Closing the Knowledge Gap on Wisconsin Hop Fertility

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Summary of Recent Hop Fertility Work in Wisconsin

2016 – Collected preliminary data on yield, nutrient removal and soil test levels.
- Verified P and K removal were within UW estimates
- Indicated need for further evaluation of recommended N rates

2017 & 2018 – Conducted study to evaluate effect of nitrogen rate and timing on hop biomass and cone yield. Incorporated petiole nitrate tissue and sap testing.

https://buffalo.extension.wisc.edu/agriculture/barley-and-hops/

2019 – Initiated a 2-year study to determine optimum N rates for Wisconsin growers.
- Included 5 N rates
- Continued petiole tissue and sap testing
- Included post harvest soil nitrate sampling
- Evaluate effect of N rate on hop quality parameters
2019 N Rate Trials

Same locations as used in 2017 and 2018
- Tomah, WI: Centennial and Cascade
- Waterloo, WI: Chinook, Tahoma
- Rosholt, WI: Magnum, Nugget

Nitrogen Treatments
- Plots consisted of 5 “plants”
- N rates: 0, 50, 100, 150, 200 lbs N/ac
- All N rates split applied: at training and after majority of bines reached top wire.
- N source: ammonium nitrate
- Used maintenance rates of P, K, Zn, and B
Data Collection

- Soil samples collected and plots harvested at discretion of the grower (July-Sept).

- Whole plants weighed before machine picking. Subsamples of machine-picked cones and bines collected for determination of moisture and nutrient content.

- Soil samples collected from a subset of plots to investigate for determination of profile nitrate.
2019 Biomass and Cone Yield Results

Variety significantly affected bine and cone yield

Bine DM Yield

- Cascades
- Centennial
- Chinook
- Magnum
- Nugget
- Tahoma

Cone Yield (adj. 10% moist.)

Suffered from Anthracnose
Significance of N rate effect on Bine and Cone Yield

<table>
<thead>
<tr>
<th>Location</th>
<th>Variety</th>
<th>N treatment effect on Bine DM yield P-value</th>
<th>N treatment effect on Cone yield P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomah</td>
<td>Cascades</td>
<td>0.001</td>
<td>0.099</td>
</tr>
<tr>
<td>Tomah</td>
<td>Centennial</td>
<td>0.012</td>
<td>0.023</td>
</tr>
<tr>
<td>Rosholt</td>
<td>Magnum</td>
<td>0.015</td>
<td>0.077</td>
</tr>
<tr>
<td>Rosholt</td>
<td>Nugget</td>
<td>&lt;0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>Waterloo</td>
<td>Chinook</td>
<td>0.014</td>
<td>0.37</td>
</tr>
<tr>
<td>Waterloo</td>
<td>Tahoma</td>
<td>0.772</td>
<td>0.633</td>
</tr>
</tbody>
</table>

P values less than 0.05 generally indicate significant effect of N treatment.
## Overall Effect of N rate on Average Bine and Cone Yield

<table>
<thead>
<tr>
<th>N Rate (lb N/ac)</th>
<th>Bine DM (lb/ac)</th>
<th>Cone Yield (adj. 10% moisture, lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2735 C</td>
<td>841 C</td>
</tr>
<tr>
<td>50</td>
<td>3480 B</td>
<td>944 CB</td>
</tr>
<tr>
<td>100</td>
<td>4191 A</td>
<td>1141 BA</td>
</tr>
<tr>
<td>150</td>
<td>4430 A</td>
<td>1226 A</td>
</tr>
<tr>
<td>200</td>
<td>4501 A</td>
<td>1188 A</td>
</tr>
</tbody>
</table>

Means that do not share a letter are significantly different.
Biomass and Cone Yield affect on N Removal

- Cone yield was not a good predictor of N removal

- N removal is well correlated with biomass yield

\[ y = 0.0181x + 4.3093 \]
\[ R^2 = 0.7009 \]

\[ y = 0.0685x + 18.767 \]
\[ R^2 = 0.3788 \]
Petiole Tissue and Sap testing

- Potentially a valuable tool for hop growers
- Samples collected when bines are $\frac{1}{2}$ - $\frac{3}{4}$ to top of trellis
- Allows for in-season adjustment of N rates
- Recommend applying 50-70% of N recommendation prior to petiole test

**General Guidelines (adapted from PNW recommendations)**
- 0-6000 ppm: Apply recommended rate plus additional 30-50lbs N
- 6000-10000 ppm: Apply recommended N rate
- 10000+ ppm: no additional N necessary
Effect on Hop Quality Parameters

- 3 varieties sampled for hop quality parameters, analyzed by AAR Labs
- Variety significantly affected HSI, total Oils, Total A-acid, Cohumulone, Total B-acid, Colupulone, and A/B ratio. (P<0.0001)
- N rate did not have a effect on any quality parameter except Colupulone. (P=0.02).
- Colupulone (as % of BA) decreased steadily with N rate in the Chinooks, but this decrease was not observed in Cascade or Magnum varieties.

<table>
<thead>
<tr>
<th>Variety</th>
<th>HSI</th>
<th>Oils (mg/100g)</th>
<th>Cohumulone (% of AA)</th>
<th>A-Acid (%)</th>
<th>Colupulone (% of BA)</th>
<th>B-acid (%)</th>
<th>A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascade</td>
<td>0.24</td>
<td>0.19</td>
<td>32.45</td>
<td>1.41</td>
<td>54.14</td>
<td>0.98</td>
<td>1.55</td>
</tr>
<tr>
<td>Chinook</td>
<td>0.26</td>
<td>0.62</td>
<td>30.55</td>
<td>2.83</td>
<td>55.27</td>
<td>0.73</td>
<td>3.87</td>
</tr>
<tr>
<td>Magnum</td>
<td>0.27</td>
<td>0.86</td>
<td>25.92</td>
<td>4.57</td>
<td>45.97</td>
<td>2.12</td>
<td>2.15</td>
</tr>
</tbody>
</table>
Effect of N rate on Colupulone (as % of BA) in Chinook

Interval Plot of Colupulone vs Nrate

95% CI for the Mean

The pooled standard deviation is used to calculate the intervals.
N treatment effect on Soil test

- N treatment had no significant effect on soil test P or organic matter, but significantly (P<0.001) affected pH and soil test potassium.
- On average pH dropped 0.5 units and K dropped 45 ppm in 200lb/ac N rate plots compared to the 0 N plots.
Deep Soil Nitrate sampling

- Collected from three varieties; Cascades (Tomah), Chinook (Waterloo), and Nugget (Rosholt).

- Used truck-mounted probe to collect samples to a depth of 7-8 ft (or refusal)

- Collected samples in row, ¼ distance between row, and ½ distance between row.

- Sampled 0, 100, and 200 lb N/acre plots.
Rosholt-Nugget

Row

¼ Distance between rows

½ Distance between rows

Nitrate-N (ppm)
Tomah-Cascade

Rocky subsoil prevented coring at most locations.
SUMMARY

- 2019 growing season data suggest, on average, N rate above 150 lb/ac did not increase cone yield.
- Cone yield doesn’t appear to be a good predictor of optimum N rate.
- Fine-tuning N rate for hop will likely involve variety-specific adjustments for biomass production.
- Petiole testing has promise for in-season adjustments of N rate – proper sampling time is important.
- Most quality parameters don’t seem to be affected by N rate, but data suggest that N fertility decreases colupulone in at least one variety.
- Managing lime and K inputs are important considerations for hop growers.
- End-of-season soil nitrate-N concentrations were generally low, and didn’t appear to reflect N rate.
Acknowledgements

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