

Summary of Educational Information Presented at Regional Hops Workshops

Rob Holland, David Hughes, David Lockwood, Aaron Smith, Eric Walker and Hannah Wright

The pages that follow represent the slides that were presented during a series of Regional Hops Workshops that were conducted in five different locations across the state during January, February, March and April of 2019. The workshops were conducted as part of UT Extension's project titled "Opportunities for Specialty Crops in Tennessee: Focus on Hops."

The locations, dates and hosts of the workshop are provided below:

January 29 – Murfreesboro, TN hosted by Rachel Painter
February 19 – Lafayette, TN hosted by Keith Allen
March 11 – Greeneville, TN hosted by Melody Rose
March 28 – Martin, TN hosted by Jeff Lannom
April 29 – Pikeville, TN hosted by Whitney Simmons

The workshops consisted of the following three presentations:

Assessment of Hops for Tennessee
(page 2-5)

by Dr. David Hughes
Department of Agricultural and Resource Economics

Hop Production
(pages 6-15)

by Dr. Eric Walker and Dr. David Lockwood
Department of Plant Sciences

Hops: Marketing and Cost of Production
(pages 16-21)

by Dr. Aaron Smith
Department of Agricultural and Resource Economics

Note: This project was developed and implemented in cooperation with the Tennessee Department of Agriculture, Funding for the Opportunities for Specialty Crops in Tennessee: Focus on Hops project was made possible in part by the US Department of Agriculture's (USDA) Agricultural Marketing Service through grant USDA-AMS-SCBGP-2017.

Assessment of Hops for Tennessee

David Hughes and Hannah Wright,
UTIA Extension
Agricultural & Resource Economics



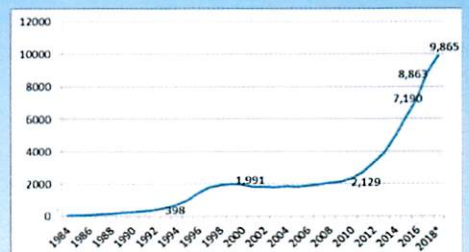
Outline

- Growth in Craft Beer-Hops
- Nature of plant, processing
- Hops in the Southeast

Hops

- Hops is a flower of *Humulus lupulus*
- used in beer production as a preservative and flavor additive
- Grown as a bine (vine) on a trellis system (16-18 feet), hops are generally dried and usually pelletized before use
- wet hops may be a source of demand held by brewers in the southeast (hops must be used or dried within in 24-36 hours due to oxidation of key ingredients)

Growth in Number of US Breweries

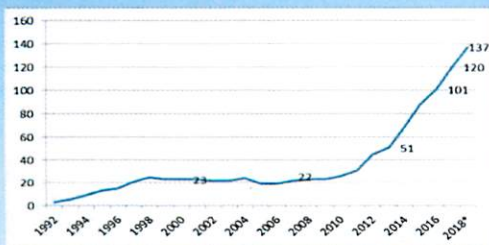


Source: Alcohol and Tobacco Tax and Trade Bureau, U.S. Dept. of the Treasury

*3rd Quarter

But Experts talking about slowdown

Growth in Number of TN Breweries



Source: Alcohol and Tobacco Tax and Trade Bureau, U.S. Dept. of the Treasury

*3rd Quarter

Hops Demand

(USA Hop Growers of America)

- Increased demand tied to tremendous growth in the US craft beer industry
 - 2016: 25.8 million barrels
 - 2011: 11.5 million barrels
 - 2003: 5.5 million barrels
- Hopping rate for craft beer
 - 1.24-1.65 pounds per barrel (31 gallons)
 - Has been increasing
- \$26.0 billion 2017

Growing Industry

- US Production:
 - 2007: \$180 m, 30,911 acres, 3 states
 - 2017: \$617.8 m, 52,963 acres, 29 states
 - 1,959 pounds average yield per acre
 - Concentrated in arid parts of PNW
- >98% used to brew beer
- 26 other states 2,504 acres, 750 pounds/acre
- Cascade, Centennial, Chinook varieties
- But:
 - Estimated loss to pest and diseases is 15%
 - Talk of looming “over acreage”

Hops Yard



Hops Flower (Cone)



Hops Flower



Alpha Acids

- Alpha acids: found in the resin glands of the flowers of the hop plant and are the source of hop bitterness.
- Alpha acids: humulone, adhumulone, cohumulone, posthumulone, & prehumulone
- As a % of dried weight level vary by variety
- Cascade 4.5-8%
- Centennial 9-11.5%
- Chinook 12-14%

Other Components

- Essential oils:
 - Often add aroma, other attributes
- Flavonoids
- Beta acids

Three Major Categories

- Bittering hops have higher concentrations of alpha acids
- Aroma hops:
 - Lower concentration of alpha acids (~5%) and are the primary contributors of hop aroma and (nonbitter) flavor.
 - Often added later in the boiling process
 - May be used in dry hopping (added after cooling-while beer ferments).
- "Dual-use" hops: bittering & aromatic

Harvest, Drying, Pelletizing

(Gorst Valley Hops)

- Cut bines down
- Remove flowers (cones) from stems and bine
- Sort cones from leaves and stems
- Oxidation of lupulin start immediately
- Dry immediately unless wet hopping (24-36 hour window)
- Subject to food safety regulations

Drying



- Oasting or drying to appropriate moisture content (8-10%)
- Air flow driven by centrifugal fans is key
- Watch, adjust for humidity level
- Excess moisture can lead to:
 - Mold and mildew
 - Loss of lupulin
 - General spoilage



Pelletizing



- Brewers typically prefer to use pellets
- Hammer Mill
- Usually baled after drying
- Pelletizing:
 - Breaking bales into powder
 - Heat generated activates resins, bind the powder into pellets

Challenges for Southeast Industry

- High establishment cost
- Small size
- Low yields
- Humid environment
 - mildews and others diseases
 - pests
- Harvest (need labor quickly)
- Lack of industry infrastructure (custom machine harvest, drying, pelletizing)
- Marketing

Challenges & Possible Solutions: Yields

- VA producers 25% of large producers in PNW (i.e., around 500 pounds / acre) (Dick & Bresowar)
- Lack of vegetation prior to flowering a likely cause
- Yields generally highest between 35(?) and 55 latitude
- Possible solutions?
 - Light extension-interruption
 - Trimming

Light Extension-Interruption

- Lack of summer sun an issue
- Several places (VA, FL, SA) looking at night time light interruption & daylight extension as ways to increase growth and yields
 - Preliminary results from FL appear promising
 - Apparently promising in South Africa but information is proprietary

Pruning as a Way to Increase Yields?

(source: hopnology)

- Optimal pruning (trimming) based on flowering date
- Flowering driven by growing degree days
- Some difference by variety and latitude
- Trimming limits node “stretching” thereby generating more and longer sidearms
- More sidearms mean more hops
- 1.9 (trimmed) vs. 0.88 (not) pounds per plant

Summary, Future Work

- May be an opportunity but many challenges
- NC, VA 30 acres each (2016)
- UTIA Hops Workshops
 - Tuesday, February 19, Macon County Fairgrounds
 - Monday, March 11, UT Research & Education Center at Greeneville
 - Thursday, March 28, UT-Martin Champions Club
- Brewery survey
 - Demand for local hops
 - Demand for local malting barley
 - Demand for other local additives (fruit)



Sources Hops

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Gorst Valley Hops. Drying to Processing: Methods Overview. Presentation at Southeast Hops Conference, Blacksburg, VA. 2018.

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Siegle, L. and H. Scoggins. 2017 Virginia Hop Grower Survey Results. Virginia Cooperative Extension. Presentation at Southeast Hops Conference, Blacksburg, VA. 2018.

Smith R.M. 2018. Future of Florida Hops Just Got a Little Brighter. July 30. <https://www.growersofamerica.com/wordpress/wp-content/uploads/2018/07/Florida-Hops-Just-Got-a-Little-Brighter.pdf>


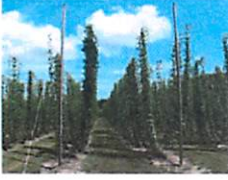
USA Hop Growers of America. Small Growers Update. Presentation at Southeast Hops Conference, Blacksburg, VA. 2018.

Questions, Comments,
Thank You!

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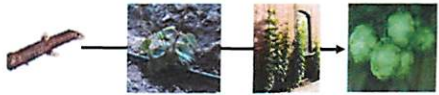
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THE UNIVERSITY OF TENNESSEE

Hop Production

David W. Lockwood
Eric Walker
Plant Sciences
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Hop Plants: (*Humulus lupulus*)



- Perennials
 - Produce bines (twining stems) from the crown or rhizomes (permanent rootstock) each spring
 - Rhizomes persist in the soil for many years
- Dioecious
 - Male & female flowers grown on separate plants
 - Only the cones produced by the female plants are used in the brewing process
- Bines (aided by trichomes) grow clockwise around strings attached to trellis systems
 - Under right conditions, bines can grow upwards of 2 ft./week,
 - lateral branches develop on bines & produce clusters of 1/2 to 4-inch papery green flowers (cones)
 - Triggered by daylength



Hop vs. Hops

- Hop:
 - vine from which hops are obtained
 - 3-to-5 lobed leaves
 - inconspicuous flowers of which the pistillate ones are in glandular cone-shaped catkins
- Hops:
 - ripe, dried pistillate catkins of a perennial north-temperate zone twining vine (*Humulus lupulus*) of the hemp family used especially to impart a bitter flavor to malt liquors

Bine vs. Vine

- Bine: hairy, stiff shoot that climbs by wrapping around a support. (Hops wrap in a clockwise direction).
- Vine: Produces tendrils which bind to the support (grapevines)



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Beer Basics

- History
- Defining Beer
- Beer Styles
- Choosing
- Serving
- Glassware
- Tasting
- Storing
- Glossary

Lupulin Glands

Lupulin glands are the tiny yellow sack found at the base of the petals of the hop cone.

They contain the alpha acids, beta acids, and hop oils that are so useful to the brewer in adding hop character to beer.

Note that cones from the male hop plant contain relatively few lupulin glands. Therefore, it is the female plant that is in demand to supply hop cones for brewers.

Related terms
Hops



Strig

Lupulin Glands

Bracts and Braceoles

Hop Cone Cutaway View

Hop History in the U. S.


- 1648 – Massachusetts Bay Settlement – 45 acres
 - 1st documented commercial hops production in the U. S.
 - Massachusetts remained the largest hop producing state for the next 150 years
- By the mid-1800's, New York was the largest producing state, reaching a peak in the late 1800's
 - Prohibition & downy mildew were credited for the demise
- Hop production shifted to the Northwest





Hop Production in the U. S. - 2017

- U.S. accounts for 42% of world hop production (#1 in the world)
 - The Northwest produces 98% of the hops produced in the U.S.
 - Washington produces 70% of the hops grown in the U.S.
- U.S. acreage has increased 79.5% since 2012
 - From 2016 to 2017, hop yield jumped 14% due to new plantings coming into production
 - Current market appears to have reached saturation
- Changes:
 - Prior to 2010, 1/2 the hops grown in WA were alpha varieties (bittering agents)
 - In 2017, U.S. farmers grew 80% aroma or dual-purpose varieties




Tri-Cities Area Journal of Business (Columbia Basin)

Challenges for Growing Hops in Tennessee

- Lack of established markets
 - Changes are occurring with the popularity of local breweries & potential premiums for locally-grown hops
- Lack of local information (no history of hop production in Tennessee)
 - Most information is adapted from the Pacific Northwest
 - Increasing amounts of information is being generated in the North Central, Northeast and Mid-Atlantic areas
- Daylength
 - Hops require long daylengths to flower & produce adequate cone yields
- High rainfall/humidity provides ideal conditions for diseases & pests
- Heat

Sample Budget for Hop Yard Establishment




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.

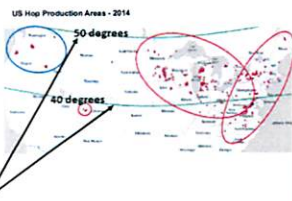
Growing Hops Successfully

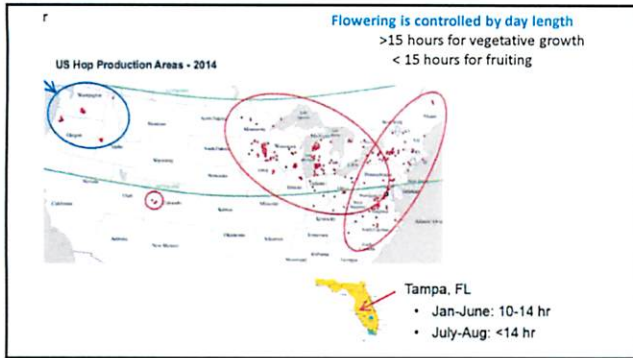
- Location
 - Majority of the world's hops are grown between 35° & 55° latitude in both hemispheres
 - Photoperiod effect - needs long day lengths to flower & produce adequate cone yields
 - Have a specific chilling requirement (needs winter temperatures below 40° F for 1 to 2 months for proper growth)
 - Needs sufficient moisture in spring followed by significant periods of summer sun and heat to ensure ample growth and full development of chemical compounds



Growing Conditions:

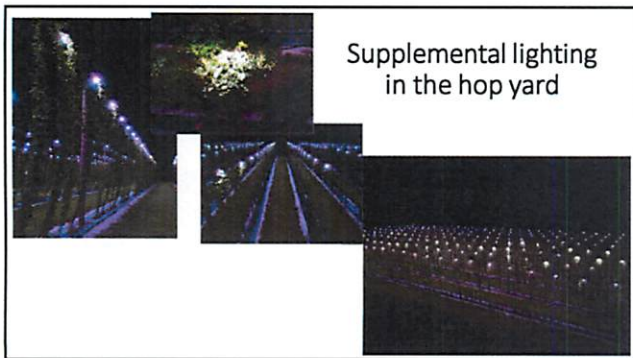
- Will grow in a variety of soils
 - Optimum: well-drained, deep, sandy loam, pH about 6.5
 - Avoid sites having heavy, poorly-drained soil
- Need supplemental water & nutrients for growth & cone development
- To flower & produce high cone yields –
 - Need long days and short nights during the growing season
 - Winter temperatures below 40° F for 1 or 2 months
 - To achieve this, most hops grown between 40 and 50 degrees latitude





Day Length & Latitude

City	Day length (June 20)	Latitude
Seattle, WA	15 hr. 59 min. 18 sec.	47.6° N
Rochester, NY	15 hr. 22 min. 50 sec.	43.2° N
Bristol, TN	14 hr. 39 min. 57 sec.	36.6° N
Lafayette, TN	14 hr. 39 min. 24 sec.	36.5° N
Martin, TN	14 hr. 38 min. 29 sec.	36.3° N
Johnson City, TN	14 hr. 38 min. 19 sec.	36.3° N
Greeneville, TN	14 hr. 37 min. 27 sec.	36.2° N
Murfreesboro, TN	14 hr. 35 min. 37 sec.	35.8° N
Knoxville, TN	14 hr. 36 min. 9 sec.	36.0° N
Raleigh, NC	14 hr. 35 min. 7 sec.	35.8° N
Asheville, NC	14 hr. 34 min. 6 sec.	35.6° N
Memphis, TN	14 hr. 31 min. 41 sec.	35.1° N
Atlanta, GA	14 hr. 24 min. 0 sec.	33.4° N
Tallahassee, FL	14 hr. 6 min. 55 sec.	30.5° N



Stages of Production

- Determined by photoperiod
 - Shorter day lengths signal maturity
 - Longer day lengths signal vegetative growth
 - Different cultivars respond to different photoperiodic signals
- Length of vegetative growth stages will also vary depending on cultivar and climate
 - Stages of production will take place at different times in PNW than MI
 - Each hop growing region must identify their 'norm'

HAAS

Why is height growth limited?

2016 production trial

Shoot apex (growing tip)

↓

Flower

↓

No more height growth

Getting Started

Cultivar Selection

- What do brewers want?
 - New
 - Local
 - Consistent Quality
- Public versus private cultivars
 - Public: commercially available
 - Private: usually grown on the farm or with select neighbors of the breeder
- Cultivars that seem to do well in NE?
 - Cascade
 - Centennial

Source: USDA NARS, prepared by Hop Growers of America

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Hop Varieties (partial list)

2 basic categories

- Bittering (with high alpha acid levels)
 - Magnum
- Aroma
 - Cascade
- Some dual purpose varieties exist
 - Nugget

Hop Variety	Average Alpha Acid	Ideal Climate/Notes
Cascade	4.5-7.0%	Grows well in all climates. Susceptible to aphid.
Centennial	9.5-11.5%	Grows well in all climates. Susceptible to downy mildew.
Chinook	11.0-13.0%	Grows well in dry, hot climates. Does not grow well in moist climates. Subject to spider mite. Great ornamental hop.
Columbus	14.5-15.5%	Grows well in dry hot climates. Vigorous but susceptible to mildew diseases.
Fuggles	4.0-5.5%	Grows well in damp climates. Suffers a little in hot climates.
Glacier	5.0-6.0%	Grows well in all climates.
Golding	4.0-5.0%	Grows well in mild, moist climates. Does okay in hot climates.
Hallertau	3.5-5.5%	Grows well in mild, moist climates. Suffers a little in dry hot climates.
Horizon	12.0-13.5%	Grows well in all climates.
Magnum	12.0-14.0%	Grows well in all climates. Good resistance to wilt and downy mildew. Susceptible to powdery mildew.
Northern Brewer	8.0-10.0%	Adequate in temperate climates but has difficulty growing when under heat stress. Susceptible to downy mildew.
Nugget	12.0-14.0%	Grows well in all climates.
Tettnang	4.0-5.0%	Grows well in a moderate climate. Suffers a little in hot climates.
Willamette	4.0-6.0%	Grows well in all climates.

Timeline for Planting Hops

- Site selection – most important decision you will make
 - “Live where you farm, don’t farm where you live”
- Site preparation – begin a minimum of 6 months to one year in advance of planting
 - The success or failure of a planting is often determined before the first plant is set
- Order plants well in advance of the time to plant
 - Use reputable nurseries
- Build the trellis prior to planting
- Have the irrigation system installed and operational before planting

Orchard Site Score Sheet

- Accessibility
- Full sun
- Elevation
- Slope – aspect and steepness
- Soil Characteristics – drainage (internal & surface), potential rooting depth, fertility
- Water – quantity & quality
- Wildlife
- Adjacent agricultural operations

Soils for Hop Production

- Sandy loam - avoid heavy, poorly drained soils
- Deep – minimum rooting depth 30 to 36 inches
- Well-drained (internal & surface)
- pH 6.0 to 6.5
- Medium to high fertility

Poor Vs. Good Internal Drainage



Site Preparation

- Soil testing
- Elimination of noxious weeds
- Remove barriers to good air drainage
- Address poor water drainage areas (if applicable)
- Remove wild/abandoned vines near the site

Taking Soil Samples

- What to Test For:
 - pH – affects availability of nutrients
 - Phosphorus – only opportunity to adjust P levels in soils (preplant)
 - Potassium – can impact uptake of certain nutrients (Ca, Mg, N)
 - Calcium – calcitic limestone?
 - Magnesium – dolomitic limestone?
 - Organic Matter – can help to determine nitrogen fertilization rates



Sample at 2 depths:
- Upper 8 inches
- 8 to 16 inches

- What NOT to Test For:
 - Nitrogen – N levels in soil can change too quickly to be of value
 - Micronutrients – soil testing is of questionable value
 - Macronutrients other than P, K, Ca of Mg unless you have strong reason to suspect a problem

Soil Testing for Hops

- Preplant soil testing
 - Collect soil samples several months or longer in advance of planting
 - Sample areas showing different growing conditions or having a different cropping history separately
 - Amend soils based on soil test recommendations in advance of planting and potassium (deep incorporation of lime, phosphor
 - There is no economically effective way to raise subsoil pH once the planting is in the ground
 - Phosphorus broadcast on the soil surface will not move down into the soil
 - Potassium varies with soil type in its ability to move down in the soil

Liming Soils – *Preplant* (also for P & K)



$$\begin{matrix} \text{Rate for upper 8"} \\ + \\ \text{Rate for 8 - 16"} \text{ depth} \end{matrix} = \text{Amt. to apply}$$

Disk or rototill (mixes lime with soil in upper 4 – 6")

Plow to put amended soil at the bottom of the furrow
(for high lime rates, apply ~ 2/3 of total & incorporate, apply remaining amount & disk into topsoil)

Orchard Nutrition Management - Stiles & Reid

Planting: Rhizomes vs. Propagated Plants

Purchase disease-free propagated plants

- Tissue culture
- Virus indexed



Rhizomes – be sure to purchase from a reputable source (risk of spreading diseases & viruses if digging from an existing hop yard)

Stages of Production

Planting a New Crop



248 Dark brown color of rhizomes infested with Pseudomonas and Fusarium. Right: healthy rhizome (C. B. Skutumpah)

• New commercial hops come from clonal sources; genetically identical to parent material

- Rhizomes
- Cuttings

• **No matter what form is used, start with virus and disease free**

HAAS

Hop Plant

- Perennial plant that produces annual bines from a crown & an overwintering rhizome
- In spring, shoots (bines) grow from rhizome buds
- Bines grow in a clockwise direction around strings attached to the trellis
 - Trichomes (stout hairs on bines) enable bines to adhere to supports
 - Bines may grow upwards of 20+ feet in a growing season
 - Bine extension occurs in the early part of the growing season
 - Around the summer solstice, bine extension stops and lateral branches grow off bines
 - Flowers are produced in clusters at the terminal buds
- Hop rhizomes that are only 1 year old will rarely flower or may flower very lightly

Basic Hop Physiology

Aboveground Growth



- Aboveground plant is annual
 - Dies back in fall and plant goes into dormancy
- Bines grow rapidly in ideal conditions:
 - Up to 18-25" per season
 - Up to one foot per day
 - Wrap clockwise around anything within reach
 - Phototropic (light) and thigmotropic (touch) mechanism
- Lateral 'side arms' extend from the bines

HAAS

Planting

- Timing: late winter to early spring
- Rhizomes:
 - Cut into 6-to 8-inch lengths & transplant immediately into hop yards or put in pots and place in a greenhouse.
 - Lay plants horizontally with bud side up and 1 to 2 inches below the soil surface
- Softwood cuttings:
 - Take from a stem with 1 or 2 nodes & 2 leaves and with 2 to 3 ¼ inches of wood beneath the nodes.
 - Plant in a nursery and grow one season before transplanting to the hop yard

Stages of Production

- Dormancy
- Planting and Spring Regrowth
 - Vegetative Growth
 - Reproductive Growth
 - Harvest
- Preparation for Dormancy

Functions of the Trellis

The trellis is a long-term investment. It should be built to last the life of the vineyard

- Support the vine and the crop
- Expose fruit and foliage to sunlight
- Open canopy to air movement and spray penetration
- Facilitate ease of vineyard operations
 - Pruning, thinning, pest control, harvest

Selecting the Right Trellis Design

- Some thoughts to immediately **discard**:

- "Poles are expensive so let's really space them out"
- "don't need such long poles if I don't put 'em 3 feet in the ground"
- "This thinner wire should work ..."
- "the rows have to be really wide 'cause I got a big tractor"
- "let's grow 10 varieties in 4 rows"
- "we won't need irrigation"
- "fertilizer is just too expensive."
- "healthy hop plants don't get bugs or disease."
- "I'm gonna plant the hops first and then put in the trellis and irrigation ..."

- If you can't get past these – **stop** here to prevent wasting a lot of time and your life savings, otherwise continue reading!



Trellising

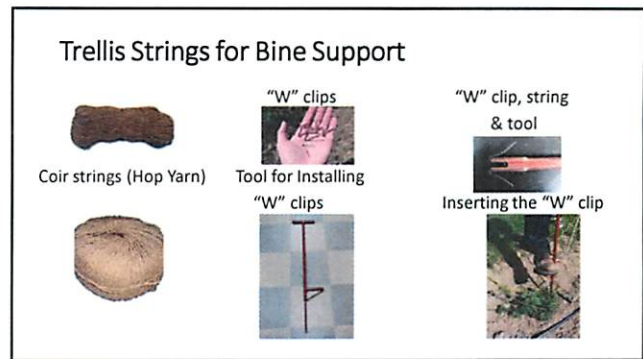
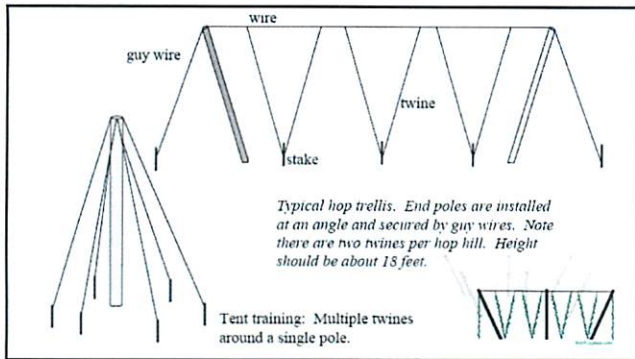
- Most hops trained on tall trellises (18 to 25 ft. tall) to maximize yields
 - Bines most fruitful in a vertical orientation
- Trellis is subject to substantial loads
 - Plant weight = approx. 35 lbs./plant
 - Winds (60 mph wind equivalent to ~ 10 lbs/ft²)



The Trellis

- Heavy poles set with 3 to 4 ft. below ground & 18 to 20 ft. above ground
- Poles spaced every 30 to 60 ft.
- High tensile heavy gauge wire or cable suspended between poles
- Earth anchors to tighten wires at each end of row
- Strings attached to the wire to the ground near a plant and back to the wire in a "V" shape
 - 2 bines will be attached to the strings by wrapping in a clockwise manner on each side of the plant (total of 4 bines/plant)





Training the Bines

- Every year:
 - When bines are 1 1/2 to 2 ft. in length, select 4 bines from each rhizome to keep & remove all others
 - Train 2 bines up each of the 2 support strings on the trellis by wrapping in a clockwise direction.
- Beginning the 3rd year:
 - Remove old bines if present
 - Prune back new shoots to control time of crop maturation & yields and to help reduce disease issues
 - Once bines reach ~6 ft. in height, strip leaves & lateral shoots off the lower 3 ft. to facilitate better air circulation and improve mildew control success

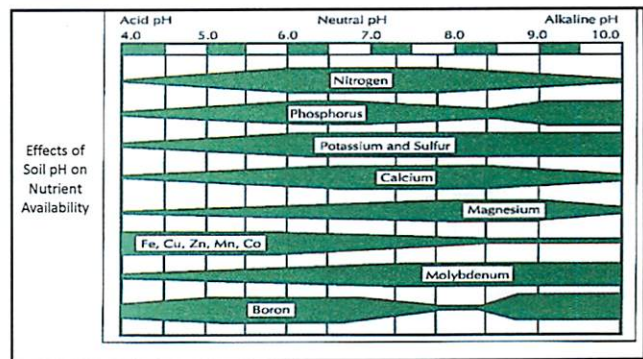
Irrigation

- Irrigation:
 - Can improve yield & quality of hops may positively affect alpha acid concentration
- Hops require ~ 27 to 32 inches of water during the growing season
- 2 critical periods for adequate growth:
 - In spring as the hop plant begins growth
 - Just before flower initiation through cone development
- Supplement rainfall to get 1.0 to 1.5 inches of water/week during dry conditions
- 1st year hop plantings require more frequent watering, but at lower amounts

ON Specialty Crops

Fertilizing hops

- Do not base fertilizer rates on postplant soil test results
 - The correlation between soil test results and the actual nutrient status of the plant can be very poor
 - The value of postplant soil testing is to monitor soil pH
 - Soil pH can affect the availability of nutrients to plants
- Use plant tissue testing to determine the actual nutrient status of the plant and to aid in formulating a fertilizer program for the crop



Two Spotted Spider Mite

Defining features:

- Very small
- Two black spots on back
- Webbing on underside of leaf

When do they appear?

- Prefer hot, dry conditions

Damage:




- Leaf stippling
- Feeding on cones
- Dry, brittle, and browning cones
- Quality and yield reduction

Management:

- Suffice irrigation to reduce dust


Regular scouting is key to monitoring hop pests!

Can cause leaf stippling

Hop Pocket Pest Guide
A pocket guide to the major hop pests in Vermont

Julija Cubins
Cropping Soil Field Technician
Dr. Heather Darby
UVM Extension Agronomist



Hop Aphid

Defining features:

- Light green
- Pear shaped
- Cornicles (butt tubes)

When do they appear?

- Migrate to hop plants in May
- Thrive in cool, wet conditions

Sooty mold:

- Sugary secretions from hop aphid can lead to fungal growth



Feeding damage:

- Feeding can remove water and vascular tissue
- Leaf wilt and curl (reduced photosynthesis)
- Unmarketable cones (limp and brown)

Management:

- Increase natural enemy habitat
- Lady beetles, lacewings, parasitoid wasps
- Use of pesticides if populations remain high after flowering
- Populations tend to decrease in hot, dry weather

Can lead to sooty mold

Potato Leafhopper

Defining features:

- Bright green
- Bullet shaped
- Side-to-side scuttling

When do they appear?

- Variable- they arrive on wind currents from southern US as temperatures rise



Hopperburn:

- V-shaped leaf chlorosis and browning
- Decreases photosynthetic abilities



Management:

- Give them something tastier (trap cropping)
 - Red clover and alfalfa
- Varietal selection
 - Susceptible varieties: Liberty, Mt. Hood, Fuggle, Tettnang, Santium, Newport
- Increase natural enemy habitat
 - Minute pirate bugs, damsel bugs, big-eyed bugs, lacewings, lady beetles, spiders, parasitoid wasps

Causes hopperburn





Japanese Beetles & Cutworms

Diseases of Hops


Powdery mildew



Downy Mildew



Verticillium Wilt



Harvest

- Variety & management dependent (mid-Aug. through late September in Michigan) Harvest date decisions based on variety, cone moisture content, weather, disease & pest issues
- Hops are in prime harvest condition for a short time (7 to 10 days)
 - Premature harvest = loss in yields & flavor in the current season & potential reduced yield in subsequent years
 - Harvesting past prime = reduced aroma & brewing quality, shattering & discoloration

Post-Harvest Hops Care

- Dry cones to reduce moisture from about 80% down to 8 to 12% for storage
- Following drying,
 - allow cones to cool purge
 - Bale
 - Pelletize
 - Nitrogen purge
 - Frozen storage



Stages of Production

Dormancy

- Onset:
 - Can be September through November
 - Shoots and fine roots die
 - Storage roots thicken and accumulate starch
 - Large resting buds develop
- Fieldwork:
 - Contain overgrown roots
 - Apply pre-emergent herbicides and compost
 - Work the ground
 - Set up new hop yards



HAAS

Stages of Production

Spring Fieldwork

- Pruning mature hop yards from March through April (if necessary)
 - Mechanical, then chemical
 - Goal is to prepare consistent shoot length for training and to prevent disease
- Simultaneous weed control
- Dry fertilizer application
- Twining
- Irrigation
- Training



HAAS

Stages of Production

Spring Fieldwork: Training

- Critical component of maximizing yield
 - Too early = early bloom risk
 - Too late = not achieving max yield
 - Train new, soft shoots
 - ~3 bines per string but varies depending on cultivar
- Additional bottom-growth is controlled with desiccant later in season



HAAS

Stages of Production

Vegetative Growth

- Typically May through July
 - From May to early July, most growth is in main bine
 - In July, bulk of growth occurs in lateral production
- Yield is determined in the plant very early, and adding fertilizer at this stage is essential



HAAS

Stages of Production

Summer Fieldwork: Pests, Diseases and Weeds


- Major challenges to quality are pests and diseases
 - Other issues, while impacting yield, may not impact quality as much
- Healthy plants have more defenses
 - Fertilize
 - Irrigate
 - Spray
- Scout fields constantly, every day



HAAS

Stages of Production

Reproductive Growth



- Typically late July through August
 - Trained vegetative growth ceases and is concentrated on hop cones
 - Mature cones can account for up to 50% of aboveground biomass
- Cannot increase number of cones
 - Maintaining plant health will maximize cone weight and quality
 - Fertilize
 - Irrigate
 - Spray

HAAS

Stages of Production

Harvest




- Timing determined by cone moisture
 - Usually mid-August to early October depending on region
 - Dry matter measurements are scaled to ratios of oil or alpha content over time and weight
- Many harvest methods
 - Most common: cut and transport strings and bines to a stationary picking machine
 - Other methods: field strippers, mobile harvesters
 - Still used in addition to a stationary cleaning facility or picking machine

HAAS

Stages of Production

Preparation for Dormancy



- Begins at harvest
 - Typically end of August through September
- Signaled by short days
- Material migration shifts to roots
 - Peaks by October
- Keeping roots healthy is important at this stage
 - Preventing drying (irrigating)
 - Preventing damage

HAAS

Fun Facts...

889 plants or "hills" make up one acre of hops, if planted on a standard 3.5 foot by 14 foot spacing.

In the Pacific Northwest, yields average about 2,000 pounds of dried hop cones per acre on mature hop yards, or a little over two pounds per hill (yields vary depending on variety and location).

Hops are typically sold in 200-pound bales.

A bale will yield between 135 - 800 barrels of beer (31 gallons each), depending on the recipe.

USA HOPS

Resources



Field Guide for Integrated Pest Management in Hops

Hops Production in Indiana

Integrated Pest Management Guide for Hops in Indiana 2014

Hops: Marketing and Cost of Production

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Overview

- Craft industry
- Breweries survey results
- Cost of production
- Marketing and market opportunities

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Growth in the Craft Brewing Industry from 2011 to 2017

United States

2,047 $\xrightarrow{+311\%}$ 6,372

Tennessee

24 $\xrightarrow{+342\%}$ 82

Craft brewery is defined as:

Annual production of 6 million barrels of beer or less (approximately 3 percent of U.S. annual sales). Less than 25 percent of the craft brewery is owned or controlled (or equivalent economic interest) by a beverage alcohol industry member that is not itself a craft brewer.

Source: Brewers Association

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Location of Craft Breweries in Tennessee

- 104 physical locations – several breweries have multiple locations
- Surveys were distributed to 72 breweries (removing those that were not in production, did not have contact information or were bringing beer from outside the state)
- 34 responses were recorded; response rate of 47%

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List of Breweries in Tennessee by City

#	City	Name	Address	City	Zip	Phone Number
1	Chattanooga	Anchor Brewing Company	1000 1/2 N. W. ...	Chattanooga	37403	423-249-9999
2	Chattanooga	Anchor Brewing Company	1000 1/2 N. W. ...	Chattanooga	37403	423-249-9999
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SURVEY RESULTS

Demand for hops by craft brewers in Tennessee

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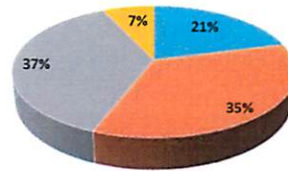
2018 Craft Brewery Survey

- 31 questions on input use, spent grain disposal, and brewery characteristics
 - The size of the craft industry
 - Demand for hops and other inputs
 - Marketing and value added opportunities

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Brewery Business Descriptions, n= 43



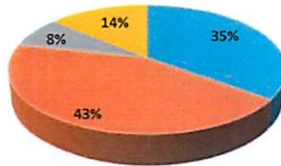
Q: Check the boxes that best describe your business (more than one box can be checked).

■ Brewery ■ Brewery with Bar ■ Brewery with Restaurant and Bar ■ Other

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Brewery Survey Respondents' Business Roles, n = 51



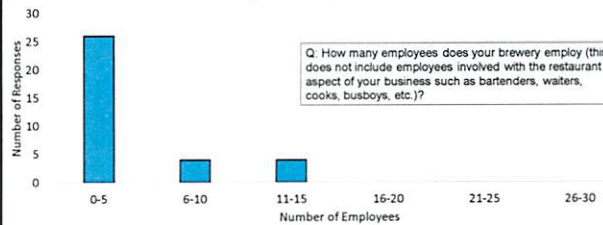
Q: What is your role or position in the business (check all that apply)?

■ Owner/Investor ■ Master Brewer ■ Marketing ■ Other

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Number of Employees Related to the Brewery Operation, n = 34



Q: How many employees does your brewery employ (this does not include employees involved with the restaurant aspect of your business such as bartenders, waiters, cooks, busboys, etc.)?

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Tours Offered

	Craft Brewery, n = 33
Yes	55%
No	45%

Q: Does your craft brewery offer public tours? If yes, indicate the cost per person.

Price of Tours

	Craft Brewery, n = 16
Average	\$3.81
Minimum	\$0.00
Maximum	\$12.00

Implication for hop growers:

Can a tour of the hop yard be incorporated?

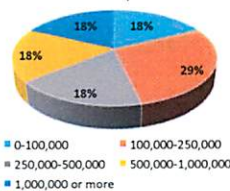
Likely would require partnering with a brewers association

Highly dependent on proximity.

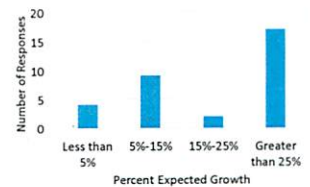
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Annual Gross Alcoholic Beverage Sales - Breweries, n = 28



Expected Sales Increase Over Next Five Years - Breweries



Q: What was the value of your gross alcoholic beverage sales in the last fiscal year?

Q: How much do you expect your sales to increase over the next five years?

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Q: Rank in order of importance factors that may have a negative impact on the anticipated growth of your craft brewery (1 is most important, 7 is least important). N=31.

Average Response Values for Factors Impacting Economic Growth

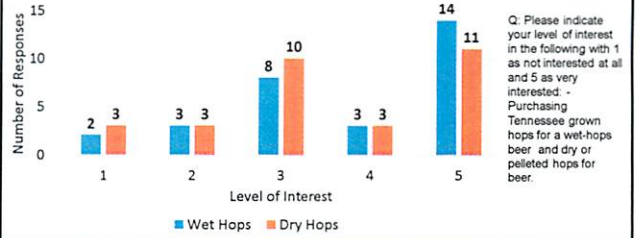
Economic Downturn	Government Regulations	Industry Saturation	Profitability	Quality of Labor	Waste Disposal	Other
3.5	3.1	2.0	3.1	4.5	5.5	6.7

Other responses: poor quality product, high maintenance equipment companies, breweries that don't know what they're doing

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Interest in Purchasing Tennessee-Grown Hops, n = 30

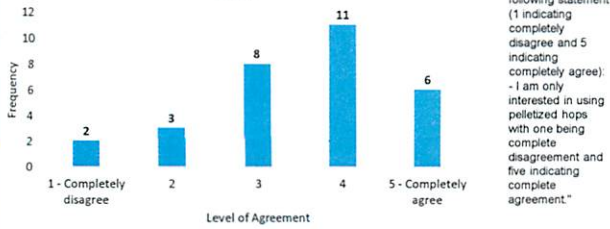


Q: Please indicate your level of interest in the following with 1 as not interested at all and 5 as very interested. - Purchasing Tennessee grown hops for a wet-hops beer and dry or pelleted hops for beer.

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Frequency of Responses When Asked Whether Respondents Are Only Interested in Using Pelletized Hops, n = 30

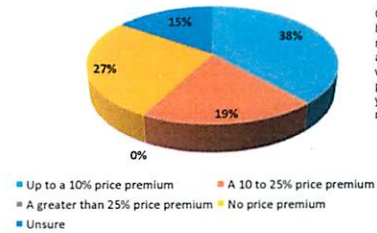


Q: Please indicate your level of agreement with the following statement (1 indicating completely disagree and 5 indicating completely agree): - I am only interested in using pelletized hops with one being complete disagreement and five indicating complete agreement."

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Willingness to Pay a Price Premium for a Tennessee Malting House Using Tennessee-Grown Barley, n = 26



Q: If a commercial malting house using Tennessee malting barley was available in Tennessee, would you pay a price premium (compared to your current supplier) for malt barley of...

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Pounds of Hops Used Annually, n = 30

	Wet Hops	Dry/Pelitized Hops
Average	46	2,301
Maximum	500	16,500
Minimum	0	100

Q: How many pounds of the following categories of hops does your brewery use annually? - Wet hops, Pelitized (or dry) hops - Pounds per year

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Hop Varieties Used at Craft Breweries in Tennessee

- The top five varieties of hops by frequency (not quantity) were:
 - Cascade
 - Citra
 - Mosaic
 - Amarillo (T), Centennial (T), Hallertau (T), and Magnum (T).
 - Simco.
- Other Hops Listed: Ace, Apollo, Azacca, Blanc, Brewers, Calypso, Chinook, Columbus, Crystal, Dorado, ekg, Ekuanol, El, Ella, Enigma, Galaxy, Galena, Gem, Gold, Goldings, Hallertauer, Hood, Loral, Mittlefruh, Motueka, Nelson, Noble, Northern, Nugget, Pacific, Piney, Rakau, Saaz, Sauvín, Sorachi, Summit, Tentenger, Warrior, and Willamette.

Q: Please list the varieties of hops used at your brewery in order of the largest quantity used to the smallest quantity used (if you are unsure please indicate "unsure" in line 1)

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Gallons of Primary Product Produced		
		Last Fiscal Year
		Breweries, n = 19
Average		46,580
Minimum		900
Maximum		384,000
		Current Fiscal Year
		Breweries, n = 24
Average		50,425
Minimum		275
Maximum		400,000

Q: Please provide your estimated production in gallons of primary product (beer) for the last fiscal year and predicted production for the current fiscal year. - Beer (in gallons) - Last fiscal year and current fiscal year

These summaries do not include values of zero for breweries that were not in production for the most recent fiscal year.

Number of Batches Produced Weekly		
		Number of Batches Produced
		Breweries, n = 26
Average		2.65
Minimum		0.25
Maximum		7
		Gallons Produced per Batch
		Breweries, n = 26
Average		1,873
Minimum		10
Maximum		36,000

Q: In the last fiscal year, how many batches did you produce per week? And what was the average batch size? - Gallons per batch




Cost considerations and revenue expectations: highly variable

COST OF PRODUCTION

Cost of Production


- Revenue
 - Multi-year estimates
- Establishment Cost
 - Trellis System
 - Planting
 - Irrigation
- Annual Costs
 - Pre-harvest
 - Harvest

Tremendous variation in costs and revenue exist



Hops Revenue

- In General (% of expected yield): Year 1 – negligible; Year 2 – 50%; Year 3 – 75%; Year 4 and beyond – 100%.
- Yields / Variety
 - Cascade, Nugget, Chinook, and Centennial
 - 1,200 to 1,800 lb established yield?
 - Right now more common 500-1,000 lb
- Prices dried
 - 2017 US average: \$5.96 per pound
 - \$7-\$15 per pound reported regionally (highly variable)



ESTABLISHMENT COSTS

Trellis Construction				
Materials	Quantity	Unit	Cost/Unit	Total Cost
Poles (Black Locust)	77	pole	\$ 80.00	\$ 6,160.00
Wire Rope (1/4")	4000	ft	\$ 0.25	\$ 1,000.00
Wire Rope (3/8")	9600	ft	\$ 0.25	\$ 2,400.00
Eye bolts	84	bolts	\$ 3.25	\$ 273.00
Shoulder bolts	52	bolts	\$ 5.00	\$ 260.00
Turnbuckles	44	turnbuckles	\$ 15.00	\$ 660.00
Ground anchors	52	anchors	\$ 14.30	\$ 754.00
Thimbles (1/4")	340	thimbles	\$ 0.85	\$ 289.00
Cable clamps (1/4")	320	clamps	\$ 0.50	\$ 160.00
Cable clamps (3/4")	300	clamps	\$ 0.80	\$ 240.00
Equipment				
Auger	4	day	\$ 100.00	\$ 400.00
Forklift	4	day	\$ 350.00	\$ 1,400.00
Lift	12	day	\$ 235.00	\$ 2,820.00
Drill	1	tool	\$ 40.00	\$ 40.00
Cable cutter	1	tool	\$ 30.00	\$ 30.00
Come-a-long	1	tool	\$ 40.00	\$ 40.00
Hayen 8"p	1	tool	\$ 60.00	\$ 60.00
Labor				
Bobcat and auger work	24	hours	\$ 7.25	\$ 174.00
Setting poles	72	hours	\$ 7.25	\$ 522.00
Ground anchor installation	32	hours	\$ 7.25	\$ 232.00
Anchoring posts	56	hours	\$ 7.25	\$ 406.00
Top wire installation	88	hours	\$ 7.25	\$ 638.00
Bottom wire installation	48	hours	\$ 7.25	\$ 348.00
Total Trellis Construction Costs				\$ 19,153.00

Source: Virginia Tech/MSU Budget

Trellis Construction

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Planting Cost				
Planting				
Materials	Quantity	Unit	Cost/Unit	Total Cost
Rhizomes	800	rhizomes	\$ 2.00	\$ 1,600.00
Mulch	20	cubic yards	\$ 18.00	\$ 360.00
Labor				
Planting	96	hours	\$ 7.25	\$ 696.00
Mulching	24	hours	\$ 7.25	\$ 174.00
Site Prep				
Discing	1	acres	\$ 15.00	\$ 15.00
Total planting costs				\$ 2,845.00

Source: Virginia Tech/MSU Budget

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Irrigation System				
Materials	Quantity	Unit	Cost/Unit	Total Cost
Mainline (10" 3/4" PVC)	40	sections	\$ 2.10	\$ 84.00
Laterals (1/2" poly)	4	roll (1000')	\$ 120.00	\$ 480.00
PVC fittings (risers)	160	fitting	\$ 0.49	\$ 78.40
Poly tube fittings	40	fitting	\$ 0.54	\$ 21.60
Irrigation pump (1 HP)	1	pump	\$ 280.00	\$ 280.00
Pump fittings	4	fitting	\$ 8.00	\$ 32.00
Pressure regulator	1	fitting	\$ 12.50	\$ 12.50
Mesh filter	1	filter	\$ 18.00	\$ 18.00
Cistern (10000 gallon)	1	cistern	\$ 5,800.00	\$ 5,800.00
Drip emitters (2000 total)	8	bags	\$ 62.50	\$ 500.00
Zip ties (4000 ties)	4	bags	\$ 24.50	\$ 98.00
Labor				
Dig mainline trench	12	hours	\$ 7.25	\$ 87.00
Install mainline	60	hours	\$ 7.25	\$ 435.00
Zip tie laterals	16	hours	\$ 7.25	\$ 116.00
Install drip emitters	28	hours	\$ 7.25	\$ 203.00
Cistern and pump setup	5	hours	\$ 7.25	\$ 36.25
Total Irrigation System Costs				\$ 8,281.75

Source: Virginia Tech/MSU Budget

Irrigation Costs

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Establishment Costs Summary	
Cost Category	1 Acre Cost
Total Trellis Construction Costs	\$ 19,153.00
Total Planting Costs	\$ 2,845.00
Total Irrigation System Costs	\$ 8,281.75
Total Establishment Costs	\$ 30,279.75

Source: Virginia Tech/MSU Budget

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Annual Costs	
Example (Adopted from MSU Budgets)	Established Levels
Pre-harvest	
Coir (String & Clips)	480
Labor	1,500
Insect/Weed/Disease Control	600
Consultants	100
Fertilization	275
R&M	250
Machinery/Labor	950
Total	4,155
Harvest	
Labor	600
Machinery	1,250
Total	1,850
Post Harvest	
Picking and processing	9,000
Transportation and Marketing	500
Total	9,500
Total	15,505

Source: Virginia Tech/MSU Budget

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Cost of Production Summary			
• Establishment Costs = \$8,000-\$36,000 per acre			
• Annual Costs = \$8,350-\$15,500 per acre			
• Revenue: \$3,500 (\$7/lb x 500lb) to \$27,000 (1,800 lb x \$15)			
	Average	Low	High
Establishment Costs (annualized): \$/acre	\$3,205	\$1,409	\$6,484
Annual Costs: \$/acre	\$11,257	\$8,350	\$15,505
Total Cost: \$/acre	\$14,462	\$9,759	\$21,989

• Huge variations in reported establishment and annual costs
• Labor versus capital cost for harvest and other functions

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Strategies

MARKETING AND OTHER MARKET OPPORTUNITIES

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Other Sources of Revenue

- Group picks
- Special events
- Hop yard tours
- Processing drying / pelletizing / hop extract
- Custom harvesting / machinery share

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Other Market Opportunities

- Craft Breweries
- Home Brewing
 - Data deficient
- Agri-Tourism
- Vertical integration of the marketing system
- Co-operatives

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Questions and discussions

THANK YOU

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