Dairy Manure-Derived Fertilizers for Use in Raspberry and Blueberry Cropping Systems: Evaluation for Agronomic, Soil Health, and Food Safety Efficacy

Chris Benedict, Meijun Zhu, Betsy Schacht, Chad Kruger, Georgine Yorgey
Overview

- Context and Background
- Project Outline
- Agronomic Results
- Food Safety Results
- Implications for Practice
Whatcom County

- 115,831 Acres
- $357 million - 8th in overall value
- “Dairy and Berry”
Whatcom County

- Roughly 45,000 cows
- 2nd in dairy value and land in silage corn

(USDA 2017)
Whatcom County

- 55% of U.S. red raspberry land
- 51% of weight
- Almost all processed

(USDA 2017, WRRC)
Whatcom County
• #1 state for blueberry production (~120 million pounds)
• Whatcom #1 acreage

(USDA 2017, WBBC)
Anaerobic Digestion

- Produces renewable power
- Reduce odor, greenhouse gas emission, and pathogens in manure
- Co-digestion
- Can be coupled with nutrient recovery technology
- Four in Whatcom
Dairy Biorefinery Units and Products

Raw manure → Anaerobic Digestion → Biogas

1. Solids Separation → Separated fiber

2. Advanced Solids Separation → Phosphorus-rich fine solids

3. Nutrient Recovery → Struvite Ammonium sulfate → Low-nutrient wastewater

AD manure
Dairies to Berries

Areas of High Demand

Areas of High Concentration
Food Safety Concerns

*E. coli* O157:H7, *Salmonella*, and *Listeria monocytogenes* are important foodborne pathogens.

FSMA: Five Areas of Focus in Produce Rule

1. Agricultural water
2. Biological soil amendments of animal origin
3. Domesticated and wild animals
4. Personnel qualifications, training, and health and hygiene
5. Equipment, tools, buildings and sanitation
Project Activities

1. Agronomic Trials: raspberries and blueberries
2. Food Safety Evaluation
3. Nutrient and Cost Impact Analysis
4. Extension and Outreach
Sites

Two Sites (commercial farms)

– ‘Meeker’ Red Raspberry (~4.6 A)
  • Seven Treatments

– ‘Draper’ Blueberry (~2.7 A)
  • Three Treatments
Treatment List

Raspberry

- Ammonium Sulfate (AS)
- Phosphorous Solids (PS)
- Digested Liquid Effluent (DLE)
- Raw Manure (MA)
- Compost (COM)

Blueberry

- Conventional Fertilizer (CON)
- Non-Fertilized Check (CHK)

- Ammonium Sulfate (AS 1X)
- Ammonium Sulfate (AS Split)
## Treatment Characterization

<table>
<thead>
<tr>
<th>Red Raspberry</th>
<th>% Carbon</th>
<th>pH</th>
<th>NH₄-N</th>
<th>Total N</th>
<th>P₂O₅</th>
<th>K</th>
<th>C:N</th>
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<tr>
<td>2  PS</td>
<td>63.9%</td>
<td>19.6</td>
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<td>38.3</td>
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<td>3  DLE</td>
<td>96.7%</td>
<td>8.5</td>
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<td>18.8</td>
<td>3.4</td>
<td>13.9</td>
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<tr>
<td>4  MA</td>
<td>93.3%</td>
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<td>9.2</td>
<td>18.9</td>
<td>3.4</td>
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<tr>
<td>5  COM</td>
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<td>8.4</td>
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<th>NH₄-N</th>
<th>Total N</th>
<th>P₂O₅</th>
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<td>3  CON</td>
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Project Assessments

- **Products**
  - Pre-Treatment Analysis

- **Soils**
  - Texture – *Randomization*
  - Nutrient (Macro/Micro, NO$_3$\textsuperscript{-}, NH$_4$\textsuperscript{+}, Soluble Salts)
    - Soil cores (pre-treatment/monthly)
    - PRS Probes (on-going, exchanged every 2-weeks)**
  - Moisture
    - Sensors

- **Quality**
  - Bulk Density
  - Infiltration
  - Compaction
  - Pathogen – RLN, Phytophthora

- **Plant**
  - Cane Diameter
  - Primocane Height
  - SPAD Metering
  - Foliar samples
  - Yield

- **Groundwater**
  - Suction Cup Lysimeter ~ 18-24” (checked every 2-weeks (April-October)*)

**BF1** – AS and CON; **BF2** – AS1, AS2, and CON

*BF1* – AS and CON; **BF2** – AS1, AS2, and CON
Red Raspberry Soil (3”) Nitrogen, 2017

Graph showing the nitrogen levels over time from 2/1/2017 to 8/1/2017. The graph compares different treatments labeled as MA, DLE, PS, AS, COM, and CHK. The graph highlights different time periods where specific treatments show higher nitrogen levels compared to others.
Red Raspberry Soil (3") Phosphorous, 2017
Blueberry (3”) Nitrogen, 2017

Soil NH₄, 7.6 cm

AS1 > AS2 > CON

NH₄, ppm


All TRT

AS1

AS2

CON
Yield Similar Across Treatments

**Red Raspberry Yield**
- MA: 2.24 g/fruit
- DLE: 2.18
- COM: 2.19
- PS: 2.03
- AS: 2.25
- CON: 2.12
- CHK: 2.25

**Blueberry Yield**
- AS1: 2.09 kg/9 m
- AS2: 2.16
- CON: 1.95

**Graphs show yield comparisons across different treatments for red raspberries and blueberries.**
Red Raspberry Bulk Density

The weight of soil in a given volume

- Surface BD reduced in DLE and PS as compared to CON
- Subsurface BD was similar across treatments
**Food Safety Evaluation**

**Soil sampling**
- Soil sample (~500 g)
  - 20-25 subsamples
  - ~20 g/subsample

**Fertilizer sampling**
- Fertilizer sample (~500 g)
  - 8-10 subsamples
  - 50 g/subsample

**Foliar sampling**
- Foliar sample (~100 g)
  - 200~250 subsamples

**Fruit sampling**
- Fruit sample (~100 g)
  - 10 subsamples
  - 10 g/subsample
Early Season
Existing Floricanes

Primocane Growth

Later Season Canopy Transfer
Coliform and Generic *E. coli* (soil)

**June**

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<th>Generic <em>E. coli</em></th>
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<td>CON</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>AS</td>
<td>a</td>
<td>b, c</td>
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<tr>
<td>PS</td>
<td>a</td>
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<td>b</td>
<td>b</td>
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<td>COM</td>
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**August**

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### E. coli O157:H7

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## Salmonella

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# Listeria monocytogenes

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</table>

**Note:**
- Pre-app: Pre-application test results.
- Post-app: Post-application test results.
Preliminary Results

Agronomic
– Raspberry treatment differences for N and P, but did not impact plant growth or yield
– Blueberry early season N higher in AS1, by mid-season similar, but no yield or plant growth difference
– Bulk density lower at surface in some treatments
– No differences in soil compaction, infiltration, plant parasitic nematodes.

Food Safety
– No *E. coli* O157:H7 or *L. monocytogenes* was detected from fertilizer, soil, foliar, or fruit sample
– *Salmonella* was detected from soil samples from PSOLIDS treated plots, but not from foliar or fruit

Overall
– Perceived vs. real food safety threat
– Current nutrient sources could prevent adoption
Acknowledgements

• Randy Honcoop Farm
• Curt Maberry Farm
• CHS Northwest
• Regenis