Hops

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MSU Beginning Farmer Series
February 24, 2014
Outline

• History
• Natural History and Taxonomy
• Characteristics and Growth Habits
• Production Stages
• Processing
• Economics and Market Trends
• Resources
Hops Gain a Foothold in The U.S.

• Dutch probably 1st to bring hops to the New World in early 1600’s

• Native hops could be found in woods, but Dutch law required hops to be imported

• New England colonists 1st to establish cultivated hops crops as early as 1628

• Massachusetts promoted “healthy” malted beverages

• Used imported, locally grown and wild hops

Source: *Tinged With Gold, Tomlan, 1992*
Hops Gain a U.S. Foothold

1839  

1859

Each dot represents 100,000 bales (1 bale = 200 lbs. dried hops)

Source: *Tinged With Gold*, Tomlan, 1992
Hops Gain a U.S. Foothold

By 1920’s majority of production had moved west

Source: *Tinged With Gold, Tomlan, 1992*
HOPS ARE KING!

Wherever raised in the North-West.

JUST PUBLISHED—A Treatise giving Plain Directions and the Practical Details, from the selection and Preparation of the Soil and Setting and Cultivation of the Plants, to Picking, Drying, Pressing and Marketing the Crop, as practiced in Sauk County, Wisconsin. Every Hop Grower and Farmer in the North-West should have one of these Pamphlets. By D. B. & E. O. RUDD, Practical Hop Growers of eight years' experience in said County.

Enclose Fifty Cents to GEORGE B. BURROWS, No. 100 State Street, Chicago, and he will send by return mail (post paid) a copy of this valuable work. Ten copies to one address, $4.00; twenty copies to one address, $7.50.

A HOP YARD

Is More Profitable than a Gold Mine.

The Hop Growers of Wisconsin have averaged for the past two years from $700.00 to $800.00 profit per acre.

Sauk County (Wis.) English Cluster Hop Roots for sale by

Geo. B. Burrows,
Natural History and Taxonomy

• *Humulus* is the genus of herbaceous climbing plants that most likely originated in China, but is indigenous to temperate areas of the northern hemisphere including Asia, Europe, and N. America.

• *Humulus* is one of two genera in the Cannabinaceae family, the other being *Cannabis*.

• Though there are three distinct species *H. lupulus*, *H. japonicus*, and *H. yunnanensis* all commercial hops are of the *Humulus lupulus* (common hop) species.
What are Hops?

• Hops are dioecious (male and female plants)
• Perennial below ground
• Annual above ground
• Produce annual bines from an overwintering rhizome (below ground stems)
The Cones

- Only the female flower “strobile” or “cone” is desirable for use in beer production
- Male plant-no real commercial value except in breeding programs
- Cones (0.5-4 in.) light green, papery, contain Lupilin glands (modified vine hairs)
- Glands contain the alpha and beta acids, and essential oils
Two Distinct Markets

- **Alpha/Bitter**
  - Processed hops
  - Yield measured in kg. Alpha per acre
  - Typically hi-alpha varieties, increasingly aroma
  - Eg. columbus, nugget

- **Aroma**
  - Minimal processing
  - Yield measured in lb. per acre
  - Typically aroma varieties
  - Eg. Cascade, crystal, amarillo,
Lupulin

- Essential oils: well over 100 compounds contribute to aroma
- Soft resins: beta acids, and the all important alpha acids.
Photoperiod Sensitivity (why location matters)
Results in: Hop Production Stages

• Stages of Growth
  – Dormancy
  – Spring regrowth
  – Vegetative growth
  – Reproductive growth
  – Preparation for dormancy

• Each stage requires its own unique management regime

Source: Jason Perrault, Perrault Farms
Dormancy (October-March)

- In late summer the plant allocates photosynthetically derived starches to the storage roots
- Starch is converted into soluble sugars
- Sugars are the energy needed for spring-regrowth

- In the field
  - Not much happening
  - Planning for next season

Source: Jason Perrault, Perrault Farms
Hops: Site Selection

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU
Beginning Farmer Series
February, 2014
Factors that can impact hop production (growth, yield, and quality)

- Environment (temp, day length, soil texture, weather)
- Production Practices
  - Cultivar
  - Soil fertility
  - Disease, pest, and weed pressure and control
  - Training and timing of training
  - Harvest and harvest timing
  - Irrigation
  - Post-harvest processing and storage
Environment

- Grow in a variety of soils from clay to sand
- Prefer well-drained soils
  - Sandy loam or silt loam
- Problem with heavy, poorly drained soils
  - May delay getting into field
  - Increase disease issues/rotting
- Problem with overly sandy soils
  - Hi input costs

Source: Neve, R.A. Hops. 1991
### 10B—Perrinton loam, 2 to 6 percent slopes

#### Map Unit Setting
- Elevation: 580 to 1,120 feet
- Mean annual precipitation: 28 to 38 inches
- Mean annual air temperature: 37 to 55 degrees F
- Frost-free period: 113 to 185 days

#### Map Unit Composition
- Perrinton and similar soils: 90 percent

#### Description of Perrinton
- **Setting**
  - Landform: Moraines, till plains
  - Landform position (three-dimensional): Rise
  - Down-slope shape: Linear
  - Across-slope shape: Linear
- **Parent material**: 24 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

#### Properties and Qualities
- **Slope**: 2 to 6 percent
- **Depth to restrictive feature**: More than 80 inches
- **Drainage class**: Moderately well drained
- **Capacity of the most limiting layer to transmit water (Ksat)**: Moderately to low to moderately high (0.06 to 0.20 in/hr)
- **Depth to water table**: About 30 inches
- **Frequency of flooding**: None
- **Frequency of ponding**: None
- **Calcium carbonate, maximum content**: 30 percent
- **Available water capacity**: Moderate (about 7.9 inches)

#### Interpretive Groups
- **Land capability (nonirrigated)**: 2e

#### Typical Profile
- 0 to 9 inches: Loam
- 9 to 13 inches: Clay loam, fine sandy loam
- 13 to 28 inches: Clay
- 28 to 38 inches: Clay
- 38 to 80 inches: Clay

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<th>Map Unit Symbol</th>
<th>Map Unit Name</th>
<th>Acres in AOI</th>
<th>Percent of AOI</th>
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<td>Kalena sand, 12 to 18 percent slopes</td>
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Totals for Area of Interest | 223.2 | 100.0%
Hops and pH

- pH optimum (6.2-6.5)
- Lime if too low
# Kinsey Agricultural Services, Inc.

**Plot ID: G3F7Y**

Client: MICHIGAN STATE UNIVERSITY EXTENSION  
City: SUTTONS BAY, MI  
Date: 12-Sep-12

## Location Details

**Crop:** HORT STATION  
**Soil:** HOPS / HOPS  
**Lab No.:** 86103

## Previous Analyses & Applications

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<th>FOR CONVENTIONAL</th>
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## Exchangeable Hydrogen (10 to 15%)

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<tr>
<td>SODIUM</td>
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## Ancillary Notes

- Apply 1 week or so before spring growth begins.
- Apply 1 week or so before bloom.
- Work into soil immediately or water in with a minimum of 1/2 inch of water.
- Apply in early spring.
- Apply at bloom.
- Apply at bloom.
- Sulfur applications including the sulfate form of 50 lbs/acre or more need to be applied at least 6 months prior to next soil sampling.
- Apply an additional 300 lbs/acre of Potassium Sulfate (0-0-60) during the growing season.

**NOTE:** Could use compost here if Ca & Mg levels in the compost are not too high. Should not be applied through without an analysis first to determine the effects this would have on soil nutrient content.

All recommendations are to be soil-applied and broadcast unless otherwise specified.
Topography

- Photo credit: Maggie Hoffman
Wind Direction and speed?
Latitude and Daylength

45° 45° 0°
What Varieties to plant?

1. What brewers want
2. Yields
3. Disease susceptibility
4. Location-soil type, etc.
What Varieties to plant?

1. What brewers want
2. Yields
3. Disease susceptibility
4. Location-soil type, etc.

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<td>1,949</td>
<td>4.66%</td>
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International Hop Variety Trial III
R.A. Neve 1983

Goals
1. Compare performance of 3 new cultivars all seedlings of N. Brewer
2. Determine extent to which they were adapted to the environment where they were selected

Methods
• All bred and selected in different countries at different latitudes
• All planted at 4 different latitudes: 46 ° N, 47 ° N, 48 ° N, 51 ° N

Results
• “Marked adaptation to the conditions under which they were selected....related to flowering dates and yield”
• “Significant reduction in yield as the cultivars were moved away from their place of origin”
To Sum

• Hop cultivars will generally do well in regions that are similar to where they were developed
• Soils
  – Will do well in most soils, but consider management costs
• Latitude (sunlight, day-length)
• Climate
• Topography
Hops: Trellis Design

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU
Beginning Farmer Series
February, 2014
Climbing bines

- Bine climbs with the aid of “Trichomes”
- In the wild-they climb up companion species
- Commercial production- Requires a trellis system for support
- Typical set-up
  - 18’ tall
  - Plants spaced 3’ x 14’
  - 1000-1200 plants/acre
- Vine wraps around string-clockwise-function of phototropism (light) and thigmotropism (touch)
Conventional High Trellis
Standard Tall Trellis Hopyard Design
Carr creek hops
Important to build a Solid Trellis!!
Short Trellis

- 3’ x 8’, 9’, or 12’
- Labor Reduction
- Lower Establishment Cost
- Lower yields
- Ill-adapted varieties
Alternative Spacing: NZ
SPRING

Spring Regrowth (April-May)

• Increasing day lengths and temperatures - signal for end of dormancy
• Plant uses soluble sugars as energy to emerge from dormancy and begin regrowth
• Initial regrowth occurs-rapidly producing vines unsuitable for production
• Plant relies on energy reserves of the root until end of May, when the starches and sugars reach their lowest points of the year
• Supplemental nutrient management is needed to maximize plant health

Source: Jason Perrault, Perrault Farms

Photo credit: Erin Lizotte
Spring Regrowth (April-May)

• In the Field
  • Soil Test
  • Stringing
  • Spring pruning-April (removing initial growth)
    • Encourage more hearty secondary growth
    • Reduce disease
  • Weed Control
  • Fertilizer application
  • Training-one of most important aspects of hop production
    • Timing is varietal specific
    • Generally 3 vines per string
  • Irrigation begins

Source: Jason Perrault, Perrault Farms
**Kinsey Agricultural Services, Inc.**

**Plot ID: G3FTY**

**Location:**
- **Crop:** HORT STATION
- **Lab No.:** 86103

**Previous Analyses & Applications**

<table>
<thead>
<tr>
<th>FOR ORGANIC</th>
<th>FOR CONVENTIONAL</th>
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<tbody>
<tr>
<td>%</td>
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**Recommendations**

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<tr>
<th>Amendment</th>
<th>Lbs/Acre</th>
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<tr>
<td>FEATHER MEAL 11-4-0 (a)</td>
<td>4.56</td>
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<tr>
<td>FEATHER MEAL 13-0-0 (b)</td>
<td>375</td>
</tr>
<tr>
<td>COMPOST</td>
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<tr>
<td>UREA 46-0-0 (c)</td>
<td>46</td>
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<tr>
<td>AMSULF 21-0-6-10 (d)</td>
<td>125</td>
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<tr>
<td>CAN 17 N (e)</td>
<td>50</td>
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<td>LIQUID N 10% (f)</td>
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**Anions**

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<th>SULFATE-S</th>
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<td>SULFUR 90-92% (g)</td>
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**Cations**

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<th>POTASSIUM</th>
<th>Value Found</th>
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<tr>
<td>POT SULFATE 0-0-50 (h)</td>
<td>250</td>
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<th>SODIUM</th>
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<td>F.P.M.</td>
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**Traces**

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<tr>
<th>BORON</th>
<th>ppm</th>
<th>ppm</th>
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<tr>
<td>DORAX 11%</td>
<td>20</td>
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<table>
<thead>
<tr>
<th>IRON</th>
<th>ppm</th>
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<tr>
<td>DORON 14.3%</td>
<td>16</td>
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<table>
<thead>
<tr>
<th>MANGANESE</th>
<th>ppm</th>
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<tr>
<td>MANG SULF 28%</td>
<td>50</td>
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<table>
<thead>
<tr>
<th>ZINC</th>
<th>ppm</th>
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<tbody>
<tr>
<td>ZINC SULFATE 35%</td>
<td>35</td>
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**Notes:**
- Apply 1 week or so before spring growth begins.
- Apply 1 week or so before bloom.
- Travel for irrigation, or water in with a minimum of 1/2 inch of water.
- Apply in early spring.
- Apply at bloom.
- Apply at bloom.
- Sulfur applications including the sulfate form of 50 lbs/acre or more need to be applied at least 6 months prior to next soil sampling.
- Apply an additional 350 lbs/ton of Potassium Sulfate (0-0-60) during the growing season.

**NOTE:** Could use compost here if Ca & Mg levels in the compost are not too high. Should not be applied though without an analysis first to determine the effects this would have on soil nutrient content.

ALL RECOMMENDATIONS ARE TO BE SOIL-APPLIED AND BROADCAST UNLESS OTHERWISE SPECIFIED.
What to test

- Soil pH
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Zinc
- Boron
- Manganese
- Organic matter
- C.E.C.
Essential Plant Nutrients for Growth-Derived from soil and/or fertilizer

**Macronutrients**
- **Primary:**
  - N – Nitrogen
  - P – Phosphorus
  - K – Potassium
- **Secondary:**
  - S – Sulfur
  - Mg – Magnesium
  - Ca – Calcium

**Micronutrients**
- Zn – Zinc
- B – Boron
- Fe – Iron
- Mn – Manganese
- Cu – Copper
- Mo – Molybdenum
- Ni – Nickel
- Cl – Chlorine
Soil testing and tissue testing

• A & L Great Lakes Lab, Inc., 3505 Conestoga Drive Fort Wayne, IN 46808. (219) 483-4759

• Michigan State University, Soil & Plant Nutrient Lab, Plant & Soil Sciences ,1066 Bogue St. Room A81 East Lansing, Mi 48824-1325, Phone: 517-355-0218, Fax: 517-355-1732 Website: http://www.spnl.msu.edu

• Kinsey Agricultural Services, Inc. 297 County Highway 357 - Charleston, Missouri 63834 Telephone (573) 683-3880 Fax (573) 683-6227 www.kinseyag.com (soil only)

• There are many others- these are just a few.
Pruning/crowning
Hops: Planting, Stringing, Training, Thinning

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU IPM Academy
February, 2014
Hop Propagation from rhizomes

Rhizomes: horizontal underground stem that emerges from plant roots
Planting

- Michigan is moving away from rhizomes
  - Disease
  - Reliability
  - New local supplies of certified plants

- Plant starts can be planted throughout the growing season but generally in spring

- Have your trellis and irrigation in place before planting

Photo Credits: Great Lakes Hops
String Options

- Sri Lanka Coconut husk Coir Twine
- Compressed bales 3200 - 3400 strings
- Breaking strength of 75-100 lbs.
- Can be pre-cut to 22’

- Wet strength bio-degradable twisted paper strings and ties (Kerr supply)
- Breaking strength of over 80 - 100lbs and can be cut to any desired length
- Easier to handle than compressed bales
- Treated if using in-ground w/ clips
- Untreated if organic (different above ground clips that can be reused)
- Michigan supplier-American Twisting Co.

Photo credit: Michiganhops.com
• At least 2000 strings/acre (2 per plant)
• Video

http://roguefarmsblog.wordpress.com/category/crops/hops-crops/
Meanwhile In Michigan
2 options for stringing

1. W clips
2 options for stringing

2. Tie strings to a lower wire

http://onspecialtycrops.wordpress.com/2013/05/14/hop-update-may-14-2013-stringing-trellising-and-irrigation/
Training

• 3-4 bines
• Clockwise only
• Timing-Cultivar and weather dependent
• Will likely have to re-train
Training Date

- Early training can lead to reduced yield (ex. Galena)
- Training date is variety-specific but usually occurs during May in the Willamette valley.
- Very little information in the literature as research results have been inconclusive.

Source: Townsend, S. Factors affecting hop production and quality.
Hops: Irrigation

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU IPM Academy
February, 2014
Irrigation

- 75-80% of total annual hop water use occurs after mid-June
- Greatest daily amounts late July-early August
- Majority of roots are in top 4’
- Hops usually extract 50-60% from top 2’, but can extract water from 8’ or below
- Overall use around 30 inches/year, depends on season

Irrigation Tips

- Baby plants more frequent light applications
- Carefully monitor soil water levels (tensiometer)
- With drip you should always think about clogged emitters:
  - Algae, silt or chemical deposits, etc.
  - Filtration, acid injection, chlorine injection.
- Applying fertilizers without enough water can lead to salt buildup
- Weed control—very important
- Good mite and aphid control—will reduce stress on plants
- Do not underwater
- Right size your well for your acreage
- Different zones for different cultivars
Irrigation: Examples

• Puterbaugh Farm-RAM pressure compensating- emitters every two feet.
• 2-4 hours cycles every other day in cooler temps, every day in hot temps
• Take the soil to saturation level but not beyond, because it would take fertilizer too deep.
• Flush lines once a month-flushes out sediment.

http://hopsdirect.blogspot.com/2008/07/drip-irrigation-systems.html
Irrigation: Examples

• Loftus Ranches
• Run two drip tubes per row
• 8 gallons per plant per day in hot season (4 on, 8 off, 4 on)
• ~8000 gallons/acre
Irrigation: Examples

NWMHRC

• Run one drip tube per row
• .42 gallon emitters every two feet
• RAM tubing
• 30 minute flush, 45 minute fertigate, 30 minute flush (every other day)
• NOT ENOUGH WATER
Fertigation
Vegetative Growth (May-July)

• Critical Stage for the purposes of crop production, occurs from end of May-end of July
• Two Phases:
  1. May-early July: Plant growth mainly in main vine and leaves
  2. July: Bulk of above ground growth occurs in the lateral production (side arms)

• Plant reserves used up
• Plant already determining yield
  • Aggressive management!!
  • Maximize health of plant & growth

Source: Jason Perrault, Perrault Farms
Vegetative Growth (May-July)

- In the Field
  - IPM-monitor, monitor, monitor
  - Pest/Disease/Weed Control
  - Fertility Management
  - Irrigation

Source: Jason Perrault, Perrault Farms
Hops: Fertility

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU IPM Academy
February, 2014
Hop Growing Requirements: Fertility

- Soil Test Before planting
- Tissues Tests and Soil tests
- Recommended fertilization rates:
  - Nitrogen (N) = 120-140 lbs/acre
    - Mid-April with urea (40-0-0) every 2-3 weeks then later come in with triple 16
    - End in late-June
    - No more than 25 lbs/acre at one time
  - Phosphorous (P) = 60-100 lbs/acre
  - Potassium (K) = 100 lbs/acre (potash)
Organic Hop Growing Requirements: Fertility

- Manure and compost
- Leguminous cover crops
- Bone meal, feathermeal, bloodmeal, kelp, etc.
- USDA national organic program: [http://www.ams.usda.gov/AMSv1.0/nop](http://www.ams.usda.gov/AMSv1.0/nop)
- OMRI approved fertilizers: [http://www.omri.org/simple-opl-search/results/fertilizer](http://www.omri.org/simple-opl-search/results/fertilizer)
- Talk to your certifier (example: MOSA in Wisconsin)
Organic Fertilizers- what’s acceptable

- Naturally occurring fertilizers or amendments

<table>
<thead>
<tr>
<th>Animal Derived Sources</th>
<th>Release time</th>
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<tbody>
<tr>
<td><strong>Material</strong></td>
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<tr>
<td>bone meal (6-12-0)</td>
<td>1-4 mo.</td>
</tr>
<tr>
<td>blood meal (12-0-0)</td>
<td>1- 4 mo.</td>
</tr>
<tr>
<td>fish emulsion (5-2-2) adds micronutrients</td>
<td>1-4 mo.</td>
</tr>
<tr>
<td>fish meal (10-6-2)</td>
<td>1-4 mo.</td>
</tr>
<tr>
<td>feather meal varies- N content 7- 12%</td>
<td>4+ mo.</td>
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<tr>
<td>manure - many types</td>
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<tr>
<td>3 to 5 ft³ per year</td>
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<tr>
<td>worm castings</td>
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### Kinsey Agricultural Services, Inc.

**Client:** MICHIGAN STATE UNIVERSITY EXTENSION  
**City:** SUTTONS BAY, MI  
**Date:** 12-Sep-12

### Location

- **Crop:** HOPS/HOPS
- **Lab No.:** 00103
- **Exchange Capacity:** 7.76
- **Desired Ca:Mg Percent:** 66:14
- **pH of Soil Sample:** 7.0
- **Humus Content Percent:** 1.2

### BASE SATURATION PERCENT

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<thead>
<tr>
<th>Base</th>
<th>Organic</th>
<th>Traditional</th>
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<tbody>
<tr>
<td>Ca</td>
<td>75.0</td>
<td>75.0</td>
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<tr>
<td>Mg</td>
<td>15.67</td>
<td>15.67</td>
</tr>
<tr>
<td>K</td>
<td>9.82</td>
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### EXCHANGEABLE HYDROGEN

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<tbody>
<tr>
<td>H+</td>
<td>0.00</td>
<td>0.00</td>
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### RECOMMENDATIONS

#### Nitrogen

- **Feather Meal 11-0-0 (a):** 4.56 lbs/acre
- **Compost:**

#### Sulfate-S

- **Sulfur 9-32% (g):** 75 lbs/acre

### Phosphates

- **Desired Value (lbs/acre):** 75.0
- **Value Found (lbs/acre):** 63.6
- **Deficit/Surplus:** -11.4

### Calcium

- **Desired Value (lbs/acre):** 2062
- **Value Found (lbs/acre):** 2309
- **Deficit/Surplus:** 247

### Magnesium

- **Desired Value (lbs/acre):** 250
- **Value Found (lbs/acre):** 256
- **Deficit/Surplus:** 6

### Potassium

- **Desired Value (lbs/acre):** 443
- **Value Found (lbs/acre):** 170
- **Deficit/Surplus:** 273

### Sodium

- **Desired Value (lbs/acre):** 35
- **Value Found (lbs/acre):** 32
- **Deficit/Surplus:** -3

### Trace Elements

- **Boron:** 0.09 ppm
- **Iron:** 411 ppm
- **Manganese:** 63 ppm
- **Zinc:** 6.50 ppm

### Notes

- **Borax 11%:** 25 lbs/acre
- **MANG SULF 28%:** 50 lbs/acre
- **ZINC SULFATE 36%:** 35 lbs/acre

- **Boron 14.3%:** 16 lbs/acre
- **MANG SULF 28%:** 25 lbs/acre
- **ZINC SULFATE 36%:** 35 lbs/acre

**NOTE:** Could use compost here if Ca & Mg levels in the compost are not too high. Should not be applied through without an analysis first to determine the effects this would have on soil nutrient content.
Figure 209. Yellowness of the youngest leaves resulting from iron deficiency. Notice that symptoms are less pronounced on older leaves. (J. Portner)

Figure 210. Yellowning and death of tissue between leaf veins caused by magnesium deficiency. (C. B. Skotland)

Figure 211. Weak growth and yellowing of lower leaves associated with nitrogen deficiency. (J. Portner)

Figure 212. Weak growth and reduced side arm development associated with zinc deficiency. (C. B. Skotland)

Figure 213. Cupped, brittle leaves caused by zinc deficiency. (J. Portner)
Weed control
New Zealand Example

- Organic producers use dried blood and bone and meal and bone fertilizers
- They also use liquid organic fertilizers
- Rock phosphate and lime (to lower acidity)
- Natural dolomite is used for Mg
- TSSM-controlled with predator mites
- Grass, oats, and clover in alleys-mow and blow into rows (oats mulched, then grass mowed every 5 days) clover feeds sheep and sheep also eat hop suckers.
Hop insects and diseases

“First the flea, then the fly; then the mould, then they die.” –
An old Kentish rhyme about hops

Diane Brown, Michigan State University Extension
Diseases to keep out of your hop yard

• Viruses and viroids
  – use planting material certified free of HSVd and other viruses is the best line of defense.
  – Purchase virus indexed stock.
  – The primary means of spread is by propagation from infected plants.
  – Unintentional propagation from infected root pieces can and does occur
  – may take 3 to 5 growing seasons before obvious symptoms of the disease appear.
Virus testing results for hops in SWMREC test plots grown from rhizomes

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<tr>
<th>ACC. #</th>
<th>Sample I.D.</th>
<th>HMV</th>
<th>ApMV</th>
<th>HSVd</th>
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<td>9293-1</td>
<td>Sterling</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
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<tr>
<td>9293-2</td>
<td>Chinook</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
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<tr>
<td>9293-3</td>
<td>Galena</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>9293-4</td>
<td>Newport</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>9293-5</td>
<td>Mt. Hood</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>9293-6</td>
<td>Brewer's Gold</td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
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Virus testing lab for hop samples: ELISA lab, 24106 N. Bunn Rd. Prosser WA
http://healthyplants.wsu.edu/contact-information/
Hops Clean Plant Network

• Hop source material is tested initially for:
  • American hop latent virus*
  • Apple fruit crinkle viroid (not known to occur in North America)
  • Apple mosaic virus* (a.k.a. Prunus necrotic ringspot virus hop isolate)
  • Arabis mosaic virus
  • Hop latent viroid
  • Hop latent virus*
  • Hop mosaic virus*
  • Hop stunt viroid*
  • Strawberry latent ringspot virus
  • Phytoplasma
  • Grown in meristem culture, tested 3x more times for *viruses
Hops Clean Plant Network

- website: [http://healthyplants.wsu.edu/hop-program-at-cpcnw/](http://healthyplants.wsu.edu/hop-program-at-cpcnw/)
- [http://healthyplants.wsu.edu/hop-program-at-cpcnw/purchasing-hop-material/](http://healthyplants.wsu.edu/hop-program-at-cpcnw/purchasing-hop-material/)
Hop cyst nematode

*Heterodera humuli*

- Reported in Michigan
- most common plant parasitic nematode found on hops.
- U. S., Canada, Europe, New Zealand, Australia and other locations.
- found in the soil and in and on hop roots.
- There are 1-2 generations per year.
- The cysts are brown to black, lemon-shaped and smaller than the head of a pin.
- Males are transparent and less than 1/25th of an inch long.
- Females are cream colored and lemon shaped and about 1/50th of an inch long.

Photos: Compendium of Hop Diseases and Pests
Verticillium wilt

- Caused by a fungus
- Soil borne
- Form microsclerotia in the soil
- Multiple hosts
- Can live for long periods in the soil
- No effective chemical controls
- Limit nitrogen
- Reduced tillage
- Remove crop debris
Pests and Diseases

- **Hop aphid** (*Phorodon humuli*)

- **Downy mildew** (*Pseudoperonospora humuli*)

- **Spider Mites** (*Tetranychus urticae*)

- **Powdery mildew** (*Podosphaera macularis*)

- **Potato Leaf Hopper** (*Empoasca fabae*)
Spider Mites

- Spider mites damage hop plants by feeding on leaves and cones, sucking plant juices from the cells—bronzing of leaves and reduces plant vigor.
- Monitor weekly beginning in mid to late May.
- Provide plants with adequate but not excessive nitrogen fertility and water.
- Reduce dust, especially in hot dry weather.
- Treat to prevent cone infestations using foliar-applied miticides.
- Avoid the use of pyrethroid, organophosphate, carbamate, and Neonicotinoid insecticides, and late-season sulfur applications.
- Can treat when average of one to two female spider mites per leaf in June and early July, or five to 10 mites per leaf after mid-July. But hop plants can tolerate much higher twospotted spider mite populations without suffering economic loss if cones are not infested.
- **Spider mite populations can build rapidly, especially in hot, dry conditions, therefore monitoring is important.**

Other options
- Prune extra bines in early May, stripping
- If the hops are in the burr stage, a lime sulphur spray may be applied to the whole plant.
- Predaceous insects—Anthocorid Bugs/Predatory mites

Aphid control

Aphids (*Phorodon humuli*) – but other aphids as well.

- Biological control-Ladybird beetles, Lacewing, Aphid Midge (*Aphidoletes Aphidimyza*)
- Begin monitoring in May when daytime temperatures exceed 58 °F.
- Avoid excessive application of nitrogen.
- Intervene early to prevent aphid establishment in hop cones.
- Rotate chemical classes to avoid resistance.
- Use selective pesticides that preserve natural enemies.
- Monitoring should begin when daytime minimum temperatures exceed 58 to 60° F. A comprehensive economic threshold does not exist for hop aphid. Most growers apply a pesticide when an average five to 10 aphids per leaf are observed before flowering. Generally, aphids are not tolerated after flowering; control with pesticides is difficult once aphids infest cones.

PLH Management

• The most common efficacious insecticides recommended for the control of potato leafhoppers include the pyrethroids and neonicitinoids

• Pyrethroids: effective, relatively inexpensive, but can cause increases in mites

• Neonicitinoids are longer lasting and narrow spectrum making them a solid choice for management

• Pyganic and Trilogy are OMRI approved insecticides organic growers might consider for PLH management
Powdery Mildew

- Powdery mildew is caused by the fungus *Podosphaera macularis*
- Extremely readily spread at all stages.
- Good sanitation in the hopyard is key.
- Bines with signs of the infection should be cut and burned away from the hopyard before the hops shatter.
- Stripping off the lower leaves of the bines also helps get rid of any early spores.
- Training and pruning the vines so that adequate sunshine and air are admitted to the entire plant will help control the outbreak of Powdery Mildew.
- Avoid heavy doses of nitrogen fertilizer or uncomposted manure- more succulent tissue is more susceptible.
- Sulphur-based fungicides control this disease, and can be applied as soon as the first spots of mold are seen on the leaves.
- Works best as a protectant though.
- Be careful that liquid sulphur formulations do not include wetting agents prohibited by organic regulations.

http://plant-disease.ippc.orst.edu/
Downy Mildew

- The single most devastating disease in Western hopyards.
- Hop Downy Mildew (*Pseudoperonospora humuli*) is specific to hops.
- Typically first noticed as the young bines grow out in spring

Basal spikes: Hop shoots systemically infected with the downy mildew pathogen. (D. H. Gent)

Dark brown discoloration of bracts and bracteoles on cones severely affected by downy mildew. (B. Engelhard)

Infection of shoots after training. Notice the yellowing, stunting, and downcurling of the leaves. (D. H. Gent)

Angular leaf lesions on hop leaves. The black discoloration is due to sporulation by the pathogen. (D. H. Gent)
Downy mildew

**Cultural control**

- Prune crown before growth starts in the spring or burn back green tissue before training. Complete removal of green tissue or pruning of entire hill is necessary for most effective disease management.
- Remove diseased hills and mark for replanting.
- Train bines early to prevent them from coming in contact with soil.
- Begin suckering as soon as vines are strung. Continue at regular intervals until warm, dry weather prevails (June to July).
- Strip leaves from bines at a height of 4’ soon after training to reduce the spread of downy mildew up the canopy.
- Avoid overhead irrigation, especially during and after burr development.
- Avoid over fertilizing with N
- Choose varieties that are resistant

**Chemical Control**

- Copper based fungicides
- Make sure whatever you use is registered in your state
- GREENBOOK.NET
Based on PNW data

- **S** = susceptible
- **MS** = moderately susc.
- **MR** = moderately resist.
- **R** = resistant
- **U** = unknown

<table>
<thead>
<tr>
<th>Variety</th>
<th>Usage</th>
<th>Powdery Mildew</th>
<th>Downy Mildew</th>
<th>Verticillium Wilt</th>
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<tbody>
<tr>
<td>Brewers Gold</td>
<td>Bittering</td>
<td>S</td>
<td>MR</td>
<td>MR</td>
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<tr>
<td>Bullion</td>
<td>Bittering</td>
<td>S</td>
<td>MR</td>
<td>R</td>
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<tr>
<td>Cascade</td>
<td>Aroma</td>
<td>MR</td>
<td>MR</td>
<td>MR</td>
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<tr>
<td>Centennial</td>
<td>Bittering</td>
<td>MR</td>
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<td>Chinook</td>
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<td>Crystal</td>
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<td>East Kent Golding</td>
<td>Aroma</td>
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<td>Fuggle</td>
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<td>Galena</td>
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<td>R</td>
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<td>Glacier</td>
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<td>S</td>
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<td>Hall. Magnum</td>
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<tr>
<td>Hall. Mittelfrüh</td>
<td>Aroma</td>
<td>MS</td>
<td>S</td>
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<td>Hall. Tradition</td>
<td>Aroma</td>
<td>MR</td>
<td>R</td>
<td>MR</td>
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<td>Horizon</td>
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<td>M3</td>
<td>M3</td>
<td>MR</td>
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<td>S</td>
<td>R</td>
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<td>Liberty</td>
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<td>MR</td>
<td>MR</td>
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<td>Aroma</td>
<td>MS</td>
<td>S</td>
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<td>Newport</td>
<td>Bittering</td>
<td>R</td>
<td>R</td>
<td>U</td>
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<td>Northern Brewer</td>
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<td>S</td>
<td>S</td>
<td>R</td>
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<td>Nugget</td>
<td>Bittering</td>
<td>R</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Olympic</td>
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<td>R</td>
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<td>Perle</td>
<td>Aroma</td>
<td>S</td>
<td>R</td>
<td>MR</td>
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<tr>
<td>Pioneer</td>
<td>Bittering</td>
<td>MR</td>
<td>MR</td>
<td>U</td>
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<td>Saazier</td>
<td>Aroma</td>
<td>S</td>
<td>MS</td>
<td>S</td>
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<td>Saazier 36</td>
<td>Aroma</td>
<td>S</td>
<td>MS</td>
<td>S</td>
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<td>Spalter</td>
<td>Aroma</td>
<td>R</td>
<td>S</td>
<td>R</td>
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<td>Sterling</td>
<td>Aroma</td>
<td>MS</td>
<td>MR</td>
<td>U</td>
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<td>Teamaker</td>
<td>Aroma</td>
<td>MR</td>
<td>MR</td>
<td>S</td>
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<td>Tettnanger</td>
<td>Aroma</td>
<td>MS</td>
<td>MS</td>
<td>S</td>
</tr>
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<td>Tolhurst</td>
<td>Aroma</td>
<td>S</td>
<td>S</td>
<td>U</td>
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<tr>
<td>U.S. Tettnanger</td>
<td>Aroma</td>
<td>MS</td>
<td>MS</td>
<td>S</td>
</tr>
<tr>
<td>Vanguard</td>
<td>Aroma</td>
<td>S</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Willamette</td>
<td>Aroma</td>
<td>MS</td>
<td>MR</td>
<td>S</td>
</tr>
</tbody>
</table>
Resources for pesticide labels

• Crop data management systems
  – www.cdms.net

• GREENBOOK
  – www.greenbook.net

• Agrian
  – http://www.agrian.com/home/label-lookup/overview#

• New Bulletin→
  – http://www.hops.msu.edu
SUMMER
End of July

• Floral Production has commenced
  • Plant shifts energy into cone production
  • Vegetative production is diminished
  • Photosynthetic capacity of the plant is maximized
  • By time cones matures they can account for up to 50% of the total above ground dry matter
  • Cannot increase cone numbers
  • Focus on: plant health to maximize cone weight and resin/oil content
  • Water management-July-August most of H2O
  • Nutrient management-cut off N, add K

Source: Jason Perrault, Perrault Farms
FALL

Preparation for Dormancy (September)

- In the Field
  - Harvest!!!!!
  - Vines cut (bottom then top)
  - Laid down into trailer
  - Taken to picking machine
  - Cones dried for 8-12 hours (10% moisture)
  - Dried cones cooled 12-24 hours
  - Cold storage

Source: Jason Perrault, Perrault Farms
Hops: Harvesting and Processing

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU IPM Academy
February, 2014
WOLF Hopfenpflückmaschine WHE 513
• **Pelletizing**

http://www.makepellets.ca/Hophead%202-1.jpg
Packaging

N Flush
Vacuum seal
O2 and light proof packaging material
Cold Storage

• For AB-This freezer keeps the hops stored within at a constant 18-26 degrees Fahrenheit at a 70% relative humidity.

http://www.fwwarehousing.com/divisions/5/cold-storage.html
The effects of storage temperature on the chemical composition of hop pellets

A. Canbaş *, H. Ertan, F. Özşahin

Department of Food Engineering, Faculty of Agriculture, University of Çukurova, 01330, Adana, Turkey
Received 28 August 2000; revised in revised form 1 January 2003; accepted 21 January 2003

Fig. 1. The effect of 6 months storage on alpha-acids of hop pellets. BG, Brewers Gold; EA, Efes Aroma; G, Galena; NB, Northern Brewer; S, Saaz; a, Initial; b, 3°C storage; c, Room temperature storage.

Fig. 5. The effect of 6 months storage on essential oil of hop pellets. BG, Brewers Gold; EA, Efes Aroma; G, Galena; NB, Northern Brewer; S, Saaz; a, Initial; b, 3°C storage; c, Room temperature storage.
Hops: Markets

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU IPM Academy
February, 2014
### U.S. Hop Acreage by State (10 Years - in Acres)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>WASHINGTON</th>
<th>OREGON</th>
<th>IDAHO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>19,492</td>
<td>5,748</td>
<td>3,429</td>
<td>28,669</td>
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<tr>
<td>2004</td>
<td>19,382</td>
<td>5,107</td>
<td>3,253</td>
<td>27,742</td>
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<tr>
<td>2005</td>
<td>21,013</td>
<td>5,163</td>
<td>3,287</td>
<td>29,463</td>
</tr>
<tr>
<td>2006</td>
<td>21,532</td>
<td>5,036</td>
<td>2,797</td>
<td>29,365</td>
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<tr>
<td>2007</td>
<td>22,745</td>
<td>5,270</td>
<td>2,896</td>
<td>30,911</td>
</tr>
<tr>
<td>2008</td>
<td>30,595</td>
<td>6,370</td>
<td>3,933</td>
<td>40,898</td>
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<tr>
<td>2009</td>
<td>29,686</td>
<td>6,108</td>
<td>4,030</td>
<td>39,824</td>
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<tr>
<td>2010</td>
<td>24,336</td>
<td>4,622</td>
<td>2,331</td>
<td>31,289</td>
</tr>
<tr>
<td>2011</td>
<td>23,320</td>
<td>4,202</td>
<td>2,265</td>
<td>29,787</td>
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<tr>
<td>2012</td>
<td>25,040</td>
<td>4,470</td>
<td>2,423</td>
<td>31,933</td>
</tr>
</tbody>
</table>

Source: USDA-NASS. Prepared by HGA.

### U.S. Average Hop Yield (Ten Years)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>WASHINGTON</th>
<th>OREGON</th>
<th>IDAHO</th>
<th>TOTAL U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>2,050</td>
<td>1,626</td>
<td>1,536</td>
<td>1,903</td>
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<tr>
<td>2004</td>
<td>2,137</td>
<td>1,686</td>
<td>1,588</td>
<td>1,990</td>
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<tr>
<td>2005</td>
<td>1,878</td>
<td>1,560</td>
<td>1,640</td>
<td>1,796</td>
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<tr>
<td>2006</td>
<td>2,058</td>
<td>1,757</td>
<td>1,613</td>
<td>1,964</td>
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<tr>
<td>2007</td>
<td>2,049</td>
<td>1,811</td>
<td>1,417</td>
<td>1,949</td>
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<td>2008</td>
<td>2,072</td>
<td>1,569</td>
<td>1,841</td>
<td>1,971</td>
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<td>2009</td>
<td>2,528</td>
<td>1,948</td>
<td>1,943</td>
<td>2,383</td>
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<tr>
<td>2010</td>
<td>2,147</td>
<td>1,791</td>
<td>2,129</td>
<td>2,093</td>
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<tr>
<td>2011</td>
<td>2,200</td>
<td>1,908</td>
<td>2,408</td>
<td>2,175</td>
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<td>2012</td>
<td>1,941</td>
<td>1,885</td>
<td>1,745</td>
<td>1,918</td>
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</table>

Source: USDA-NASS. Prepared by HGA.
## IHGC AROMA ACREAGE (FIVE YEARS)

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2011-12</th>
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<tbody>
<tr>
<td>Australia</td>
<td>82</td>
<td>67</td>
<td>79</td>
<td>119</td>
<td>128</td>
<td>8.33%</td>
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<tr>
<td>Austria</td>
<td>479</td>
<td>474</td>
<td>460</td>
<td>479</td>
<td>477</td>
<td>-0.52%</td>
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<tr>
<td>Belgium</td>
<td>126</td>
<td>126</td>
<td>126</td>
<td>148</td>
<td>175</td>
<td>18.33%</td>
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<tr>
<td>China</td>
<td>1,433</td>
<td>1,433</td>
<td>1,433</td>
<td>946</td>
<td>853</td>
<td>-9.92%</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>12,486</td>
<td>12,316</td>
<td>12,215</td>
<td>10,791</td>
<td>10,413</td>
<td>-3.50%</td>
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<tr>
<td>France</td>
<td>1,814</td>
<td>1,068</td>
<td>983</td>
<td>892</td>
<td>922</td>
<td>3.32%</td>
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<tr>
<td>Germany</td>
<td>25,386</td>
<td>23,673</td>
<td>23,844</td>
<td>23,569</td>
<td>22,489</td>
<td>-4.58%</td>
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<td>New Zealand</td>
<td>531</td>
<td>568</td>
<td>568</td>
<td>655</td>
<td>655</td>
<td>0.00%</td>
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<td>Poland*</td>
<td>1,905</td>
<td>1,905</td>
<td>1,008</td>
<td>1,008</td>
<td>988</td>
<td>-1.96%</td>
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<td>Romania</td>
<td>183</td>
<td>158</td>
<td>158</td>
<td>151</td>
<td>151</td>
<td>0.00%</td>
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<tr>
<td>Russia*</td>
<td>376</td>
<td>84</td>
<td>855</td>
<td>208</td>
<td>208</td>
<td>0.00%</td>
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<tr>
<td>Serbia*</td>
<td>84</td>
<td>84</td>
<td>84</td>
<td>84</td>
<td>84</td>
<td>0.00%</td>
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<tr>
<td>Slovakia</td>
<td>531</td>
<td>581</td>
<td>566</td>
<td>549</td>
<td>529</td>
<td>-3.60%</td>
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<td>Slovenia</td>
<td>3,615</td>
<td>3,581</td>
<td>3,210</td>
<td>3,168</td>
<td>2,634</td>
<td>-16.85%</td>
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<td>South Africa*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.00%</td>
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<tr>
<td>Spain*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.00%</td>
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<tr>
<td>Ukraine</td>
<td>1,606</td>
<td>1,589</td>
<td>1,663</td>
<td>1,268</td>
<td>853</td>
<td>-32.75%</td>
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<td>UK - England</td>
<td>1,977</td>
<td>2,002</td>
<td>2,019</td>
<td>1,984</td>
<td>1,905</td>
<td>-1.00%</td>
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<td>USA</td>
<td>15,182</td>
<td>13,425</td>
<td>10,811</td>
<td>11,921</td>
<td>15,558</td>
<td>30.51%</td>
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<tr>
<td>IHGC Total</td>
<td>67,614</td>
<td>63,450</td>
<td>60,082</td>
<td>57,940</td>
<td>59,082</td>
<td>1.97%</td>
</tr>
</tbody>
</table>

*Countries with partial provided report updates for the IHGC. Missing figures were used from previous reports or from IHGC estimates.

SOURCE: IHGC Economic Commission annual reports.

Numbers may not total exactly due to rounding and standard/metric conversions.
MARKET POTENTIAL

- Craft beer accounts for only 4% of total beer consumption in MI and only 2% is made in MI

beervanabuzz.blogspot.com
Roll out the barrels
Michigan ranks fifth nationally in craft breweries, and in-state sales are rising sharply.

Most craft breweries, as of August 2010
(Michigan has gained at least four since then)

Michigan craft beer sold in state
Sales in barrels / 31 gallons per barrel

Brewing an industry
Top ten Michigan beer producers (in barrels, overall sales):
1. Bell's Brewery Inc.: 153,973
2. Founders Brewing Co.: 28,516
3. New Holland Brewing Co.: 12,314
4. Michigan Brewing Co.: 9,856
5. Arcadia Brewing Co.: 8,759
6. Short's Brewing Co.: 8,420
7. Dark Horse Brewing Co.: 6,179
8. Keweenaw Brewing Co.: 5,420
9. Atwater Block Brewery: 4,700
10. Arbor Brewing Co./Corner Brewery: 4,057

Michigan's newest breweries
A. Blackrocks Brewery
B. Midland Brewing Co.
C. Odd Side Ales
D. Michigan Beer Cellar
E. Brewery Vivant
F. Jaden James Brewery (Cascade Winery)
G. Paw Paw Brewing Co.
H. Fenton Winery & Brewery
I. Wolverine State Brewing Co.
J. Frog Island Brewing Co.
K. MillKingIt Productions

COMING SOON
Harmony Brewing Co., Grand Rapids
Soo Brewing Co., Sault Ste. Marie
The Local Pub & Brewery, Jackson

*Projection based on first nine months

SOURCE: Brewer Association, August 2010;
Michigan Liquor Control Commission
Brewer Variety Needs

Top five varieties used by brewers

1. Cascade - 65%
2. Centennial - 50%
3. Perle/Saaz/Simcoe – 30%
4. Columbus/N. Brewer/Tettnanger – 25%
5. EK Golding/Willamette – 20%

50% noted Cascade as #1 variety
Brewer Variety Needs

Brewers wish they had more...

1. Amarillo/Simcoe - 35%
2. Summit/Saaz – 15%
3. Note: several brewers said “all varieties”
Will brewers pay a premium?

Percent Premium by Hop Category

- Local
- Organic
- Local & Organic

- 50-75
- 25-50
- 10-25
- 1-10
Quality Needs

- Hops are generally purchased as extracts, whole flower, or pelletized with quality defined by:
  - $\alpha$-acid, B-acid (as % dry weight)
  - Cohumulone content (as % $\alpha$-acid)
  - Total Oil (as % dry weight)
  - Hop Storage Index

Results:

- Pelletized: All but one!!
- $\alpha$-acid: 80%, cohumulone: 14%
- Storage or packaging: 23%
Hops: Cost of Production

Rob Sirrine
MSU Extension
Leelanau County, MI

MSU IPM Academy
February, 2014
## Table 1. 2013 Hopyard Preparation and Establishment Costs (Per Acre and Per 5 Acre yard)

<table>
<thead>
<tr>
<th>Land Preparation</th>
<th>Per Acre</th>
<th>Notes</th>
<th>5 Acre Yard</th>
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<tr>
<td>Disc</td>
<td>$26.00</td>
<td>$26/acre</td>
<td>$130.00</td>
</tr>
<tr>
<td><strong>Establishment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Holes- digging</td>
<td>$312.50</td>
<td>2.5 hrs * $125/hr (145 hp tractor)</td>
<td>$1,562.50</td>
</tr>
<tr>
<td>Post Holes-placement</td>
<td>$750.00</td>
<td>6 hrs * $125/hr</td>
<td>$3,750.00</td>
</tr>
<tr>
<td>Poles-field</td>
<td>$1,590.00</td>
<td>50 @ $30/pole</td>
<td>$7,950.00</td>
</tr>
<tr>
<td>Poles-end&quot;</td>
<td>$1,840.00</td>
<td>46 @ $40/pole</td>
<td>$5,360.00</td>
</tr>
<tr>
<td>Earth Anchor</td>
<td>$650.00</td>
<td>50 per acre @ $13 each</td>
<td>$3,250.00</td>
</tr>
<tr>
<td>Wire</td>
<td>$1,000.00</td>
<td>Galvanized 7 strand ($800) + #9 ($200)</td>
<td>$5,000.00</td>
</tr>
<tr>
<td>Misc Hardware/supplies</td>
<td>$500.00</td>
<td>staples, etc.</td>
<td>$2,500.00</td>
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<tr>
<td>Labor-poles</td>
<td>$480.00</td>
<td>4 workers- $10/hr x 12 hrs</td>
<td>$2,400.00</td>
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<tr>
<td>Management</td>
<td>$240.00</td>
<td>12 hrs @ $20/hr</td>
<td>$1,200.00</td>
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<tr>
<td>Hop Plants</td>
<td>$3,000.00</td>
<td>($3/plant, 1000 plants per acre; 14’ x 3.5’)</td>
<td>$15,000.00</td>
</tr>
<tr>
<td>Labor-planting</td>
<td>$700.00</td>
<td>(70 hrs x $10/hr)</td>
<td>$3,500.00</td>
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<tr>
<td>Irrigation&quot;</td>
<td>$1,500.00</td>
<td>Includes installation</td>
<td>$7,500.00</td>
</tr>
<tr>
<td>Well</td>
<td></td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td><strong>Total Initial Costs</strong></td>
<td>$12,588.50</td>
<td></td>
<td>$59,102.50</td>
</tr>
</tbody>
</table>

* For a 5 acre yard: 53 field poles/ac & 27 end poles/ac=265 field poles and 134 end poles or 80/acre

^ 50 gallon/min, 2 inch main (no filtration)-cost is variable depending upon needs, # zones, etc.
### Table 2. 2013 Hopyard Annual Operating Costs and Returns (Per Acre)

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Operating Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coir (1 string yr 1; 2 strings yr 2 +, $.20/ string; clips $80)</td>
<td>$240.00</td>
<td>$480.00</td>
<td>$480.00</td>
<td>$480.00</td>
<td>$480.00</td>
</tr>
<tr>
<td>Labor-stringing (5 workers x 10 hours X $10/hr)</td>
<td>$350.00</td>
<td>$500.00</td>
<td>$500.00</td>
<td>$500.00</td>
<td>$500.00</td>
</tr>
<tr>
<td>Labor-training</td>
<td>$500.00</td>
<td>$750.00</td>
<td>$750.00</td>
<td>$750.00</td>
<td>$750.00</td>
</tr>
<tr>
<td>Pest/Disease Chemicals (insecticide/fungicide/herbicide)</td>
<td>$400.00</td>
<td>$600.00</td>
<td>$600.00</td>
<td>$600.00</td>
<td>$600.00</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>$250.00</td>
<td>$275.00</td>
<td>$275.00</td>
<td>$275.00</td>
<td>$275.00</td>
</tr>
<tr>
<td>IPM Consultant</td>
<td>$25.00</td>
<td>$25.00</td>
<td>$25.00</td>
<td>$25.00</td>
<td>$25.00</td>
</tr>
<tr>
<td>Repairs/Parts/Maintenance</td>
<td></td>
<td>$250.00</td>
<td>$250.00</td>
<td>$250.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>Machinery/Labor-Stringing</td>
<td>$100.00</td>
<td>$100.00</td>
<td>$100.00</td>
<td>$100.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Machinery/Labor-Fertility</td>
<td>$300.00</td>
<td>$400.00</td>
<td>$400.00</td>
<td>$400.00</td>
<td>$400.00</td>
</tr>
<tr>
<td>Machinery/Labor-Mowing/Till</td>
<td>$100.00</td>
<td>$100.00</td>
<td>$100.00</td>
<td>$100.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>Machinery/Labor-Spraying</td>
<td>$300.00</td>
<td>$350.00</td>
<td>$350.00</td>
<td>$350.00</td>
<td>$350.00</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>$2,565.00</td>
<td>$3,830.00</td>
<td>$3,830.00</td>
<td>$3,830.00</td>
<td>$3,830.00</td>
</tr>
<tr>
<td><strong>Harvest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor-harvesting (10 hrs, 4 workers-cut, load)</td>
<td></td>
<td>$400.00</td>
<td>$400.00</td>
<td>$400.00</td>
<td>$400.00</td>
</tr>
<tr>
<td>Management ($20/hr* 10 hrs)</td>
<td></td>
<td>$200.00</td>
<td>$200.00</td>
<td>$200.00</td>
<td>$200.00</td>
</tr>
<tr>
<td>Machinery ($125/hr)</td>
<td></td>
<td>$1,250.00</td>
<td>$1,250.00</td>
<td>$1,250.00</td>
<td>$1,250.00</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>$1,850.00</td>
<td>$1,850.00</td>
<td>$1,850.00</td>
<td>$1,850.00</td>
</tr>
<tr>
<td><strong>Total Annual Operating Costs</strong></td>
<td>$2,565.00</td>
<td>$5,680.00</td>
<td>$5,680.00</td>
<td>$5,680.00</td>
<td>$5,680.00</td>
</tr>
</tbody>
</table>

- Analysis does not include land cost or overhead like interest on loans, taxes, etc.
- Does include per hour rate for machinery, labor, and management that would be charged if hired out (opportunity cost)
- Standard trellis design is 3.5 x 14 ft ~1000 plants/acre
### Post Harvest Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>0</th>
<th>2,565.00</th>
<th>$ 180.00</th>
<th>2,820.00</th>
<th>5,820.00</th>
<th>5,820.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picking processing fees ($6/lb.) (energy, supplies, labor, etc.)</td>
<td>$ 4,500.00</td>
<td>$ 6,750.00</td>
<td>$ 9,000.00</td>
<td>$ 9,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport to processor (variable)</td>
<td>$ 500.00</td>
<td>$ 500.00</td>
<td>$ 500.00</td>
<td>$ 500.00</td>
<td>$ 500.00</td>
<td></td>
</tr>
<tr>
<td>Interest on Equipment (picking machine, hammer mill, pelletizer)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales Costs (Commission, transportation, shipping, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>0</td>
<td>$ 5,000.00</td>
<td>$ 7,250.00</td>
<td>$ 9,500.00</td>
<td>$ 9,500.00</td>
<td></td>
</tr>
</tbody>
</table>

### Gross Revenue/acre

<table>
<thead>
<tr>
<th>Description</th>
<th>0</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of total yield- (full production 1500 lbs. dried/acre)</td>
<td>0</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Total yield in pounds dried/acre</td>
<td>0</td>
<td>750</td>
<td>1125</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Fresh wholecone wet (5-6/lb.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wholecone dried (10-12/lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pellitized (12-14/lb.)</td>
<td>0</td>
<td>$ 10,500.00</td>
<td>$ 15,750.00</td>
<td>$ 21,000.00</td>
<td>$ 21,000.00</td>
</tr>
</tbody>
</table>

### Net Revenue/acre

<table>
<thead>
<tr>
<th>Description</th>
<th>$ (2,565.00)</th>
<th>$ (180.00)</th>
<th>$ 2,820.00</th>
<th>$ 5,820.00</th>
<th>$ 5,820.00</th>
</tr>
</thead>
</table>

- UVM-$1.60/lb for picking only
- A couple of MI processors- ~$5.50/lb (including a 10% sales commission)
- Ontario $4.50/lb (no sales or marketing)
- Quebec and BC- (they charge 35% of sales amount) or currently $5.50/lb since they are selling for close to $16/lb (including access to mechanized harvester + dryer) and post-harvest services (including pelletization, packaging, commercialization)
- A group in Wisconsin was charging $4/lb just for pelletizing, packaging, and selling.
- **Depends on your assumptions** (lbs per acre, cost of labor, payment on debt, etc.), but it looks like things are shaking out at around **$5/lb** for the process of picking through selling.
TAKE HOME MESSAGES

• Quality is crucial
• Don’t underestimate the amount of labor required
• Do not skimp on establishment
• Need for picking and processing equipment if you plant >1/2 acre
• You will not get rich growing hops
• Line up supplies well in advance
• Hi initial and annual costs with questionable returns in the future
• How will you sell your hops?
• Will most likely need a price premium to do organic

• Wolf (picker) $50,000+
• Hammermill & Pelletizer $15,000-$60,000
• Vacuum Sealer $2500-$10,000
• Dryer $12,000 +
• Energy (wet hop to pellet) $1.50 / lb
• Cold Storage $ ?????
• Annual labor for 14 acres $600/day
  Crew of six (2 months working 10 hour + days)
http://www.hops.msu.edu
“Michigan State University Hops News”
Beer is living proof that God Loves Us and wants us to be Happy

~Benjamin Franklin
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