Hops Production

Dr. Heather Darby
UVM Extension Agronomist
Cumulative Degree Day Normals (50-95 F) for WA, MI and VT

Station Name
- Beulah, MI
- Burlington, VT
- Yakima, WA

Harvest
- Cascade
- Centennial
- Chinook
- Cluster
- Crystal
- Fuggle
- Galena
- Glacier
- Hallertau
- Liberty
- Mt Hood
- Newport
- Nugget
- Perle
- Saaz
- Santiam
- Sterling
- Tettnang
- Vanguard
- Willamette
Yields among the best (1000 to 1500 lb/a):

• Centennial
• Chinook
• Newport
• Cascade
• Nugget
• Galena
Low performance cultivars

Yields among the five worst (below 500 lb/a):
- Liberty
- Crystal
- Saaz
- Sterling
- Cluster
High performance cultivars

Yields among the best (800 to 400 lb/a):
• Centennial
• Chinook
• Newport
• Cascade
• Nugget
• Galena (best in 2015)

2015 Yields Disappointing?
What is Driving Yields?

- Fertility
- Pests
- Training Timing
- Growing Season
Downy Mildew Life Cycle

- Overwinters in buds and crown
- Spores travel, landing on leaves
- Primary basal spikes emerge in spring
- Systemic (year after year)
- In-Season Infection

Image Credit: Dr. Lily Calderwood
Ideal Downy Mildew Conditions

36 of 108 of days, or 33% of days, between 1-May and 16-Sep increased downy mildew susceptibility
Hop Downy Mildew

Systemic (year after year)

Overwinters in buds and crown

Primary basal spikes emerge in spring

Spores travel, landing on leaves

In-Season Infection

What can you do?
1. Predict emergence
2. Reduce habitable area for spores

1. Predict emergence
2. Reduce habitable area for spores
Mechanical Control

• Crowning – removal top 1 to 2 inches of crown before bud break (April)

• Scratching – disks scratch soil and remove buds from crown (Early May)

• Pruning – removal of shoots before training (Mid-Late May)
Scratching in the Spring
Post-Scratch
Mechanical Crowner
Whole Row Crowning Critical
Crowning Works. (Gent et al. 2012)

**Downy Mildew**

<table>
<thead>
<tr>
<th>Pruning quality</th>
<th>Excellent</th>
<th>Moderate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>59</td>
<td>27</td>
<td>24</td>
</tr>
</tbody>
</table>

**Excellent** = no green leaves or stems present

Most effective when plants were *crowned* twice.
- mechanical
- chemical
# UVM Crowning Trial

<table>
<thead>
<tr>
<th>Year</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>2015</td>
<td>23</td>
<td>13</td>
</tr>
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</table>
Crowning Trial Disease Incidence 2014 vs 2015

April

May

Control

2014 2015

2014 2015

2014 2015

2014 2015
Crowning and Dry Yield

Mean Yield per Acre (dry lbs)

- Early 4/23
- Not Crowned
- Late 5/13

Crowning Time
2 inch soil cover ready to train 17-May

4 inch soil cover ready to train 22-May

8 inch soil cover ready to train 28-May

Fig. 88. Temperature of soil near old wood, under soil layers of different thickness, at different times of the day: a – air temperature, b – no cover, c – the cover 5 cm thick, d – the cover 10 cm thick, e – the cover 15 cm thick, f – the cover 20 cm thick.

Rybacek, 1991
Pre-train: Pruning, Weeding, Fertilizing

- 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
  - Split applications better
  - As-needed basis is best

Del Moro, 2016
Managing Downy Mildew by Crowning

Historical Crowning Dates in Variety Trial

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
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<tbody>
<tr>
<td>2013</td>
<td>19-Apr</td>
</tr>
<tr>
<td>2014</td>
<td>14-Apr</td>
</tr>
<tr>
<td>2015</td>
<td>1-May</td>
</tr>
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Growing degree day normals (50-95 F) for WA, MI and VT
HOP TRAINING

One of the most IMPORTANT factors in determining cone density!

40 to 60% increase yields

Fig. 93. Effect of time of starting training on the structure of the hop plant and on the yield of cones:
  a – yield (in kg) of fresh hop per plant, b – length of cones in mm, c – number of shoots, d – density of setting (number of cones per 10 cm of shoot), e – mean length of shoots (in cm).
Cascade, Centennial: May 1-5  47-51 days to solstice
Nugget, Chinook:  May 8-12  40-44 days to solstice
Galena:            May 17-21  31-35 days to solstice
Finish Crowning 30 days before training!!

- Late Season Varieties – April 1\(^\text{st}\)
- Early Season Varieties – May 1\(^\text{st}\)

Prediction based on 10 year normals:

<table>
<thead>
<tr>
<th>Date</th>
<th>DDs</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>5-2-16</td>
<td>172</td>
<td>1% probability of spike emergence</td>
</tr>
<tr>
<td>5-7-16</td>
<td>223</td>
<td>50% probability of spike emergence</td>
</tr>
<tr>
<td>5-28-16</td>
<td>520</td>
<td>95% probability of spike emergence</td>
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Stations
- Beulah, MI
- Burlington, VT
- Yakima, WA

Vermont training dates
- May 19-30
Growing degree days (50-95 F) at the UVM research farm 2014 and 2015
High performance cultivars

Yields among the best (1000 to 1500 lb/a):

- Centennial
- Chinook
- Newport
- Cascade
- Nugget
- Galena – Should do Well in our Climate

What is Limiting Yields?
Managing Downy Mildew with Fungicides

<table>
<thead>
<tr>
<th>Date</th>
<th>Champ WG</th>
<th>Regalia</th>
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<tbody>
<tr>
<td>21-May</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>29-May</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5-Jun</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12-Jun</td>
<td>X</td>
<td>X</td>
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<tr>
<td>19-Jun</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>26-Jun</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6-Jul</td>
<td>X</td>
<td>X</td>
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<tr>
<td>13-Jul</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>27-Jul</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>14-Aug</td>
<td>X</td>
<td>X</td>
</tr>
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Variety Trial Spray Schedule
Hop Cone Discoloration

Cone browning from Alternaria + Phoma

Healthy

Dark bracts from downy mildew or other secondary infection

Severe dry-down from disease
Spores Identified on Hop Cones
(Severity Scale 0-5)

Mean Spore Abundance on Cones Sampled

- Fusarium
- Downy Mildew
- Cercospora
- Phoma
- Alternaria

Pathogen
Hop Requirements

PRODUCE 5000 LBS DM/acre
- 3.0% Nitrogen = 150 Lbs
- 2.0% Potassium = 100 Lbs
- 0.50% Phosphorus = 25 lbs

CONES 1/3 to 1/2 of DM/acre
- 3.0% Nitrogen = 75 Lbs
- 2.0% Potassium = 50 Lbs
- 0.50% Phosphorus = 12.5 lbs
Nitrogen Removal by Variety

Added 169 lbs N acre

<table>
<thead>
<tr>
<th></th>
<th>Cascade</th>
<th>Chinook</th>
<th>Newport</th>
<th>Nugget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bine</td>
<td>45.2</td>
<td>64.6</td>
<td>58.8</td>
<td>55.6</td>
</tr>
<tr>
<td>Cone</td>
<td>32.8</td>
<td>30.2</td>
<td>26.4</td>
<td>29.2</td>
</tr>
<tr>
<td>Total</td>
<td>78.0</td>
<td>94.8</td>
<td>85.2</td>
<td>84.8</td>
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Expected Range
Fertigating – 75% Increase in Biomass

Aroostok Hops, 2014
Farms adding 100 – 75 lbs N @ training
3 to 5 lbs N per acre per day through drip

4 to 6 week of fertigating = 84 to 210 lbs N acre
Bad Year for Potato Leafhopper (PLH)

Damage:
Hopperburn
2012 and 2013 Mean # PLH/leaf in Alburgh, VT
(2\textsuperscript{nd} and 3\textsuperscript{rd} yr old plants)
Hop Plant Defenses

Liberty

Centennial

Bulbous Trichome

Peltate Trichome (Lupulin Gland)

Area Measured = 61.64 cm²
Hop Plant Defenses

![Graph 1: Mean % alpha acid vs. Mean # potato leafhoppers/leaf](image1)

![Graph 2: Mean % beta acid vs. Mean # potato leafhoppers/leaf](image2)
Effect of Cover Crops on Potato Leafhopper

A large, established stand of clover served as a PLH trap crop
Leafhoppers were more attracted to a full stand of clover than hop plants.

\[ P < 0.005 \]
In years with high PLH population and well established clover stand

Clover stand (10 x 30 ft) > Hop plants > Diverse mix (Polyculture)
• Do not mow the legume!
• How big does a legume stand need to be?
• Would clover or alfalfa work better?
• What is the ideal distance from trap crop to hops?
• Do the leafhoppers need to be removed from the trap crop?
Natural Enemies are in the Landscape

• Overwintering habitat
• Alternative food sources
Effect of Natural Enemies on Pests

**P:NE Ratio = 1.3:1**
1.3 pests to each natural enemy

Lacewing larva can eat 4 PLH/day
Two Spotted Spider Mites

TSSM Stippling Damage

Spider Mites on Underside of Leaf

Characteristic Webbing
Two-spotted spider mites, spider mite destroyer lady beetles

- Two-spotted spider mites
- Mite destroyer larva
- Mite destroyer adult
- Mite destroyer pupa
1 mite destroyer – 20 spider mites per leaf threshold

- Two-spotted spider mites
- Mite destroyers

Scouting date:
- 29-Jun
- 8-Jul
- 13-Jul
- 19-Jul
- 27-Jul
- 11-Aug
The University of Vermont

Hops

NW CROPS & SOILS PROGRAM

www.uvm.edu/extension/cropsoil/hops on the link for further details. Don’t forget to RSVP to our office by February 11th or call (802) 524-6501!

Hop Surveys

Click here to take the Hops Survey for Growers

Click here to take the Hops Survey for Brewers

The Vermont Hops Project

Hop production was common throughout the Northeast in the 1800s. However, today most hop production occurs in the Pacific Northwest. Renewed interest and demand for local hops is breathing new life into an otherwise "historical" crop. To increase hop production in Vermont, the UVM Extension Crops and Soils Team is developing an outreach and applied research program for hops. Public interest in sourcing local foods also extends into...