Best Fertilizer Practices for Blackberries & Raspberries

How to Assess and Plan

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Oregon State University
Most important nutrient management problems

• Soil pH is not in the ideal range for caneberry (5.6 – 6.8)
• Tools available for management of fertilization programs are not used properly
• Excess or insufficient nutrients available at key times reducing growth and/or fruit quality
• Using the wrong type of fertilizer or application method
Outline

• Soil pH
• Soil and tissue sampling and interpretation
• Fertilizer rate starting points
• Timing of fertilizer applications
• Fertilizer sources
Maintaining proper soil pH

- Long-lived perennial crop
- Fertilization lowers soil pH over time
- When soil pH too low, see nutrient deficiencies and growers must use nitrate-N (or stays in ammonium form)
- Growers must apply lime to field regularly to maintain suitable pH
- Soil testing (for pH) and tissue testing (leaf Mn) are important for monitoring pH
Maintaining proper soil pH

Liming established caneberry field (trailing blackberry)
Soil Sampling

Ensure nothing is limiting or in excess

Soil sampling in established plantings

- Every few years unless correcting problem
- Collect samples at same time of year; avoid spring after fertilization
- Collect in the row. If drip irrigated, sample within a few inches of emitter
- Collect samples down to 1.5 feet
- Remove any mulch that is present prior to sampling
- Compile sub-samples from a representative area in the block
### Critical levels for soil nutrients

Note: test methods vary by lab which may affect results. Values in table are from Oregon.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficient at less than (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (P; Bray)</td>
<td>20 to 40</td>
</tr>
<tr>
<td>Phosphorus (Olsen)</td>
<td>10 to 20</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>150 to 350</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1000</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>120</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>20 to 60</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>0.5 to 1.0</td>
</tr>
</tbody>
</table>

Soil pH: 5.6 to 6.8 (2:1 v/v in water)
Soil EC: < 2 dS/m

Soil levels of N not recommended as management tool for deciding on N fertilizer rate
(values in autumn may point to N fertilization problems)
Nutrient mobility in the soil

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mobility in soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>High (NO$_3^-$); Medium (NH$_4^+$)</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Low</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Low – Medium</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Low</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Low</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Medium</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>High</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Low</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Low</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Low</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>Low-Medium</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Low</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>High</td>
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</tbody>
</table>
Plant tissue analysis

- Provides information on the nutrient status of the plant
- Goal is to detect nutrient problems before visual symptoms or yield reductions appear
- Tool to diagnose visual symptoms and evaluate fertilizer programs
- Does not work well for anticipating current season fertilizer needs, especially in floricane-fruiting cultivars (except for micronutrients)
- Need to know: 1) What tissue to sample; 2) When to sample; 3) Interpreting results
What tissue to sample

• Sample cultivars separately
• Collect most recent fully-expanded primocane leaves (about 50); do not wash (soak)
• About 1 foot from tip of primocane in floricanefruiting types and below flowers/fruit in primocane-fruiting types
• Published sufficiency levels ("standards") are only for primocane leaves

Ensure nothing is limiting or in excess

(Adapted from Hughes et al., 1979)
Many raspberry & blackberry types – impact of this?

Florican-fruited blackberry and raspberry

Primocane-fruited types
Impact of growth habit in blackberry?
Current published primocane leaf nutrient sufficiency levels

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>OSU</th>
<th>N.E. North America</th>
<th>California</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (%N)</td>
<td>2.3 to 3.0</td>
<td>2.0 to 3.0</td>
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</tr>
<tr>
<td>Phosphorus (%P)</td>
<td>0.19 to 0.45</td>
<td>0.25 to 0.40</td>
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<tr>
<td>Potassium (%K)</td>
<td>1.3 to 2.0</td>
<td>1.5 to 2.5</td>
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</tr>
<tr>
<td>Calcium (%Ca)</td>
<td>0.6 to 2.0</td>
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<td>0.6 to 2.5</td>
</tr>
<tr>
<td>Magnesium (%Mg)</td>
<td>0.3 to 0.6</td>
<td>0.6 to 0.9</td>
<td>0.3 to 0.9</td>
</tr>
<tr>
<td>Sulfur (%S)</td>
<td>0.1 to 0.2</td>
<td>0.4 to 0.6</td>
<td>-</td>
</tr>
<tr>
<td>Manganese (ppm Mn)</td>
<td>50 to 300</td>
<td>50 to 200</td>
<td>50 to 200</td>
</tr>
<tr>
<td>Boron (ppm B)</td>
<td>30 to 70</td>
<td>30 to 70</td>
<td>30 to 50</td>
</tr>
<tr>
<td>Iron (ppm Fe)</td>
<td>60 to 250</td>
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<td>50 to 200</td>
</tr>
<tr>
<td>Zinc (ppm Zn)</td>
<td>15 to 50</td>
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<tr>
<td>Copper (ppm Cu)</td>
<td>6 to 20</td>
<td>6 to 20</td>
<td>7 to 50</td>
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OSU - Hart et al., 2006;    NE North America - Bushway et al., 2008;   California - Bolda et al. 2012

Sufficiency levels are given in concentration (% or ppm) per unit dry weight of the leaves.
Current published primocane leaf nutrient sufficiency levels

**Raspberry & Blackberry**

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Sufficiency levels are given in concentration (% or ppm) per unit dry weight of the leaves.

“late-July to early August”

“after fruit harvest”

“May to August”

OSU - Hart et al., 2006; NE North America - Bushway et al., 2008; California - Bolda et al., 2012
Raspberry leaf nutrient changes over time

From: Bryla and Strik (unpublished)
Floricane-fruiting blackberry

From Strik and Vance (2017)
Tissue sampling in primocane-fruiting blackberry
Aug. 5: Branches ~ 1 ft long (early bloom)

Sept. 10: Green fruit

Sept. 16: Early black fruit

Sept. 24: Early red fruit
Leaf nutrient changes in primocane-fruiting blackberry

Calcium and magnesium

Sampling primocane leaves

Published sample time of late July to early August

Adapted from: Strik (2015)

New recommended sample time & standard
When to sample to assess plant nutrient status to adjust fertilizer programs

• Standards published in North America are for primocane leaves regardless of type of raspberry or blackberry grown
• Tissue nutrient concentrations change over the growing season, naturally so sample at the correct time
• Standards are for late-July to early August in Oregon
• In primocane-fruited blackberry sample leaves on primocane branches at late bloom through red fruit stage
• Sufficiency levels are meaningless when used at another sampling time or for another tissue (e.g. fruiting lateral leaves or fruit)
Summary – Tissue Sufficiency levels for Primocane leaves

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<tr>
<th>Nutrient</th>
<th>Current</th>
<th>Proposed</th>
</tr>
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<td>Nitrogen (%)</td>
<td>2.3 to 3.0</td>
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<td>Potassium (%)</td>
<td>1.3 to 2.0</td>
<td>0.9 to 1.8</td>
</tr>
<tr>
<td>Calcium (%)</td>
<td>0.6 to 2.0</td>
<td>0.5 to 1.5</td>
</tr>
<tr>
<td>Magnesium (%)</td>
<td>0.3 to 0.6</td>
<td>0.25 to 0.60</td>
</tr>
<tr>
<td>Sulfur (%)</td>
<td>0.1 to 0.2</td>
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</tr>
<tr>
<td>Manganese (ppm)</td>
<td>50 to 300</td>
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</tr>
<tr>
<td>Boron (ppm)</td>
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</tr>
<tr>
<td>Iron (ppm)</td>
<td>60 to 250</td>
<td>70 to 500</td>
</tr>
<tr>
<td>Zinc (ppm)</td>
<td>15 to 50</td>
<td>20 to 50</td>
</tr>
<tr>
<td>Copper (ppm)</td>
<td>6 to 20</td>
<td>5 to 15</td>
</tr>
<tr>
<td>Aluminum (ppm)</td>
<td>na</td>
<td>50 to 400</td>
</tr>
</tbody>
</table>

Proposed by B. Strik, 2019
Fertilizer programs

• Consider rate of fertilizer needed or recommended
• Adjust rate of fertilizer based on observations of growth and tissue and soil test results
• Consider best source of fertilizer nutrient to apply
• Apply nutrient at best time of season and/or stage of plant growth for most efficient plant uptake and desired effect
• Choose best application method
Nitrogen Rate Recommendations
Soil-grown (currently published for USA)

**Blackberry**

New plantings:
25 – 50 lb / acre

Established:
50 – 80 lb / acre +
additional 20 – 25 lb at bloom of late-fruiting types

**Red raspberry**

New plantings:
25 – 55 lb / acre

Established:
40 – 80 lb / acre +
additional 20 – 25 lb at bloom of primocane-fruiting cultivars

Red raspberry (California)

**Floricane-fruiting:**
10 lb N/acre/month from late winter or early spring until end of harvest

**Primocane-fruiting:**
20 lb N/acre/month from late winter or early spring until end of harvest
Fertilizer programs

- Rates of nitrogen are recommended starting points
- Adjust as needed based on observations of growth and tissue test results
- There are no recommended rates of other nutrients. Rates depend on soil and tissue test results
Research on N fertilization rates

- Low N rates reduce cane number per plant, vigor, berry size, and yield
- High rates of N can increase internode length (reducing yield per cane) and fruiting lateral length (harvest & disease issues)
- High N rates may increase fruit and cane disease
- Late or high rates of N may increase risk of winter cold injury
- High N rates may reduce fruit firmness and shelf life
- High N rate increases the amount of reversion in blackberry
What do we know about nutrients lost in harvested fruit and prunings?

<table>
<thead>
<tr>
<th>Red raspberry</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>B (oz/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit (lb/ton fresh)</td>
<td>3.5 - 5.0</td>
<td>0.5 – 0.7</td>
<td>3.0 – 3.8</td>
<td>0.3 – 0.7</td>
<td>0.4 – 0.5</td>
<td>0.04 – 0.15</td>
</tr>
<tr>
<td>Pruning (lb/acre)</td>
<td>12 - 17</td>
<td>0.9 – 1.2</td>
<td>6.5 – 9.4</td>
<td>13 - 15</td>
<td>2.4 – 3.1</td>
<td>1.0 – 1.7</td>
</tr>
<tr>
<td>Total (lb/acre)</td>
<td>18 – 42</td>
<td>3 – 5</td>
<td>22 – 28</td>
<td>15 - 19</td>
<td>4 - 6</td>
<td>1 - 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blackberry</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>B (oz/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit (lb/ton fresh)</td>
<td>2.9 – 4.6</td>
<td>0.5 – 0.7</td>
<td>2 - 4</td>
<td>0.3 – 1.1</td>
<td>0.3 – 0.5</td>
<td>0.05 – 0.11</td>
</tr>
<tr>
<td>Pruning (lb/acre)</td>
<td>32</td>
<td>4.5</td>
<td>36</td>
<td>30</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>Total (lb/acre)</td>
<td>61 - 78</td>
<td>10 - 12</td>
<td>56 - 76</td>
<td>33 - 41</td>
<td>9 - 11</td>
<td>0.7 – 1.3</td>
</tr>
</tbody>
</table>

(Strik and Bryla, 2015)
(Strik et al., in progress)
Fertilizer N uptake research findings in blackberry & raspberry
Best timing of N fertilizer application

Same conclusions in floricane-fruiting raspberry and blackberry
- Primocane growth is dependent on new fertilizer N (or soil-available N)
- Very little stored N used for primocane growth in the second year
- Stored N (roots, crown, cane) used for fruiting lateral and fruit growth
- New fertilizer N will go to the fruit
- N is remobilized from dying floricanes to storage organs
- Chopping up floricanes between rows leads to nutrient recovery by plants

- ‘Kotata’ trailing blackberry, field-grown in Oregon (Mohadjer et al., 2001; Strik’s program)
- ‘Arapaho’ field-grown, Arkansas (Naraguma et al., 1999; Clark’s program)
- ‘Chester Thornless’ in pots (Malik et al., 1991; Clarks’ program)
- ‘Meeker’, field-grown in Oregon (Rempel et al., 2004; Strik et al., 2006; Strik’s program)
Fertilizer sources & application methods

- Granular conventional and organic fertilizers (soil applied)
- Liquid conventional and organic fertilizers (soil applied, fertigated, or foliar)
- Controlled-release fertilizers (conventional)
- Composts (organic and conventional) – may lead to build up of soil K, in particular, causing problems
- Humic acids and seaweed products (liquid, fertigated, foliar; organic and conventional) – may be a threshold
Fertilizer sources of Nitrogen

• Caneberry plants preferentially take up nitrate-N (NO$_3^-$)
• Ammonium-N (NH$_4^+$) is rapidly converted to nitrate-N at the upper end of the recommended soil pH range (6.0-6.8)
• Organic sources of N are essentially all ammonium-N (granular and liquid forms)
• Inorganic granular sources include calcium nitrate, urea, ammonium phosphates, ammonium sulfate. Various granular organic sources available
• Fertigation sources include urea-ammonium nitrate (UN-32), calcium ammonium nitrate (CAN-17), or ammonium nitrate (AN-20). Various plant- or animal-based liquid organic sources may be used
Phosphorus

- Mobile in plant, but immobile in soil
- Excess P will increase root to shoot ratio. No evidence that added P will increase growth/yield if leaf values sufficient
- Excess P may lead to micro-nutrient deficiencies
- Most commonly applied as granular in soil-grown; fertigated in substrate

Potassium

- Mobile in plant, but somewhat immobile in soil
- High rates of K can lead to “salt” injury
- High soil K and low leaf %K often related to production problems
- Application of high rates or build up in soil may reduce uptake of other cations and yield
- Most commonly applied as granular in soil-grown; fertigated in substrate
Calcium

- Immobile in plant and soil
- Low soil moisture & cool, cloudy, humid conditions limit Ca uptake leading to “temporary” symptoms
- Commonly applied when adjusting soil pH (lime)
- Can be applied with calcium nitrate or with feather meal
- Fertigated in substrate systems
- Foliar applications to reach target tissues are difficult

Increasing fruit %Ca difficult
Foliar Ca to leaves
Foliar calcium application studies

- We applied from 0.05% to 0.16% of Ca chloride, silicate, acetate, chelate & CaCl₂ + Boron. Applied 3 to 4 times from late bloom/early green fruit to 1 to 4 weeks pre-harvest. Product labels do not recommend a surfactant so none was added. No products increased fruit %Ca (Vance et al., 2017)
- Higher rates of CaCl₂ (than label recommended) had positive impact in blueberry, but risky (Gerbrandt et al., 2019)
- No effect was found of various Ca or B foliar products in blueberry in Washington (Arrington and DeVetter, 2017)
Why didn’t we see an impact?

• Label rates do not recommend higher concentrations
  o Work in apples and cherries shows higher concentrations having benefits on fruit Ca and storage
  o In blueberry, higher rates of CaCl$_2$ had positive impact (Gerbrandt et al., 2019); but risky

• Differences between berries and stone fruit where Ca applications have worked?
  o Stomata?
  o Shorter fruit development period
  o Number of applications
Magnesium

- Mobile in plant, but immobile in soil
- Commonly applied when adjusting soil pH (dolomite lime)
- Can apply as a granular or through drip
- Deficiency may occur with high rates of K fertilization
Boron

- Very immobile in plant; mobile in soil
- B deficiency reduces percent bud break and reduces seed or drupelet set in caneberries
- Toxicity can occur – tip burning of shoots and/or leaves
- Annual applications, without soil or tissue tests not recommended as may reduce yield
- Foliar applications or fertigation

- For other needed micronutrients (based on tissue testing), apply through drip/fertigation and, if needed, as foliar to target tissues
Timing of fertilization, soil-grown

- Most do granular applications of P and K (if needed) in rainy season; lime in autumn
- Granular N applied with half just before primocane emergence (late March) and half about 4 to 6 weeks later (earlier for organic sources)
- If have drip irrigation, will fertigate for N needs during a similar period or longer (at least; maybe other nutrients). May add Ca or K
- Foliar application of boron or any needed micronutrients at early bloom
Substrate systems

- Little published research for commercial style production systems
- Tendency is for more micro-management than needed by plant
- More risk (and cost) with excess fertilization
Questions?

‘Columbia Star’