HERE’S TO THE MOMENTS
That make brewing beer the best job in the world.

Hans shares your passion for creating flavors that people love. From field to glass, everything we do is to help you brew great beer. Haas is here for your success.

John Eaton, Brewing Manager, Craft Beer Alliance

www.johnihaas.com
Getting Started

• Hops… in Michigan?
  • Growing Pains
  • Considerations
  • Cultivar Selection
Where to Start?

• Thinking about hops! …over a beer perhaps?
• There are many things to consider
• Locations of U.S. hop production:
  • Washington: 74%
  • Oregon: 14%
  • Idaho: 10%
  • Other States: 2%
• U.S. hop economic value:
  • $ 272 million in 2014
  • Crop value has been turbulent

<table>
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<tr>
<th>Marketing Year</th>
<th>Total Crop Value (x 1,000)</th>
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<tr>
<td>2005</td>
<td>$102,818</td>
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<tr>
<td>2006</td>
<td>$118,008</td>
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<td>2009</td>
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<td>$214,589</td>
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<td>2011</td>
<td>$203,378</td>
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<td>2012</td>
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<td>$232,308</td>
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<td>2014</td>
<td>$271,992</td>
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Source: USDA-NASS, prepared by Hop Growers of America
Agriculture is an important industry in MI!
• 2\textsuperscript{nd} only to CA in U.S. for crop diversity
• Although CA leads in U.S. for economic activity generated from agriculture (~$100 bil.)
• … according to Wikipedia

Source: Michigan Ag Council (www.michiganagriculture.com)
Thinking About Hops?

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- Agriculture, especially when diverse, is a GOOD economic driver
  - Healthy, more buffered, fun
  - Interest in hop production is not surprising
Getting Started

Growing Pains

- Increasing acreage of hops is expensive relative to other crops
  - Labor
  - Pesticides & Fertilizer
  - Equipment
  - Infrastructure (can cost millions of dollars)
    - Picking machine
    - Kiln
    - Cooling/conditioning, baling, and storage
Getting Started

Considerations

• Climate
  • Day length drives hop maturity (photoperiod sensitive)
  • Latitude determines day length
  • Heat determines growth during each stage
50\textsuperscript{th} Parallel

40\textsuperscript{th} Parallel

30\textsuperscript{th} Parallel

HAAS
Getting Started

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• Climate
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• Soil type
  • Physical: soil texture, drainage
  • Chemical: pH and nutrients
  • Biological: microbes, organic matter, etc.
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- Most suitable cultivar?
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-NASS, prepared by Hop Growers of America
Basic Hop Physiology

• Phylogeny
  • Roots and Rhizomes
  • The Bine and Aboveground Plant
    • Dioecious Flowers
  • Components of the Hop
Basic Hop Physiology

Hop Phylogeny

• Family: Cannabaceae
  • Cannabis
    • C. sativa
  • Humulus spp.
    • H. lupulus
    • H. japonicas
    • H. yunnanensis

• H. lupulus variety we cultivate:
  • H. lupulus var. lupulus

• Other, infertile varieties:
  • H. lupulus var. cordifolius
  • H. lupulus var. lupuloides
  • H. lupulus var. neomexicanus
  • H. lupulus var. pubescens

(Neve, 1991)
Basic Hop Physiology

Root System

- Water roots:
  - Grow deep in soil
  - Location of plant’s energy reserves
- Crown:
  - Large, central mass of roots
  - Produces many shoots
- Rhizomes:
  - Produce buds that become new spring growth
  - Can be extracted to plant new hop yards
  - Typically found closer to surface
  - Covering bines with soil creates more rhizomes
- Fine Roots
- Rhizome/root system will grow extensively if not managed
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
Hops (C3 plant) have a growth rate that exceeds that of corn and sorghum (C4 plants).
Aboveground Plant Growth

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Source: www.hgtv.com
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  - Phototropic (light) and thigmotropic (touch) mechanism

Source: www.plantandplate.com
Basic Hop Physiology
Colorized scanning electron microscope image of hop trichome.

Photographed at Ludwig Maximilians University, Munich, Germany by Dr. Andre Kempe
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- Lateral ‘side arms’ extend from the bines
Basic Hop Physiology

Flowers

- Dioecious: plants are either male or female (there are some exceptions)
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Female plants produce commercially valued strobiles, or hop cones
Male plants are valued for breeding
Pollination undesirable in commercial fields:
  - Seeds
  - Increased cone size
Basic Hop Physiology

The Hop Cone

- Hop cones contain the commercial value of the plant
The Hop Cone

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  - Amazing phytochemical content in lupulin glands!
    - 100+ essential oil compounds
    - Important alpha acids, beta acids and resins
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  - Amazing phytochemical content in lupulin glands!
    - 100+ essential oil compounds
    - Important alpha acids, beta acids and resins
- Lupulin glands are actually modified trichomes (glandular trichomes)

Source: www.planttrichome.org
Lupulin glands account for 20-30% of cone weight.

**The Hop Cone**

Isolation of glandular trichomes from female hop bracts:

A. Glandular trichomes at the base of the female bracteole

B. Female bracteole after trichome isolation

C. Isolated glandular trichomes

Source: American Society of Plant Biologists (www.plantphysiol.org)
Stages of Production

• Dormancy
• Planting and Spring Regrowth
  • Vegetative Growth
  • Reproductive Growth
• Harvest
• Preparation for Dormancy
Stages of Production

- **Determined by photoperiod**
  - Shorter day lengths signal maturity
  - Longer day lengths signal vegetative growth
  - Different cultivars respond to different photoperiodic signals
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’
Dormancy

- Onset:
  - Can be September through November
  - Shoots and fine roots die
  - Storage roots thicken and accumulate starch
  - Large resting buds develop
Dormancy

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  - Shoots and fine roots die
  - Storage roots thicken and accumulate starch
  - Large resting buds develop

- **Fieldwork:**
  - Cut back overgrown roots
  - Apply pre-emergent herbicides and compost
  - Work the ground
  - Set up new hop yards
Stages of Production

Planting a New Crop

- 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

Left, Dark discoloration of rhizomes infected with *Pseudoperonospora humuli*.
Right, Healthy rhizome. (C. B. Skotland)
New commercial hops come from clonal sources; genetically identical to parent material
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Several hop yard schemes
  - Most common in U.S.: 18.5’ tall x 14’ between rows x 3.5’ between plants
  - Many other layouts:
    - Row spacing: between 7’ and 14’
    - Between plant spacing: at least 1’
    - Low-trellis options
Rhizome pieces and crowns can be planted directly into new fields
- Low temperatures are ok
• Rhizome pieces and crowns can be planted directly into new fields
  • Low temperatures are ok
• Rhizome pieces can also be propagated in pots
  • Kept in greenhouses or cold-frames for planting later in the season (after dormancy period)
  • Requires period of exposure to the elements before direct planting
  • Longer shoots must be cut
  • Typically planted after frost season
  • More expensive
Planting Softwood Cuttings

- Softwood cuttings are typically one or two nodes
- Generally not preferred over direct planted or potted rhizomes
  - Weaker tissue, requires delicate establishment of roots
  - More time, greenhouse space and resources
- Used to increase acreage of new cultivars with limited parent material
  - Can get thousands of new plants from one
**Onset:**
- Typically March through May
- Signaled by increasing day length and temperatures
- Storage roots are depleted as shoots emerge rapidly from over-wintered buds
**Stages of Production**

**Spring Fieldwork: Pruning, Weeding, Fertilizing**

- Chemical or mechanical pruning from March through April
- Goal is to prepare consistent shoot length for training and to prevent disease
- Established plants produce more shoots than new plantings
- Weeding is accomplished at same time
- Dry fertilizer application
  - Split applications better
  - As-needed basis is best
Stages of Production

Spring Fieldwork:
Twining and Irrigation

• Rough coir or paper
  • Germany actually uses wire
Stages of Production

Spring Fieldwork: Twining and Irrigation

- Rough coir or paper
  - Germany actually uses wire
- Best yields can be attained when twine is at >65° incline
  - Ideal rate of growth with more internodes; therefore more laterals
  - Can depend on cultivar
- In PNW, drip irrigation installed along with twine
  - Hops require about 2 acre-feet, or 20-30 inches of water
Spring Fieldwork: Training

- Critical component of maximizing yield
  - Too early, too much vegetation
  - Too late, not enough vegetation

- Select newest shoots
  - Soft, supple, many nodes
  - # of shoots depends on cultivar, usually 3

- Weeding and removal of older shoots is done at training
Stages of Production

Spring Fieldwork: Training
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
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Yield is determined in the plant very early, and adding fertilizer at this stage is essential
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
- Goal is to have healthy crop while managing growth
  - Smaller internode length is better
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

Basal foliage stripping

Scout fields constantly, every day.
Reproductive Growth

- Typically late July through August
  - Vegetative productions nearly ceases
  - Growth 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

Stages of Production
Harvest

- Timing determined by cone moisture
  - Can be mid-August to early October depending on region

- Many harvest methods
  - Most common: cut and transport strings and bines to a stationary picking machine
  - Field strippers and mobile harvesters are also used
    - Almost always used in addition to a stationary picking machine
Stages of Production

Harvest
Stages of Production

Harvest
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- Hops are picked and cleaned in one facility...
Harvest

- Hops are picked and cleaned in one facility…
- Dried in the kiln…
Stages of Production

Harvest

• Hops are picked and cleaned in one facility…
• Dried in the kiln…
• Cooled and baled…

Source: Rogue Farms, Independence, OR
Stages of Production

Harvest

- Hops are picked and cleaned in one facility…
- Dried in the kiln…
- Cooled and baled…
- Then shipped to cold storage before downstream processing

Source: www.deck-donohue.com
Preparation for Dormancy

- Typically end of August through September
  - Signaled by short days
  - Aboveground growth is over
  - Starch and soluble sugars are transported to roots
  - Accumulation in roots peaks by October
- Important to continue irrigating through this stage
Re-cap

• There are many things to consider about growing hops
  • Hops are physiologically complex
  • New cultivars are continuously developed

• Stages of production require different management schemes
  • Requires thinking ahead; each growth stage pre-determines the next few stages
Take Home Message

• Quality is the #1 goal:
  • Value will be realized in the quality you produce
  • To achieve consistent quality, know your plants and your environment
  • Can be a lot of work and expense while not always a high value

• Next steps are to collect a lot of information
  • The management decisions you make will depend on your specific region
  • How do you know if your management scheme is optimal?
  • How do you measure a response?
Thank You!