2019 Spring Webinar Series
2 p.m. CST

EXTENDING KNOWLEDGE ➔ CHANGING LIVES

NDSU EXTENSION
Upcoming Webinars

• February 20 – Growing Apples in North Dakota
  – Tom Kalb, NDSU Extension Horticulturist

• February 27 – Trendy and Healthy Houseplants
  – Esther McGinnis, Assistant Professor and NDSU Extension Horticulturist
Zoom Controls

- Mute/unmute
- Open chat box
- Chat box
- Question/Answer Controls
Please Complete the Survey

• Please complete the short online survey that will be emailed to you after today’s webinar. It will take just a couple minutes!

• Be sure to sign up for an opportunity to win a prize in the drawing. After submitting the survey, a form to fill out with your name/address will appear.

• Acknowledgement: This project was supported by the U.S. Department of Agriculture’s (USDA) Agricultural Marketing Service through grant 14-SCBGP-ND-0038.
Hops in North Dakota: What you need to know before you get started!

Field to Fork Webinar series
February 13, 2019
Why are hops in demand?


NORTH DAKOTA BEER AND WINE TRAIL
Today:

I. History
II. Botany
   1. Chemistry
   2. Stages of production
III. Plant Requirements
IV. Hops Here in North Dakota
V. Pest Problems
Origins

First written records 736 AD from the Hallertau region in Bavaria, Germany
US History 101

- European explorers from England brought hop plants to America in 1629
- In 1808, first commercial hop yard was established in New York.
What about North Dakota?

North Dakota has a rich beer history that began long before statehood.
Glossary

Beer
Hop yard
Hops
Inflorescences
Resins

• “An alcoholic beverage usually made from malted cereal grain (such as barley), flavored with hops, and brewed by slow fermentation.” - Merriam-Webster

• “A field in which hops are grown; also called hop field, hop garden” - MSU Extension Publication E3236

• “Female flowers of the perennial hop plant (Humulus lupulus)” - MSU Extension Publication E3236

• “The complete flower head of a plant including stems, stalks, bracts and flowers.” - Merriam-Webster

• Found only in the lupulin glands of hop plants, chemical compounds that make up the acid profile
Nomenclature
Hops belong to the family *Cannabinaceae*.
Three recognized species *Humulus lupulus*, *H. yunnanensis* and *H. japonicas*

Botany
Hops are *dioecious*-[di, two + oikos, house]”Unisexual; having the male and female elements on different individuals of the same species” – Biology of Plants 6th Edition
Figure 1.3 (a) ‘Pin’; young flowering shoots developing in the leaf axils; (b) ‘Wye Target’; young female inflorescence with papillated stigmas. Mature cones of (c) Fuggle; (d) Yeoman; (e) ‘Strig’; central axis of cone; (g) bract; (h) bracteole encased in cone; (i) bracteole with seed; (j) removed (after R. F. Farrar).
Figure 1.3 (a) ‘Pin’; young flowering shoots developing in the leaf axils; (b) ‘Burr’; young female inflorescence with papillated stigmas. Mature cones of (c) Fuggle; (d) Wye Target; (e) Yeoman; (f) ‘Strig’; central axis of cone; (g) bract; (h) bracteole with enclosed seed; (i) bracteole with seed; (j) removed (after R. F. Farrar).
Soft Resins

α-acids
• Humulone
• Cohumulone
• Adhumulone

β-acids
• Lupulone
• Colupulone
• Adlupulone

Both α-acid and β-acid impart bitterness to the beer!
Essential Oils

• Impart aroma and flavor to the beer
• Represents 0.5-1.5% of weight of dried cones
• Consists of complex mixture of 200 or more components
• Less is understood about the nature of the essential oil chemistry
Plant Stages of Production

- Dormancy
- Spring growth
- Vegetative growth
- Reproductive growth
- Harvest
- Back to dormancy
Glossary

Perennial
Rhizome
Bine
Trichome
Tropism

• “A plant in which the vegetative structures live year after year” - Biology of Plants 6th Edition
• “Horizontal underground stem.” – Biology of Plants 6th Edition
• “The climbing stem of the hop” – Oxford English dictionary
• “[Gk. trichos, hair] An outgrowth of the epidermis, such as a hair, scale or water vesicle.” – Biology of Plants 6th Edition
• “The turning of all or part of an organism in a particular direction in response to an external stimulus”
Tropism

• Clockwise direction around anything within reach
• Phototropic (light) and thigmotropic (touch)
Trichomes

Dormancy

- Killing fall frost Late September to March late April
- Plant translocate nutrients from shoots down to the storage roots
- Above ground shoots die back to the ground
- Buds for next year are in the resting phase

Figure 1.7 Perennial storage organ of young plant consisting of new shoot, old stem of original trimmed sett and new storage roots (Williams, 1960).
Spring Growth

- Time to plant new
- Plant emerging March through May
- Increasing day length and temperatures

Fieldwork:
- Early season weed control
- Fertilizer application
- Stringing your trellis
- Irrigating
- Training
Training

• Too late—not achieving maximum yield
• Approximately 3 bines per string
**Aboveground Growth**

Bines grow 18-25’ per season

• Up to one foot per day!

Laterals extend from the bines
Vegetative Growth

- Typically May through July

1. June 21\textsuperscript{st} Summer Solstice
2. Days get shorter signaling reproductive phase

- Side-arm (lateral) growth begins late June early July

Fieldwork:
- Another round of fertilizer
- Keep irrigating
- Scouting for pests and diseases
Reproductive Growth

- July to August
  - Hop bines have reached the top of trellis
- Cones develop
- Cannot increase the number of cones
  - Maintaining plant health will maximize cone weight and quality
Harvest

- Mid-August to late-September depending on cone moisture and variety
- Many harvest methods
  - Most common: cut and transport bines to a stationary picking machine
  - Other methods: mobile harvesters
  - Hand picking?
Back To Dormancy

- End of August through first hard freeze late-September, early October
- Autumnal equinox-days have gotten shorter until they are around the same as night
- Nutrient translocation to storage roots

Fieldwork:
- Take care of perennial weed issues
- Keep irrigating hops until freeze
- Prevent crown damage
So far:

I. History

II. Botany
   1. Chemistry
   2. Stages of production

III. Growth Requirements

IV. Hops Here in North Dakota

V. Pest Problems
Growth Requirements

- Grow best between 34-50° Latitude north or south
- Day length sensitive
- Soil preference: pH 6-7.5
- Fertilizer:
  1. First year 75 lb N/Acre
  2. Subsequent years 100-150 lb N/Acre
     20-30 lb P/Acre
     80-150 lb K/Acre
- Irrigation: 16 gallons/plant/week
  (1-acre hopyard, ~900 plants = 15,000 gallons)
  *During hottest months
Considerations…

• Site selection
  – Full sun
  – Protection from wind
  – Space to build trellis
  – Equipment access
  – Irrigation access
At the Williston REC
<table>
<thead>
<tr>
<th>Variety</th>
<th>Alpha Acid %</th>
<th>Brew Usage</th>
<th>Typical Beer Style</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascade</td>
<td>5-7%</td>
<td>Aroma</td>
<td>American Pale Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Centennial</td>
<td>9.5-11%</td>
<td>Dual</td>
<td>American Pale Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Challenger</td>
<td>6.5-9%</td>
<td>Dual</td>
<td>English Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Brewer’s Gold</td>
<td>8-10%</td>
<td>Bittering</td>
<td>English Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Galena</td>
<td>10-15%</td>
<td>Bittering</td>
<td>Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Glacier</td>
<td>5.5%</td>
<td>Dual</td>
<td>American Pale Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Mt. Hood</td>
<td>4-7%</td>
<td>Aroma</td>
<td>Lager</td>
<td></td>
</tr>
<tr>
<td>Newport</td>
<td>13-17%</td>
<td>Bittering</td>
<td>Barley Wine</td>
<td>Domestic</td>
</tr>
<tr>
<td>Nugget</td>
<td>12-14%</td>
<td>Bittering</td>
<td>Barley Wine</td>
<td>Domestic</td>
</tr>
<tr>
<td>Willamette</td>
<td>4-6%</td>
<td>Aroma</td>
<td>English Style Ale</td>
<td>Domestic</td>
</tr>
<tr>
<td>Spalt Select</td>
<td>3-6.5%</td>
<td>Aroma</td>
<td>Bock</td>
<td>Domestic</td>
</tr>
<tr>
<td>Zeus</td>
<td>20%</td>
<td>Bittering</td>
<td>Pale Ale</td>
<td>Domestic</td>
</tr>
</tbody>
</table>
Planted August 1\textsuperscript{st} 2014
Hopster5P

Hops Harvester LLC
Economics

- Labor
- Pesticides and Fertilizers
- Equipment
- Infrastructure
  - Hop trellis
    - Including coir (string) each year
  - Harvesters
  - Dryers
  - Post harvest processing
Diseases & Insects

Mildews
- Downy mildew
- Powdery mildew

Wilts
- Verticillium
- Fusarium
- Sclerotinia

Viruses
- American hop latent virus
- Hop latent virus
- Hop mosaic virus
- Apple mosaic virus

Viroids
- Hop stunt viroid

Hop Aphid
Hop Flea Beetle
Japanese Beetle
Potato Leafhopper
Spider Mites
Loopers
(Lepidopteran larvae in photo)
Two-spotted Spider Mite
Leaf hopper
Bine Wilts

- Fusarium Canker
- Verticillium Wilt
Powdery Mildew vs Downy Mildew

- **Causal agent:** *Podosphaera macularis*
- **Wiped out hop yards in 1900s**
- **Symptoms:** powdery white colonies on leaves, stems buds, and cones.
- **Favorable Environment:** rapid plant growth, mild temperatures, high humidity and cloudy weather.

- **Causal agent:** *Pseudoperonospora humuli*
- **One of most important diseases in wet, humid regions**
- **Symptoms:** newly emerging basal spikes-stunted, pale, downward curling leaves.
- **Favorable environment:** mild to warm temperatures with prolonged leaf wetness.
Powdery Mildew vs. Downy Mildew

Figure 11. Angular leaf lesions on hop leaves. The black discoloration is sporulation by the pathogen. (D.H. Gent)

Figure 13. Dark brown discoloration of bracts and bracteoles on cones with severe downy mildew. (B. Engelhard)

Figure 14. Left, dark discoloration of rhizomes infected with Pseudoperonospora humuli. Right, healthy rhizome. (C.B. Skotland)
Figure 36. Life cycle of *Podosphaera macularis* on hop. The sexual stage of *P. macularis* (shown by arrows on the bottom and left side of the figure) is not known to occur in the Pacific Northwest. (Prepared by V. Brewster)
Figure 15. The life cycle of *Pseudoperonospora humuli* on hop. (Prepared by V. Brewster)
Cone Disorders

- Fusarium Cone Tip Blight
- Alternaria Cone Disorder
- Downy Mildew on cone
- Gray Mold
- Powdery Mildew
Beneficial Insects

This generalized information is presented only for key groups of predatory arthropods.

Photographs depict adult stages.

Many other natural enemies occur in hop yards and can contribute to control of spider mites, aphids, and caterpillar pests.

See text for detailed information on the biology, life cycle, and importance of these and other beneficial organisms.

Dormancy  Emergence  Training  Flowering  Harvest  Post-harvest
Join us for Field Days!

**Williston REC Field Day**
- Wednesday July 10\(^{th}\) 3-7pm (CST)
  - 3:00 pm Registration
  - 4:00 pm Dryland and Horticulture tours begin
  - 7:00 pm Dinner

0.6 miles west of Hwy 2 & 85 junction

**Nesson Valley Irrigation Tour**
- Thursday July 11\(^{th}\) 8:30-Noon (CST)
  - 8:30 am Coffee and Rolls
  - 9:00 am Irrigation Tour
  - 12:00 lunch

23 miles east of Williston on Hwy 1804
Questions?

Thank you!

www.ag.ndsu.edu/fieldtofork