Wisconsin
A unique growing area
Your Challenge!
The Need for Breed
What Brewers Want
What Brewers Don’t Want
Pesticides
Nitrates
Best Time to Harvest
The Dangers of Hop Drying
Opportunities in Hop Drying
Hop Baling
Pelletizing – Another Danger
A Word About Hop Testing
Hops are Food

Only in Wisconsin!
<table>
<thead>
<tr>
<th>Country</th>
<th>Average Farm Size (acres)</th>
<th>Average Yield (pounds per acre)</th>
<th>2017 Crop (million pounds)</th>
<th>% of World Harvest</th>
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<tbody>
<tr>
<td>USA</td>
<td>780</td>
<td>1,880</td>
<td>106</td>
<td>41%</td>
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<tr>
<td>Germany</td>
<td>43</td>
<td>1,875</td>
<td>91</td>
<td>35%</td>
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<td>China</td>
<td>280</td>
<td>2,300</td>
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<td>Czech Republic</td>
<td>105</td>
<td>1,200</td>
<td>15</td>
<td>6%</td>
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<td>Poland</td>
<td>5</td>
<td>1,675</td>
<td>7</td>
<td>3%</td>
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<tr>
<td>Slovenia</td>
<td>35</td>
<td>1,500</td>
<td>7</td>
<td>3%</td>
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<tr>
<td>New Zealand</td>
<td>57</td>
<td>1,500</td>
<td>1.7</td>
<td>0.6%</td>
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</table>
You are unique! This is a Double Edged Sword

- You are small and inefficient but quick to adapt. Play to your strengths. More attention to every detail
- You are experienced farmers but lack long term experience in hops. You come with a unique perspective.
- You should not have a sales and marketing staff. You have a unique and personal story. Brewers like farmers not sales people. Don’t waste money and time on hiring a sales staff. Invest that money in research. Work with a University.
- Brewers don’t know you and have a hard time, collectively, expressing what they want from you. Brewers rely on the technology and experience offered from large farmers and brokers. You cannot offer that. Thus you have a steep learning curve so be clever!
- Brewers are working through long term contracts so sales will be slow at first. This is an opportunity to hone your skills
- Hop varieties were not bred for Wisconsin. Yakima is a desert – different climate and different pests. Invest in breeding!
- Climate change is disturbing traditional hop varieties. Europe is experiencing low precipitation and high heat. Noble hops will suffer
- New Zealand should be your inspiration.
- The technology of Germany and Poland, not Yakima, is better suited to your needs
- Price of Hops per “Lupulin Exchange” range from $0.22 / pound to $50.00 / pound.
- Average Prices are $5.00 - $12.00 / pound
- Some scarce and unique Australian and New Zealand Hops sell for $13.00 - $18.00
- Let’s create our world so that someday brewers around the world will say “Wisconsin is a small growing area but they grow really nice hops” so you can charge a premium and brewers still feel they are getting a bargain
Breeding Hops to Succeed in Wisconsin
Per Dr. Val Peacock

“For breeding Wisconsin friendly hops, first step is to collect wild hop material from the state. Natural selection has already screened these hops for vigor & disease tolerance. Both males and females are useful. You may get really lucky and one of these is actually commercially viable - but unlikely. Then cross these wild plants with males and females with known desirable characteristics (yield, vigor, flavor, and / or disease resistance) from the USDA hop collection in Corvallis. Part of John Henning's job is to supply such material to interested parties in the USA. I would be happy to instruct folks where to find wild hops and how to "collect" them. Such a program will result in hops that grow better in Wisconsin and are unique to the State.”
What are Brewer’s Expectations for Quality?

• Select from whole cones not pellets
• Select the best hops and reject poor quality
• Are cones intact? Do they fall apart?
• Are they Green or brown
  Brown on exterior only = wind or mechanical damage
  Brown to center = disease
• Leave and Stem content?
• Mold? Aphids, Downy Mildew, Powdery Mildew.
• Rub vigorously to break lupulin. Is aroma typical? Off?
• Problems that compromise quality:
  Hop pest and disease damage
  Mechanical damage from the field or processing (hop conveying!)
  Weather or wind damage
  Harvesting too early or too late
  Improper harvesting
  Improper drying
  Improper baling
  Contamination with non-hop materials or odors.
Pesticides

• There are no MRL’s (Maximum Residual Levels) for pesticides in beer. As long as MRLs are not exceeded in hops, there are no health concerns for beer consumption. None the less, the court of public opinion holds sway
• Detection limits of pesticides in beer are being lowered with refined analysis technology. Detection limits are approaching 0.5 ppb.
• Pesticides in hops can be detected in beer especially in strongly hopped beers. This correlates with residues in hops and their solubility in beer.

• An Opportunity – “The Red Queen” and Breeding
• Hops fall under pesticide regulations like all crops and require that the grower possess a pesticide applicator’s license and a logbook recording all chemical applications.
• Be ready to show your customers your spray records
• Do not store chemicals and farm equipment in the same building as harvest and drying during growing season and harvest
<table>
<thead>
<tr>
<th>Pesticide Name</th>
<th>Type</th>
<th>Class</th>
<th>Possible Trade Name(s)</th>
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<td><strong>Ametoctradin</strong></td>
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<td>Quinone Inhibitor</td>
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<td>Glycosides</td>
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Nitrates

- High Nitrate levels in foods is considered a health hazard
- EPA standard for drinking water is < 50 ppm as NO₃
- There is no standard for beer
- Hops contain circa 10,000 ppm NO₃
- Dry hopping @ > 1.5 pounds / bbl can exceed 50 ppm NO₃ in beer
- Take care with nitrogen application. It’s worth tracking petiole NO₃ levels in your hops
When to Harvest?

- Harvest Window is important
- Know what your customers want
- You are small farmers so can be more exacting than Yakima growers with choosing harvest dates
- As cones mature, Cone Color goes from green to light green to yellow to brown
- Early Harvest = Better looking hop but may not have better aroma(?) and Lower alpha.
- Late Harvest = More Oil and less moisture but hops might be a bit brown.
- If Harvest is too late = sour, garlic, onion aroma
When to pick?

Picking Index = (HSI x 100) + Dry Matter
For example = 45 – 52 for Bravo at Roy Farms

“Frequently in the hop world the question of “when to pick” comes up. I think it is an important question if we are looking for **constancy and quality** in our product. From a growers perspective, guidelines for picking must be simple, affordable and easily implemented. There are a multitude of variables that impact quality and consistency and I believe that our “pick index” program works well for us. Since most growers do look at Dry Matter we tried to see what we could do with the same sample at the same time. Sample prep for dry matter is no different than sample prep for UV Spectro. For us the most informative info derived from UV Spectro is HIS. Additionally HSI is the only qualitative data available pre harvest to most growers.”

Jim Boyd, Roy Farms, Washington
Hop Drying

“All too often, improper drying & baling of hops turns good hops in the field into a nearly useless product. Over-drying of hops will not only result in cones that break apart during bailing (causing accelerated aging), but also will evaporate much of the hop oil”. Val Peacock

• 8 – 12% moisture
• Pacific Northwest dryer Inlet Temperatures < 145 °F.
• Best farms ≤ 130°F (125 °F with 26 – 30” bed)
• 6 – 8 hour drying.
• Germany maximum is 144°F for aroma hops and 149°F for high alpha hops.
• Three level tower dryers with 12 – 15” bed.
• 4 - 6 hour drying.
• Why so hot? To allow for higher throughput but quality suffers.
• Air Speed and Evaporative Cooling. Loss of aromatic oils and alpha acid increases at higher temperature. Temperature versus time.
• Take care to avoid pick up of off aromas from smoke, auto fumes etc
A Better Mouse Trap!

- Larger farms have limited drying capacity. You don’t
- So dry hops like the “old days”
- “Until the 19th century hops were dried in layers of 3 to 5 centimeters over 2 to 10 days. The duration of the drying period was mainly dependent on weather conditions. Later, picking machines increased the amount of hops that had to be dried and consequently more efficient ways to dry hops evolved”
- My visit to Saaz
- Read “A Comparison of Hop Drying with Unheated, Dehumidified Air Versus Traditional Drying with Heated Air” by Dr. Val Peacock et al. Master Brewers Technical Quarterly vol 55, no. 3
- Ambient drying followed by dehumidification in recycle is most gentle and relatively energy efficient. Takes 2 days instead of 4 – 8 hours but may make a better hop (?)
- With ambient drying you have time to make decisions based on present moisture
- No need for post drying conditioning
- Shallow Bed is better
- Fast air movement so prevent condensation on hops
- Down draft air flow
Hop Baling

• No need to follow Yakima tradition of 200 pound bales
• Presentation is important for a high value crop so don’t pack in cardboard and plastic trash bags.
• Hops should be allowed to breathe when packed. This allows them to lose garlic/onion aroma if present and equilibrate moisture.
• The primary material used in the industry is polypropylene cloth.
• Burlap is also used but is rejected by one large brewer because of possible off odors from burlap.
Pelletizing Table Stakes

• Pelletizing is not easy! Hops have a mind of their own! A terrible thing to do to hops!
• Pelletizing ruptures the lupulin glands exposing them to oxidation and volatilization. Need to get hops into an inert atmosphere as soon as possible
• Hop Storage
  Bales at ≤ 28 °F
  Pellets at ≤ 40 °F. We store hops at 0 °F
• Split open bale before “Bale Breaker” to see if hops are spoiled or contaminated internally
• Heat develops in the hammer mill and especially the pellet press due to friction. Worst with low alpha hops.
• Maximum Temperature of Pellets Exiting Pellet Press ≤ 50°C (122 °F) for aroma hops
• Remove and discard Breakout Pellets (e.g. glassy or scorched pellets) at start up. Scorched or glassy pellets should not be feed back into the pellet stream.
• Cool pellets to < 25°C (77 °F) within 20 minutes of pelletizing
• It is acceptable to use Liquid Nitrogen Cooling at Press but plant must achieve proper temperature measured out of Pellet Press without artificial cooling
• Pellet density not to exceed 550 gms/liter. 485 gms/liter is optimum.
• Larger particles at hammer mill. Dusting is not a problem for craft brewers
• Pellets must be at < 77 °F before packaging
• Foil Integrity
  Leak test foils by submerging in water to detect bubbles/leaks.
  Maximum O₂ Concentration in Foil Immediately After Sealing < 2.5%
• Must be moved to Cold Store at ≤ 40 °F as soon as possible but less than 12 hours after packaging
• Check HSI before and after pelletizing

Only in Wisconsin!
Hop Testing

• Find a lab you like and stick with it
• Three ways to quantify hop acids
  Spectrophotometric Method - ASBC 6A
  Lead Conductance Method - EBC 7.5 and ASBC 6B
  HPLC Method - HPLC-14 and EBC 7.7
HSI

• Developed in the early 1970’s by two USDA Scientists, Gail Nickerson and Sam Likens.
• Ratio of Hop oxidized acids to the remaining alpha and beta acids. Higher number = more oxidation
• Hops have different Storage Stability.
• Mistreated hops produce a lingering bitterness, poor aroma and inferior foam.
• Want > 0.20 at harvest. < 0.2 is too low especially if you want aroma
• Typical industrial norm in PNW = 0.20 to << 0.30
• If >> 0.35 = cheesy flavor.
• Best HSI results when hops are harvested at optimum time, with lower stripper speed, controlled drying and baling, low temperature pelleting and cold storage at all times
• HSI increase across pelletizing should be < 0.05. Best if ≤ 0.015
• General Farm Sanitation
• Picking, drying and baling areas should be kept clean and free of undesirable materials during the harvest.
• Unauthorized people should not have access to hop processing areas.
• Food, beverages, chewing gum and tobacco products shall not be consumed or present in processing areas. A separate and convenient break area shall be supplied for workers suitable for eating meals. Sufficient covered waste and recycling containers must be present in this area to keep waste from finding its way into the processing areas.
• Toilet and hand-washing facilities with adequate signage shall be provided for workers.
• All lighting should be enclosed or utilize “shatter-proof” bulbs.
• Only food grade lubricants, greases and fluids are to be used on equipment in the processing areas.
• Insulation in the ceiling, or paint above hop-containing areas should be in good repair.

Pest Control
• Picking machines and hop drying & baling areas should be kept rodent, bat & bird-free during unused months of the year.
• Care should be taken to seal or block all possible entry points for birds in the off-season. Netting.

Equipment Sanitation & Maintenance
• All surfaces that may come in contact with hops must be washed and sanitized just before harvest. Special care is to be taken to remove bird droppings and any foreign material.
• Built-up lupulin and non-hop material are to be removed from conveyor belts before the start of the harvest.
• Excessive dirt, dust and loose material on rafters, lights & equipment above hop beds in drying & baling facilities are to be removed before the harvest. Use forced air or water as is practical.
• Care must be taken to assure fuel & fluids from motor vehicles do not contaminate flood surfaces that come in contact with hops. It is strongly recommended that motor vehicles and farm equipment not be stored in the off-season where hops contact floors. Or if this is not possible, put some type of material under the vehicle to protect the floor from fuel, oil & grease.
• Bale wrap is to be stored in the off-season (and during harvest), off the floor in a clean, dry, bird, rodent & bat-free area. Not under the eaves of a building.
• A magnet should be present above the conveyor belt carrying hops to the baler. The magnet should be cleaned daily to remove what material it has collected.
THANK YOU!