Hop Breeding: 
Branding, Patenting, and the Race to Create New and Improved Hop Varieties

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History Being Made Right in Front of Us

Brewers Association
Microbreweries Have Seen the Largest Growth

Brewers Association
Hop Production in the United States

US Hop Production Areas - 2014
Hop Production in the PNW

Willamette Valley Hops
Hop Production Outside the PNW
Regional Differences

Latitudinal Differences (Photoperiod)

Soil Differences (East to West)

Climate Differences (Northwest to Southeast)
  Precipitation
  Temperature
Daylength (Photoperiod) Issues

Duration of Daylength Among Different Hop Production Regions

- Grand Rapids, MN
- Rosemount, MN
- Yakima, WA
- Corvallis, OR
- Asheville, NC
- Apopka, FL
Infrastructure
Post-Harvest Processing

Michigan Hops Farm

Sierra Nevada Brewing

Real Agriculture
Hop Downy Mildew (*Pseudoperonospora humuli*)
Hop Powdery Mildew (*Podosphaera macularis*)

Twomey *et al.* (2015)
Distribution of Hop Powdery Mildew
So what is it that Growers need from a New Hop?

• Tolerant or resistant (immune) to disease
  • Resistance is not forever, the pathogen can evolve around “vertical” resistance

• Yields better than varieties from the PNW
  • Varieties that are adapted to different photoperiods, climates, soils, lower inputs

• Has bittering/aroma/flavors that brewers like
  • Novel compounds or novel combinations? “Terroir”?  

• GROWS AND SELLS ITSELF...?
The Low-Hanging Fruit in Hop Breeding

• Are there disease-resistant (or tolerant) wild hops? Can we find them? Where do they exist?

• Which disease(s) are they tolerant of? (Many? Just one?)

• Are they female (or male)? (If you’re growing from seed, you don’t know until they flower.)

• What are their agronomic properties? (i.e. yield, growth, vigor, etc.)
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Developing a Germplasm Collection
In vitro Disease Screening Assessments
Foliar Disease Differs Between Genotypes

$N = 112$
Disease Phenotypes are Correlated

Kralj et al., 1998; Woods and Gent, 2016
How are these related to each other?

These hops are from the Upper Midwest.

These hops are from the Southwestern US.

These are primarily hop cultivars, interspersed with some that are likely feral (escaped) or resulting hybrids between cultivars and native hops.

These hops are from the Upper Midwest.
Hop Breeding in the PNW
Our Breeding Program
(Not in the PNW)
Screening Procedures

We test for powdery mildew resistance. (Can be qualitative or quantitative.)

We test for downy mildew resistance. (This is quantitative.)

Selected plants go into the field for evaluations of vigor and sex.

Males are rogued or removed to a different location for evaluation.

Only the best females in the first year are selected for further study. (This is primarily due to space restrictions.)

Wash, rinse, and repeat in subsequent years.
Greenhouse Powdery Mildew Rating Scale
Resistance is a fickle mistress
Field Hop Downy Mildew Rating Scale

1
1 – 25%

2
26 – 50%

3
51 – 75%

4
76 – 100%

0 = No disease

5 = Dead
Parents and Grandparents of these Breeding Lines

• Brewer’s Gold
• Challenger
• Chinook
• Nugget
• Southern Brewer
• Sterling
• Spalter Select

Richard Torrens
SROC Female Breeding Lines (Since 2012)

• 2012 crosses
  • 1 selection in single-hill plot
    • on-farm trial since 2016
• 2014 crosses
  • 2 selections in single-hill plot
  • 2 selections in multi-hill plots in 2018
• 2015 crosses
  • 3 selections in single-hill plots
• 2016 crosses
  • 7 selections from 2 crosses in single-hill plots in 2018

5-6% alpha, moderate-high CoH, 1 - 1.5% oil, mild aroma w/ fruit, late-maturing, vigorous

~10% alpha, aroma similar to BG/Cluster, vigorous

7-8% alpha, late-maturing, decent yield, variable aroma

5-6% alpha, slow starter, variable aroma, decent yield

Several others with 1-year evals. indicating potentially high-alpha, high-yielding, and favorable aromas
SROC Male Breeding Lines

- 6 males generated from novel crosses
  - 2 used for breeding so far
- 2 USDA males used
  - One novel
- 1 feral male used

- Males are commonly assessed by how well their children perform, specifically their daughters

Charlie Rohwer
Wild Hop Evaluations for Breeding

• 30 ‘feral’ and USDA seedlings in single-hill plots (2017)
  • selected for relative tolerance to foliar downy mildew
“Heritage” and “New” Hops

Great Lakes Hops
Heritage Collection

- GLH - ARCADIAN  Light, Floral, Pure
- GLH - WALHALLA  Harvester in a Hop
- GLH - PRUSSIAN  German-Style...Delicious.
- GLH - PETOSKEY  Did someone say...Pineapple?
- GLH - HARTWICK  Like Michigan Pines this hop leaves an impression.
- GLH - SAUGATUCK  Fragrant and kind of a Big Deal!
- GLH - OLD MISSION  Get your pinot noir ready for this yield.
- GLH - SHADDOCK  Like playing baseball with a Pedalos.
- GLH - DIAMOND SPRINGS  Bright Citrus-Lemony

Available for purchase by GLH Select Hop Grower Members
"Membership Application Required"

Top Secret™
Shhh... For your eyes only
Summary

• Hop breeding is a **LENGTHY** process (a minimum of 10, closer to 12 – 15)
  • We’re beginning our 6\textsuperscript{th} year.
  • We’re in the 3\textsuperscript{rd} year of on-farm trials.

• We’re **FOCUSED** on disease resistance
  • We’ve identified wild hops that appear to be highly-tolerant to DM and resistant to PM.
  • Will they be agronomically useful?

• We’ve identified hops that are genetically **UNIQUE**
  • Some are from local populations that appear to be adapted our climate.
  • Further testing will tell how useful they are.

• We have some **EARLY** breeding lines that show promise
  • We’re working to get enough hops to get into brewers hands, so they can tell us if they’re interesting.
Acknowledgements
Thanks!

• Questions?

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The Growler Magazine
Foliar Disease Differs Between Groups

![Bar chart showing foliar disease (%) for different taxonomic varieties, species, or cultivars. The chart indicates differences among groups marked with letters a and b. Pacific Gem has the highest disease percentage.](image-url)
Foliar Resistance Differs Between Origin of Material
New Goals

Red = Seed Collections
Blue = Clonal Collections