying to the entire crop as first-year hop plants are most susceptible to injury.

Nutrition

The nutritional needs of the hop plants during the establishment year are different than when they are being grown for cone production in the second year and beyond. Plants received as rooted cuttings should have adequate nitrogen reserve for the first few weeks but may benefit from a single high-phosphorus application at planting (e.g., a 9-45-15 (NPK) fertilizer). For spring planting, nitrogen applied during the season would be slightly half of that needed for a mature crop as plant growth is directed to root and rhizome establishment and not to vegetative growth.

It is important to conduct a soil test to best determine available nutrients and those that need to be supplemented. Literature often presents nutrient requirements on a pounds per acre basis, which can be misleading for hop. Trellising systems and plant spacing often differ among growers as a result of their specific site and cultivation equipment. In general, when information is provided on a “per-acre” basis for hop, this translates to roughly 1,000 individual plants. Fertilizers need to be broadcast directly over the root feeder zone uniformly to maximize plant growth and control nutrient waste or leaching.

Balanced fertilizers are typically not used because nitrogen uptake in mature hops is as much as 100–150 pounds per acre. This is 1.6–2.4 ounces nitrogen by weight (oz wt) on a per plant basis but can be as much as 4.3 oz wt in soils with limited nutrition (sandy soils). Urea (46-0-0) or ammonium nitrate (33-0-0) can be applied in small doses beginning two weeks after planting and repeated every other week until around the first week of August.

In soils that test in the medium range for phosphorus and potassium, an additional 30 pounds of phosphorus and 100 pounds of potassium per acre should be provided for optimal plant growth. An increase of 10–30 pounds per acre for phosphorus and 20–40 pounds per acre of potassium may be necessary in soils showing low levels in the soil test. Micronutrient availability in Nebraska soils is typically above sufficiency levels required by hops and applied only when determined through soil testing to be limited.

Plant Health

Many biotic and abiotic stressors can affect hop plant health and survival. The following are some key issues to monitor and potentially treat during the establishment year.

Drought injury: Tissue will appear whitened to pale green and will be crispy/crunchy when touched. Cut back the affected area for regrowth. Check irrigation system for uniformity or increase frequency or duration of irrigation.

Spider mite: A very small (1/50th of an inch) organism found on the underside of leaves. It causes stippling damage that appears as a bronzing or dusty look and may show faint webbing near leaf mid-vein or between petiole and stem. Mite pressure increases during hot and dry environmental conditions, typically mid to late summer. Predatory mites and insects can suppress spider mites; however, chemical control (e.g., abamectin, fenpyroximate) may be necessary under heavy pressure.

Potato Leafhopper: Adults are 1/8 inch long and feed through piercing and sucking mouthparts. These insects move quickly in an angular or sideways direction. When

feeding, they inject a solution into the plant tissue to aid in their feeding. This damages vascular system flow and causes leaf edge yellowing, browning, and upward curling. There are many plant hosts for leafhopper, and this insect will move quickly from one species to another. Controlling the leafhopper is best attempted through careful crop scouting and use of predatory insects (e.g., green lacewing, ladybird beetle, parasitic wasp). Use chemical methods only when necessary.

Caterpillars: Many moth and butterfly larvae feed on hop, resulting in holes in leaves or complete defoliation. Monitor closely August through September as populations increase quickly. A biological pesticide containing *Bacillus Thuringiensis* (BT) is quite effective in controlling these larvae, but caution must be exercised in its application to prevent killing desirable larvae of butterflies for the landscape.

Herbicide injury: First-year hops are particularly sensitive to herbicides. Glyphosate can cause interveinal yellowing of upper leaves and slowed growth. 2,4-D injury typically appears as leaf and stem distortion, with twisting and irregular growth. Injury on early growth can be removed with the timed spring cutback of hop shoots, but later-season injury on trained shoots will greatly reduce plant productivity and yield for that growing season. The best solution for avoiding herbicide drift is to choose a location distant or buffered (e.g., windbreaks) from neighboring crop production where herbicide use is common. Also consider the prevailing spring and summer wind direction, and try to avoid hop yard establishment immediately downwind of adjacent cropland.

Nitrogen deficiency: Appears as generally weak growth, overall light green appearance with leaf yellowing that is more pronounced on older leaves. Careful nutrition monitoring and the appropriate timing of nitrogen applications are important.

Iron deficiency: Observed as yellowing between veins on young leaves near the top of bines. Nebraska soils are rarely iron deficient, but plant deficiency symptoms may become evident during certain environmental conditions early in the growing season. This will often self-correct once cool and wet soil conditions have improved. Iron deficiency symptoms will additionally occur in alkaline soils and can be addressed with pH correction.

Disease Management

Susceptibility for disease in hops is dependent on the distribution and abundance of specific pathogens and having environmental conditions suitable for disease expression. It is

best to start with clean stock, follow best management practices (BMP), and implement integrated pest management (IPM) strategies to reduce the detrimental effects from disease.

Downy Mildew: This disease is first evident in spring on new shoots, appearing as stunted shoots with brittle, down-curved, and yellowed leaves. Expression of downy mildew on older material appears as dark purple or black discoloration on leaf undersides with dry, angular leaf lesions and stunted lateral branch spikes with a “blind” shoot tip. No single method will control downy mildew, but losses can be prevented through avoidance of excessive irrigation, reducing nutrient rates as the season progresses, removing previous season plant debris from the field, and integrating BMP in the farming operation.

Verticillium Wilt: Symptoms vary but infected bine stems will be noticeably swollen, and interior vascular tissue will have prominent brown/dark brown discoloration. Symptoms are more pronounced when plants are large and nearing flowering or when plants are moisture stressed. Plant resistant cultivars from clean stock sources and adhere to strict sanitation procedures; specifically, remove diseased or dead bines immediately from the field and compost off-site.

Fusarium Canker: Easily identified as bines that suddenly wilt and die. The pathogen infects the stem at injury sites, typically at the bine connection to the rhizome. The base of the bine will be swollen a short distance near the attachment and will easily snap off when plants are exposed to winds or other movement. Prevent infections by avoiding excessive irrigation and hilling up soil at the base of the bines to promote healthy, adventitious roots.

Alternaria Cone Disorder: Brown discoloration ranging from only the cone bract tips to entire bracts or cones. This disorder is caused by a fungus that infects damaged tissue, either by insect feeding, wind exposure, or mechanical operations. Prevent cone damage by managing insects, careful cultivation activities, and preventing plant water stress.

Harvest

Cone Harvest Determination

Harvest date differs by hop cultivar and also is influenced by the location, specific care, and environmental conditions. Qualities of interest for the brewing industry are the alpha-acid content, related to bittering ability, and essential oils, which include more than 300 complex compounds that create the unique fruity, spicy, nutty, or floral aroma characteristics. Also of importance to brewers is beta-acid content. These acids contribute slightly to beer bittering but are most important in bringing antiseptic qualities into the beer and

improving shelf life of the final product. Hop cones should be harvested when these three components are at their optimal stage. If harvested too early, the acid content of the cones may be too low. If harvested too late, the aroma will have faded and the cone storage life shortened.

A simple test to check on maturity of the hop cones is the “feel and smell” method. A cone that is not ripe will be soft and light, feel slightly damp, and remain compressed when lightly squeezed. Pull back a bract leaf of the cone and note the amount of yellow lupulin formation. Ripe cones will have large, oily lupulin crystals present, whereas immature cones will have a light dusting. Cones ready for harvest will feel dry, spring back to shape when squeezed, and have their distinct cultivar hop aroma.

Commercial hop growers determine optimal harvest time when cone moisture content reaches an average of 23 percent dry matter. This stage of maturity is typically considered to hit a balance between the three important characteristics of hops for brewing. To test for dry matter content of hops, perform the following procedure:

1. Collect a total of 100 to 125 cones from a random sampling of plants in the hop yard
2. Weigh an empty container in grams (tare weight)
3. Put collected cones in the container and get the wet weight
4. Dry the hops for 8 to 10 hours in a food dehydrator or convection oven at 135oF; this will bring the moisture content down to 0 percent
5. Weigh the dried hops in the original container with the known tare weight
6. Calculate percent of dry matter as:

$$\frac{(\text{Dry cone weight} \div \text{Wet cone weight}) \times 100}{=} \% \text{ Dry Matter}$$

Observationally, hop cones nearing maturity will be light green, have a dry papery feel, and the lupulin coloring will transition from a light yellow to a dark yellow- orange within the bract leaves.

Harvesting Hops

The hop cone harvesting technique should be considered during the planning phase of the hop yard. For this quarter-acre planting, harvesting can be completed by hand if multiple cultivars are being grown and harvest times are sequential. If a single cultivar or the cultivars chosen have similar harvest timing, mechanized equipment should be considered.

Two harvesting methods can be employed:

- Picking cones off the bine as each appears to be mature in the field, or



Figure 5. Hop plants are trained using two or three shoots that are 18–24 inches long and gently wrapping them approximately two times around the coir rope without injuring the growth tip.



Figure 6. Cones are ready to harvest when the dry weight accumulation of the cones is approximately 20 percent. Harvest date is dependent upon variety but will generally be late August through mid-September.

- Choosing a date that the entire plant generally has mature cones and cutting down the entire bine for cone removal at a picking station.

If growers choose to pick in the field, they must use a ladder, portable scaffolding system, or lift to reach cones

Examples of Timelines

First Year Timeline: Establishment

March

- Trellis installation

April

- Take soil core samples and have a soil nutrient analysis completed
- Prepare soil and planting rows or raised beds

May

- Correct soil nutrient deficiencies as directed through soil test
- Install drip irrigation
- Plant rooted cuttings or potted plant starts after danger of frost

June

- Short, frequent irrigation cycles
- Weed management through pulling, hoeing, or mulching
- Low dose nitrogen fertilizer application mid-June

July

- Increase irrigation duration and reduce frequency
- Monitor and control insects as needed
- Do not train hop plants but encourage branching by tip removal (snapped by hand or sanitized pruning shears between each plant) of longest stems
- Two low-dose fertilizer applications

August

- Irrigate as indicated using a soil moisture meter to maintain plants
- Monitor and control insects as needed, especially caterpillars and mites during this period
- Production note: first-season hop plants are typically not trellised, greatly limiting cone development. Plants that have been trained may potentially be harvested; however, yields will be very light.

September

- Reduce irrigation frequency

October

- Stop irrigation

- Cut top vegetation off approximately 18 inches above the ground. Plant debris should be removed from the field and composted to suppress insect and disease infections
- Edge beds and mound approximately 1 inch of soil over plant crowns for protection

Second Year Timeline: Cultivation to Harvest

Plant vigor and growth rates will vary by the cultivars grown, site characteristics, and cultivation methods. The following example is typical of many commercially grown alpha hop types but may differ by location and grower.

March

- Cut off previous year stems
- Visible buds and new shoots emergence

Mid-April

- Fertilizer application—75–100 lb N per acre (half of full season need)
- Timed “cut-back”—Cut off all vegetation to the soil surface to time new growth to reach top trellis wire by summer solstice

May

- Select 2–3 each of 18 to 24 inch bines for training on support ropes (*Figure 5*)
- Planned fertilizer application of 25–50 lb N per acre

June

- Goal is for the bines to reach the top wire by late June, at which time flower initiation occurs due to natural shortening of the length of days
- Planned fertilizer application of 25 lb N per acre

July

- Flower formation, or burring and cone development
- Monitor insects and diseases and treat as needed

August

- Cone maturation (*Figure 6*) and harvest begins late August for early cultivars

September

- Harvest continues for late cultivars
- Edge beds and mound as needed for winter rhizome protection

October

- Growth slowed and dormancy

across the hop yard. This may prove to be difficult and time consuming. Most growers select a general maturity date for harvesting the entire plant at one time.

The cones have high moisture content at harvest and must be either used immediately for a “fresh hops brew” or dried within hours after picking. Hop cones can be dried to an 8–10 percent moisture content by using a food dehydrator, a convection oven that can hold temperatures under 135°F, or by placing them on a drying screen. Provide gentle air movement through the cones during the drying process for product and color uniformity. Once the harvested cones are at 8–10 percent moisture content, they should be packaged in airtight, light-occluding packages and stored in a cool dry place until used. Storage duration varies by cultivar and is best determined through HSI (Hop Storage Index) analytical testing.

Summary

Hop production is unique because of distinct cultivation methods, the substantial trellising system necessary for plant training, and the harvest is of a non-seed bearing cone (strobiles). Of importance is the accumulation of essential oils within the lupulin glands of the strobiles that provide aroma

and flavoring characteristics to beer, as well as potential medicinal benefits. It is best to explore this unique crop through a trial planting before investing a significant amount of money into expanded, commercial hop yard production. The proposed quarter-acre planting offers growers the opportunity to better understand hop growth, cultivation, and harvest methodology, and the time to evaluate their interest level and market opportunities in the hop industry.

FOR MORE INFORMATION

Learn about Nebraska hop research and specific cultural considerations for the region by visiting the “Nebraska Hops” website: <http://agronomy.unl.edu/nebraska-hops>

Learn about hops farming, national statistics, and other research through the USAHOPS organization website: www.usahops.org

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