Fine-Tuning Organic Nitrogen Fertilizer Sources, Rates, and Cut-Off Times in Organic Highbush Blueberry

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Washington Leads in Organic Blueberry Production

Washington State is the largest national producer of organic highbush blueberries

~ 46% of nation’s organic production
~ $38 million estimated value

Source: USDA-NASS, 2017
Background - Why Eastern Washington?

- 75% of WA’s organic blueberry acreage
- Unique soil and climatic conditions within the PNW
- Little research on nutrient management
- Recommendations from other states (e.g. Oregon) may not be applicable

<table>
<thead>
<tr>
<th>Variable</th>
<th>Requirements for blueberry</th>
<th>Native soil conditions in eastern Washington</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.0-5.5</td>
<td>7.5-8.3</td>
</tr>
<tr>
<td>Organic matter</td>
<td>High (3-5%)</td>
<td>Low (&lt;1%)</td>
</tr>
<tr>
<td>Predominate form of nitrogen</td>
<td>NH₄-N</td>
<td>NO₃-N</td>
</tr>
</tbody>
</table>

Source: Brady et al., 2015; Dancer et al., 1973; Hart et al., 2006
Blueberry cultivars respond differently to organic fertilizer nitrogen (N) sources.

‘Duke’ performed better with fish emulsion, while ‘Liberty’ performed better with feather meal.

In western Oregon, higher yields have been associated with lower N fertilizer rates.

Little research on nutrient management in eastern WA.

Source: Larco et al., 2013

Photos: Lisa DeVetter
• Climactic conditions in eastern Washington are unique for blueberry
• There may be a benefit to post-harvest applications of fertilizer N in early-fruiting cultivars

**Potential Benefits:**
• Post-harvest N application may encourage lateral shoot growth and provide additional fruiting wood for the following season
• Contribute to N storage pool in plant
• Bañados et al. (2012) showed late-season N application increased dry weight allocation and N concentrations in leaves and shoots

**Potential drawback:**
• N applied too late can reduce fruit bud set and/or delay acclimation

Source: Bañados et al., 2012; Throop and Hanson, 1997
Objectives

Experiment #1 – Source and Rate
• Evaluate the impacts of commercially available organic N fertilizer sources applied at low, medium, and high rates on blueberry plant growth, development, yield, and soil characteristics

Experiment #2 – Timing of N Cut-Off
• Study the impacts of post-harvest N fertilization on plant growth, yield, fruit bud set, and cold hardiness in an early-fruiting cultivar

Both experiments conducted in eastern Washington
Approach - Experiment 1 (Source and Rate)

4 N sources each applied @ 3 different rates

1. WISErg™ (3-2-2)

2. Blood Meal (14-0-0)

3. True® Fish Emulsion (4-0-2)

4. Combo (40% Blood meal + 60% WISErg)

ProPhos and ProK fertilizers were applied across all plots to maintain uniform P and K rates throughout
• Split-Plot Design
  • Main plot factor - fertilizer source
  • Sub-plot factor - rate

• 12 plants/plot

• Each block was replicated 4 times

• Orientation: N - S

• Experiment size: 0.2 acres
Approach – Experiment 1 (Source and Rate)

- Fertilizer applications began at ~5 to 10% bloom (19 April and continued to 2 July 2018)

- Blood meal applied twice in the season

- Blood meal applied with four parts water (1:4)

- Liquid fertilizers (TRUE 402, WISErg, Combo) applied every two weeks

- All fertilizers were applied around the crown of the plants
Data Collection – Vegetative Growth

- Lateral shoot length
- Production of suckers and whips
- Unmanned aerial vehicles (i.e., drones)
  - Crop density
  - Canopy cover
  - NDVI / GNDVI – to estimate nitrogen levels
Data Collection – Other Plant Variables

• Yield
• Average berry mass
• Fruit firmness using a FirmTech 2
• Soluble solid content (°Brix)
• Titratable acidity

Photos: Lisa DeVetter
Estimating Nitrogen Availability

• PRS (Plant Root Stimulators) – NH$_4$-N, NO$_3$-N
• Temperature probes
• Soil moisture probes

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Preliminary Results
Results – Experiment 1 (Nitrogen Source and Rate)

Average Yield

Bar chart showing the average yield in lbs/bush for different fertilizers: B. Meal 50 LBS N, B. Meal 100 LBS N, WISEg 50 LBS N, WISEg 150 LBS N, True 50 LBS N, True 150 LBS N, Combo 50 LBS N, and Combo 150 LBS N.
Results – Experiment 1 (Nitrogen Source and Rate)

Cumulative Shoot Length

<table>
<thead>
<tr>
<th>Month</th>
<th>B. Meal 50 LBS N</th>
<th>B. Meal 100 LBS N</th>
<th>B. Meal 150 LBS N</th>
<th>WISErg 50 LBS N</th>
<th>WISErg 100 LBS N</th>
<th>WISErg 150 LBS N</th>
<th>True 50 LBS N</th>
<th>True 100 LBS N</th>
<th>True 150 LBS N</th>
<th>Combo 50 LBS N</th>
<th>Combo 100 LBS N</th>
<th>Combo 150 LBS N</th>
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<tbody>
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<td>September</td>
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</tr>
</tbody>
</table>
## Leaf Tissue Analysis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>50 LBS/acre</th>
<th>100 LBS/acre N</th>
<th>150 LBS/acre N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Meal</td>
<td>1.45</td>
<td>1.53</td>
<td>1.51</td>
</tr>
<tr>
<td>WISErg (2-0-2)</td>
<td>1.47</td>
<td>1.53</td>
<td>1.61</td>
</tr>
<tr>
<td>True (4-0-2)</td>
<td>1.47</td>
<td>1.53</td>
<td>1.56</td>
</tr>
<tr>
<td>Combo</td>
<td>1.51</td>
<td>1.51</td>
<td>1.61</td>
</tr>
</tbody>
</table>
Results – Experiment 1 (Nitrogen Source and Rate)

Average Berry Weight

![Bar graph showing average berry weight for different fertilizer sources.]

- Fertilizer source options: B. Meal 50 LBS N, B. Meal 100 LBS N, WISErg 50 LBS N, WISErg 150 LBS N, True 50 LBS N, True 150 LBS N, Combo 50 LBS N, Combo 150 LBS N.

grams/ berry
Results – Experiment 1 (Nitrogen Source and Rate)

Average Berry Firmness

![Graph showing average berry firmness for different fertilizer sources.](image)
Approach – Experiment 2 (Nitrogen Timing)

- 4 treatments applied @ 125 lbs N/acre
- Fertilizer source was WISErg (3-2-0)
- Fertilizer applied weekly from 17 April to 22 Aug. 2018

**Treatments**
1. Control (100% of N applied pre-harvest; standard grower practice)
2. 80/20 (80% pre-harvest, remaining 20% post-harvest)
3. 70/30 (70% pre-harvest, remaining 30% post-harvest)
4. 60/40 (60% of N pre-harvest and remaining 40% post-harvest)

Photos: Lisa DeVetter
Randomized complete block design

- 16 plants/plot

- Each block was replicated 4 times

- Orientation: S-N

- Experiment size: 0.05 acres
Data Collection – Vegetative Growth

- Lateral shoot length
- Production of suckers and whips
- Unmanned Aerial Vehicles (i.e., drones)
  - Crop Density
  - Canopy Cover
  - NDVI / GNDVI – to estimate nitrogen levels
Data Collection – Other Plant Variables

- Yield
- Average berry mass
- Fruit firmness using a FirmTech 2
- Soluble solid content (°Brix)
- Titratable acidity

- Fruit bud set (N-Cut off only)
- Cold hardiness (measured monthly in October, November, and December) (N-Cut off only)

Photos: Lisa DeVetter
<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. whips/bush</th>
<th>Yield (lbs/bush)</th>
<th>Average berry mass (g/berry)</th>
<th>Firmness (g/mm of deflection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/0 (Control)</td>
<td>7</td>
<td>32.3</td>
<td>1.8</td>
<td>196.8 ab^z</td>
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<tr>
<td>80/20</td>
<td>7</td>
<td>27.2</td>
<td>1.8</td>
<td>191.7 b</td>
</tr>
<tr>
<td>70/30</td>
<td>7</td>
<td>33.6</td>
<td>1.7</td>
<td>200.3 ab</td>
</tr>
<tr>
<td>60/40</td>
<td>7</td>
<td>35.1</td>
<td>1.7</td>
<td>206.2 a</td>
</tr>
</tbody>
</table>

| P-value          | NS^z          | NS             | NS                           | 0.0143                       |

^zNS denotes means within a column are not statistically significant due to treatment at α = 0.05.
Results – Experiment 2 (Nitrogen Timing)

Cumulative Shoot Length

- 80/20
- Control
- 70/30
- 60/40

\(^2\text{NS} \text{ denotes not statistically significant at } \alpha = 0.05.\)
## Results – Experiment 2 (Nitrogen Timing)

### Leaf Tissue Analysis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nitrogen %</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/0 Control</td>
<td>1.5</td>
</tr>
<tr>
<td>80/20</td>
<td>1.5</td>
</tr>
<tr>
<td>70/30</td>
<td>1.5</td>
</tr>
<tr>
<td>60/40</td>
<td>1.5</td>
</tr>
</tbody>
</table>

| P-value | NS |

\(^2\text{NS denotes means within a column are not statistically significant due to treatment at } \alpha = 0.05.\)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (lbs/bush)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/0 (Control)</td>
<td>32.3</td>
</tr>
<tr>
<td>80/20</td>
<td>27.2</td>
</tr>
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<td>70/30</td>
<td>33.6</td>
</tr>
<tr>
<td>60/40</td>
<td>35.1</td>
</tr>
</tbody>
</table>

| P-value | NS |

\(^2\text{NS denotes means within a column are not statistically significant due to treatment at } \alpha = 0.05.\)
Results – Experiment 2 (Nitrogen Timing)

**UAV Data**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Mean NDVI Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/0 (control)</td>
<td>0.82</td>
</tr>
<tr>
<td>80/20</td>
<td>0.83</td>
</tr>
<tr>
<td>70/30</td>
<td>0.83</td>
</tr>
<tr>
<td>60/40</td>
<td>0.83</td>
</tr>
</tbody>
</table>

P-value: NS

2NS denotes means within a column are not statistically significant due to treatment at $\alpha = 0.05$. 
Conclusions and Future Work

• Few differences observed in 2018

• Perennial plants have stored nutrient reserves, so treatment responses take time

• Project is in progress - need additional data for further interpretation

• Experiments will be repeated in 2019 and shared with industry

Photos: Lisa DeVetter
Acknowledgements

▪ Graduate Committee: Dr. Lisa Wasko DeVetter, Dr. Joan Davenport, and Dr. Gwen Hoheisel

▪ Team: Mia Blom, Yareli Cureli, Prudence Diamkatso, Lav Khot, Juan Quiros Vargas, Abhilash Chandel, Sean Watkinson, Huan Zhang, Weixin Gan, and Nadia Bostan
References:


Thank you!

Questions?

For more information
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email: amit.bhasin@wsu.edu
SFH Website: https://smallfruits.wsu.edu/
Results – Experiment 1 (Nitrogen Source and Rate)

Berry Size

<table>
<thead>
<tr>
<th>Fertilizer Source</th>
<th>Berry Size (mm)</th>
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</thead>
<tbody>
<tr>
<td>B. Meal 50 LBS N</td>
<td>16.00</td>
</tr>
<tr>
<td>B. Meal 100 LBS N</td>
<td>16.50</td>
</tr>
<tr>
<td>B. Meal 150 LBS N</td>
<td>17.00</td>
</tr>
<tr>
<td>WISErg 50 LBS N</td>
<td>17.50</td>
</tr>
<tr>
<td>WISErg 100 LBS N</td>
<td>18.00</td>
</tr>
<tr>
<td>WISErg 150 LBS N</td>
<td>18.50</td>
</tr>
<tr>
<td>True 50 LBS N</td>
<td>19.00</td>
</tr>
<tr>
<td>True 100 LBS N</td>
<td></td>
</tr>
<tr>
<td>True 150 LBS N</td>
<td></td>
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<tr>
<td>Combo 50 LBS N</td>
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<tr>
<td>Combo 100 LBS N</td>
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<tr>
<td>Combo 150 LBS N</td>
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</table>
Line break for Y axis.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rates</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>50 lbs acre N</td>
<td>100 lbs/acre N</td>
<td>150 lbs/acre N</td>
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</tr>
<tr>
<td>Blood Meal</td>
<td>169.24</td>
<td>172.26</td>
<td>169.31</td>
<td></td>
</tr>
<tr>
<td>True Fish</td>
<td>155.24</td>
<td>177.13</td>
<td>172.72</td>
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<tr>
<td>Treatments</td>
<td>50 lbs acre/ N</td>
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<td>150lbs/acre N</td>
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<td>Blood Meal</td>
<td>169.24</td>
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<td>169.31</td>
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<tr>
<td>True Fish</td>
<td>155.24</td>
<td>177.13</td>
<td>172.72</td>
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<tr>
<td>WISErg</td>
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<td>162.87</td>
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<tr>
<td>Combo</td>
<td>171.44</td>
<td>183</td>
<td>175.43</td>
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</table>