SÉMINAIRE
Résultats de la recherche en agriculture biologique dans l’Est du Canada –

Programme

Partie 2

- Effet des paillis sur la fertilisation et les mauvaises herbes dans le bleuet de corymbe (Effect of Mulch Applications on Nitrogen Fertility and the Growth and Productivity of Organically Managed Highbush Blueberry)........................... page 33

- Fertilité des sols : production laitière, pommes de terre, pommiers (Nutrient Management for Organic Dairy and Potato Farms)....................................................... page 39
Effect of Mulch Applications on Nitrogen Fertility and the Growth and Productivity of Organically Managed Highbush Blueberry

Nicole Burkhard, MSc.
D. Lynch and D. Percival, NSAC

Background
- Highbush Blueberry (Vaccinium corymbosum L.) is cultivated in rows amended with sawdust/pine bark and has a low pH and N requirement, favouring NH₄-N uptake
- An organic protocol excludes the use of most chemical fertilizers and pesticides
- Mineral N release from organic sources can be unpredictable
- Use of organic amendments (compost and mulch) can alter N balance due to chemical and biological characteristics
- One novel way of monitoring NO₃-N and NH₄-N flux in soil under mulch/compost layer is to use ion exchange membranes such as PRS™-probes (Western Ag Innovations, Saskatoon, SK)

Objectives
1) to test the efficacy of natural mulches as a method of weed control, and
2) to assess the effect of conventional and organic fertility treatments and thickly applied mulches on HBB growth, leaf nutrient uptake, yield and crop quality under organic production.

Objectives
1) Determine the mineral N release from thick layers of mulch, applied for weed control, and effect on blueberry plant performance (growth and yield)
2) Assess Plant Root Simulator (PRS™)-probes as a tool for testing plant-available mineral N in blueberry fields
Methodology

- Location: Annapolis Valley, NS
- Split-plot design:
  - 5 blocks
  - Whole plots - 6 mulch fertility treatments
  - Subplots - level of hand-weeding (+/−)

<table>
<thead>
<tr>
<th>Mulch/Fertility Treatments</th>
<th>Whole plot treatments</th>
<th>Application Rate</th>
<th>C-N Ratio</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS – Ammonium Sulphate fertilizer</td>
<td>(NH₄)₂SO₄</td>
<td>30 kg N ha⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW – Sawdust</td>
<td>Pine Needle</td>
<td>60 kg N ha⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC – Manure/Sawdust Compost</td>
<td>25 cm (110 T ha⁻¹)</td>
<td>67.1</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>SC – Seafood Waste Compost</td>
<td>25 cm (350 T ha⁻¹)</td>
<td>46.4</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>NC – Seafish Waste Compost</td>
<td>25 cm (340 T ha⁻¹)</td>
<td>22.1</td>
<td>6.8</td>
<td></td>
</tr>
</tbody>
</table>
Weeds main effects

- Weeds negatively affected HBB growth and productivity, resulting in reduced canopy volumes, leaf N (in the application year) and lower berry yields.

- These results were even more pronounced in the second season (i.e. year after application).

### Weed Biomass (kg/ha)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 1R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1815</td>
<td>1642</td>
<td>3559</td>
</tr>
<tr>
<td>AS</td>
<td>2979</td>
<td>1246</td>
<td>2586</td>
</tr>
<tr>
<td>NW</td>
<td>2463</td>
<td>2005</td>
<td>3588</td>
</tr>
<tr>
<td>PN</td>
<td>808</td>
<td>448</td>
<td>1300</td>
</tr>
<tr>
<td>MC</td>
<td>1122</td>
<td>2607</td>
<td>2608</td>
</tr>
<tr>
<td>SC</td>
<td>5137</td>
<td>3122</td>
<td>4244</td>
</tr>
</tbody>
</table>
Weed Composition

- The species composition, time of onset, and biomass of weeds was influenced by mulch type
- Composts suppressed sheep sorrel and vetch generally
- Common ragweed – SC treatment only

pH (0-6 cm)

- pH was increased under the seafood waste compost after 1 year
- In the second plot, pH was slightly higher under the manure/sawdust compost after 3 months

Soil

- Mulches increased soil moisture and reduced fluctuations in soil temperature
- No detrimental effects to plant productivity were noted despite high C:N ratios of PN and MC (72:1 and 48:1, respectively).

Soil Mineral Nitrogen (0-45 cm)

- June 22, 2005
- Sept 6, 2005
Blueberry Yield and Quality

2005 - No treatment affect on yields
2006 – Yield increased 3x with mulching, with composts (SC, MC) > PN
2006 (Trials 1r) – PN greater yields than SC

Total phenolics and titratable acidity were not affected by treatment, although SC caused a slight increase in sugar content over MC.

Acknowledgements

- NSERC Industrial Postgraduate Scholarship Program
- NSDAF Technology Development Fund
- Envirom Technologies Inc. (Fredericton, NB)
- Nova-Agri Associates (Centreville, NS)
- Western Ag. Innovations (Saskatoon, SK)
- Canada Research Chair Program
**NUTRIENT MANAGEMENT FOR ORGANIC DAIRY AND POTATO FARMS**

D. Lynch, NSAC

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**SUSTAINABILITY OF DAIRY SYSTEMS**

- Dairy farms - large nutrient (NPK) surpluses, varying with intensity of production system
  - Klausner, 1995
  - Anderson and Magdoff, 2000

- Integrated nutrient management - evaluate nutrient status of all farm components
  - Powell et al., 2001
  - Lynch et al., 2003

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**WHOLE FARM NUTRIENT BUDGETS**

- Imports
  - Bedding
  - Feed
  - Minerals
- Internal flows
- Exports
  - Milk, Meat
  - Cash crops

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**BIOLOGICAL NITROGEN FIXATION**

Biological nitrogen fixation (BNF): $\text{N}_2 \rightarrow \text{NH}_3$

1880: Cultivated legumes represented 20-30% of all cultivated land in W. Europe

Provided 40-150 kg N/ha and up to 75% of crop N requirements.

1960: BNF-N only 50% of global crop N

2000: BNF-N only 20% of global crop N

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**LIVESTOCK DENSITY, P FLOWS AND ORGANIC DAIRY SYSTEMS**

<table>
<thead>
<tr>
<th>Production System</th>
<th>Stocking Density</th>
<th>Imports (kg P)</th>
<th>Exports (kg P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Self-Sustaining’</td>
<td>1.27</td>
<td>43</td>
<td>273</td>
</tr>
<tr>
<td>‘Flexible’</td>
<td>1.65</td>
<td>453</td>
<td>451</td>
</tr>
</tbody>
</table>


---

**DAIRY SYSTEM AND P SURPLUS**

<table>
<thead>
<tr>
<th>Production System</th>
<th>Stocking Rate (LU/ha)</th>
<th>Net P surplus (kg/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confinement</td>
<td>2.0</td>
<td>36.7</td>
</tr>
<tr>
<td>Anderson and Magdoff, 2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture-based</td>
<td>1.2</td>
<td>11.3</td>
</tr>
<tr>
<td>Anderson and Magdoff, 2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture-based</td>
<td>0.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Lynch et al., 2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>-</td>
<td>3.1</td>
</tr>
<tr>
<td>Watson et al., 2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic: SS</td>
<td>1.3</td>
<td>-4.0</td>
</tr>
<tr>
<td>Weller and Bowling, 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PF</td>
<td>1.7</td>
<td>0.0</td>
</tr>
</tbody>
</table>
KIPAWO HOLSTEINS, GRAND PRE, NS

- 1988 - 2000: management changes
  - adoption of MIG system
  - crop diversification
  - no fertilizer purchases
  - routine soil testing, composting

• Milk production increased (666 kg/cow)
• Feed costs declined (14.3 to 11.6 cents/litre)
• N and K farm budgets indicated low surpluses
• Internal N flows close to optimum for crop mix
• No soil fertility deficiencies (but soil P incr. 2 ppm/yr)

FARM N FLOWS (kg/ha)

- Feed 34 → Milk: 22
- Kelp meal 0.2 → Meat: 3
- Fixed N 53 → Manure 46
- Manure 7 → Feed 86
- Seed 0.5 → Deposition 6

CHANGES IN SOIL FERTILITY

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM (%)</td>
<td>3.3</td>
<td>3.9</td>
</tr>
<tr>
<td>Ca (ppm)</td>
<td>1293</td>
<td>1488</td>
</tr>
<tr>
<td>Mg</td>
<td>568</td>
<td>279</td>
</tr>
<tr>
<td>K</td>
<td>291</td>
<td>166</td>
</tr>
<tr>
<td>P</td>
<td>117</td>
<td>151</td>
</tr>
</tbody>
</table>
INTEGRATED NUTRIENT MANAGEMENT

- Target dietary P: 0.40 - 0.50 g P kg^{-1} DM
- Reduced diet P by 10%
- Impact - Reduced farm P surplus by 1 kg ha^{-1} yr^{-1}

Lynch et al., 2003 Am.J.Alt.Ag 18:137-145

ONTARIO DAIRY FARMS

1. Characterize farm productivity and nutrient (NPK) status
2. Assess phosphate rock availability
3. Examine soil P pools

Location:
15 long-term organic dairy farms

FARM SELECTION CRITERIA

Selection Criteria
- >10 years certified
- Farm at 'Steady State'
- Diversity of management


FARM CHARACTERISTICS

- Farm size: 110 ha (±55)
- Herd size: 52 cows (±22)
- Productivity: 5656 (±836) kg milk cow yr^{-1}
- Pasture and hay = 65% (±21) of acreage
- Corn = 6% of acreage (50% of farms - no corn)
- Four farms sold cash crops
FARM CHARACTERISTICS

Rozzi et al. (2007):
- Emphasis on functional traits
- 3 farms have pure Holstein herds
- 1 farm has Holstein and Jersey
- Crossbreeding: Average of 30% of herd composition on 8 farms.

NITROGEN

94.8 kg N ha$^{-1}$
Surplus = 75.3 kg ha$^{-1}$ yr$^{-1}$
Efficiency = 21%

POTASSIUM

15.7 kg K ha$^{-1}$
Surplus = 11.2 kg ha$^{-1}$ yr$^{-1}$

PHOSPHORUS

4.7 kg P ha$^{-1}$
Surplus = 1.0 kg ha$^{-1}$ yr$^{-1}$
AVERAGE FARM P FLOWS

Minerals 303 kg
Feed 159 kg
Bedding 30 kg
Seed 9 kg
Other 5 kg

Milk: 264 kg
Meat: 83 kg
Crops: 64 kg

SOIL FERTILITY

Organic Matter (OM)
Average: 4.8%

Phosphorus (P) - (0.5M NaHCO₃)
Average: 12.2 mg kg⁻¹
50% of farms – fields averaged < 10 mg kg⁻¹

Potassium (K) - (1.0M NH₄OAc)
Average: 108 mg kg⁻¹

SOIL AVAILABLE P

Distribution of NaHCO₃ Extractable Phosphorus
(n=225)

<table>
<thead>
<tr>
<th>mg P kg soil⁻¹</th>
<th>0-5</th>
<th>5-10</th>
<th>10-15</th>
<th>15-20</th>
<th>20-25</th>
<th>25-30</th>
<th>30-40</th>
<th>40-50</th>
<th>&gt;50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fields</td>
<td>225</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NPK SURPLUS - ORGANIC DAIRYING

<table>
<thead>
<tr>
<th>Location</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>N kg ha⁻¹ yr⁻¹</th>
<th>P kg ha⁻¹</th>
<th>K kg ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>75</td>
<td>1</td>
<td>11</td>
<td>15</td>
<td>74</td>
<td>100</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>76</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Europe</td>
<td>92</td>
<td>2</td>
<td>9</td>
<td>60</td>
<td>91</td>
<td>100</td>
</tr>
</tbody>
</table>

Roberts et al., 2008
Lynch et al., 2003
Watson et al., 2002
### FEED MANAGEMENT IMPACTS

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of farms</td>
<td>4</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Feed imports</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>Stocking rate (LU ha⁻¹)</td>
<td>0.87</td>
<td>0.99</td>
<td>1.21</td>
</tr>
<tr>
<td>Milk produced (L ha⁻¹ yr⁻¹)</td>
<td>2208</td>
<td>2752</td>
<td>3111</td>
</tr>
<tr>
<td>Nutrient surplus</td>
<td>----</td>
<td>53.3</td>
<td>77.6</td>
</tr>
<tr>
<td></td>
<td>Nitrogen</td>
<td>1.5</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Phosphorus</td>
<td>1.4</td>
<td>6.5</td>
</tr>
</tbody>
</table>

### IMPROVING FARM P STATUS

- conserve P on farm (manure and feed)
- reduce P exports (manure and feed)
- explore options to increase P imports
  - *minimum* feed imports, adjust dietary P
  - apply phosphate rock (or other P sources)

### FARM NUTRIENT FLOWS

- Legumes/ N₂ Fixation
- Feeds/ Grazing
- Composts

### LEGUMES AND FORAGE QUALITY

- Timothy
- Timothy & Red Clover (30%)

- Soil amendments: N fertilizer
- Liquid dairy manure
- Three different composts
Why Combine Compost with Legumes?

- Predicting compost N release difficult
- Variability in compost quality
- Unfavourable ratio of PK to N

Producing and Applying Compost

- Dairy Manure (HMC)
- Sewage Sludge (SSC)
- Corn Silage (CSC)

Composts

<table>
<thead>
<tr>
<th></th>
<th>LDM</th>
<th>HMC</th>
<th>SSC</th>
<th>CSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM (g kg(^{-1}))</td>
<td>77</td>
<td>288</td>
<td>344</td>
<td>332</td>
</tr>
<tr>
<td>Lignin %</td>
<td>7.4</td>
<td>27.7</td>
<td>21.3</td>
<td>27.3</td>
</tr>
<tr>
<td>Ttl N (g kg(^{-1}))</td>
<td>48.9</td>
<td>18.9</td>
<td>12.5</td>
<td>40.0</td>
</tr>
<tr>
<td>C:N</td>
<td>6.6</td>
<td>20.9</td>
<td>23.3</td>
<td>9.8</td>
</tr>
<tr>
<td>Ttl P (g kg(^{-1}))</td>
<td>6.1</td>
<td>6.1</td>
<td>5.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Ttl K (g kg(^{-1}))</td>
<td>25.1</td>
<td>25.3</td>
<td>4.9</td>
<td>34.8</td>
</tr>
</tbody>
</table>

Amendment Composition

FORAGE YIELDS (3 years)

Cmp A

Cmp B

Cmp C

DM/ha

Timothy

Timothy/Clover

07-BIO-20
FORAGE QUALITY (PROTEIN YIELD)

Kg N/ha

Cmp A  150 300
Cmp B  150 300
Cmp C  150 300

Timothy
Timothy/Clover

Lynch et al., 2004 JEQ. 33:1509-1520

Phytoextraction of Phosphate Rock P

H₂PO₄⁻

Ca²⁺

Rhizosphere
diffusion
Root
dissolution

Phytoextraction of Phosphate Rock P

Arcand M., U. of Guelph, 2007

Buckwheat P uptake

Arcand M., U. of Guelph, 2007

2004
2005

2004
2005
Mulch quality and soil P flux

<table>
<thead>
<tr>
<th>P release unchanged</th>
<th>Increased P release</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR 800</td>
<td>CPR 400</td>
</tr>
<tr>
<td>VPR 800</td>
<td>Control</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.70 \]

New Research Directions (2008-2010)

1. Determine forage quality, species composition, and legume \( N_2 \) fixation, and relationship to soil fertility/soil health.

2. Assess scope for improving legume \( N_2 \) fixation and forage productivity.

ACKNOWLEDGEMENTS

Collaborators: P. Voroney, U of Guelph
Graduate students: C. Roberts, U. of Guelph
M. Arcand, U. of Guelph
Technical Assistance: K. David, J Ferguson, L. Eccles, Andrea Farrow and Allison Van Horne
Producers: 15 throughout Ontario.

ACKNOWLEDGEMENTS

- OMAF New Directions Program
- Canada Research Chairs Program
- Organic Agriculture Centre of Canada
- Ontarbio/Organic meadow
- Harmony Organic Dairy Products Inc.
- Ecological Farmers Association of Ontario
PRODUCTIVITY AND NITROGEN DYNAMICS IN ORGANIC POTATO PRODUCTION

Locations: NSAC, Brookside, NS Kentdale Farms, PEI
Varieties: Shepody, A90586-11

<table>
<thead>
<tr>
<th>Amendments</th>
<th>N applied (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>Nutriwave manure</td>
<td>300; 600</td>
</tr>
<tr>
<td>Compost</td>
<td>300; 600</td>
</tr>
</tbody>
</table>

Amendment Composition

<table>
<thead>
<tr>
<th></th>
<th>Compost</th>
<th>Poultry Manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM (g kg⁻¹)</td>
<td>33.0</td>
<td>97.6</td>
</tr>
<tr>
<td>Ttl N (g kg⁻¹)</td>
<td>11.3</td>
<td>44.4</td>
</tr>
<tr>
<td>NH₄-N (g kg⁻¹)</td>
<td>1.7</td>
<td>6.1</td>
</tr>
<tr>
<td>C:N</td>
<td>21.6</td>
<td>8.7</td>
</tr>
<tr>
<td>Ttl P (g kg⁻¹)</td>
<td>3.4</td>
<td>14.7</td>
</tr>
<tr>
<td>Ttl K (g kg⁻¹)</td>
<td>0.4</td>
<td>18.9</td>
</tr>
</tbody>
</table>
Total Tuber Yields - Kentdale

Efficiency of Amendment N

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Nutr 300</th>
<th>Nutr 600</th>
<th>Comp 300</th>
<th>Comp 600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant N uptake (kg N ha⁻¹)</td>
<td>112</td>
<td>189</td>
<td>216</td>
<td>116</td>
<td>98</td>
</tr>
<tr>
<td>ANR (% of total N applied)</td>
<td>-</td>
<td>25.7</td>
<td>17.4</td>
<td>-1.5</td>
<td>-2.3</td>
</tr>
<tr>
<td>Tuber N accumulation (% of plant biomass N)</td>
<td>60</td>
<td>52</td>
<td>49</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>Tuber N concentration (%)</td>
<td>1.2</td>
<td>1.6</td>
<td>1.8</td>
<td>1.2</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Seasonal Changes in Soil Nitrate

Seasonal soil moisture content

SEASONAL CHANGES IN SOIL NITRATE

Seasonal soil moisture content

Kentdale
Relationship between Spring soil mineral N and plant N accumulation

Shepody, control plots

PRS™ Probe Flux and Net Soil Mineral N

Cumulative Available N:

PRS-N (0-30DAP) and plant N uptake

Kendale

Shepody

R² = 0.98; y = 58.76 + 23.9x

R² = 0.98; y = 48.75 + 23.9x
**Variety Trials**

Yields

- 28-35t/ha
- (250-300 cwt/acre)

Residual nitrate-N:

- 2002: 22 kg NO$_3$-N ha$^{-1}$
- 2003: 19 kg NO$_3$-N ha$^{-1}$

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**Plant Health and Potato Beetle Dynamics**

Colorado Potato Beetle dynamics (larvae development) are influenced by plant health/fertility

Boiteau et al., J. Applied Entomology, 2008

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**PRS-N (0-30DAP) and tuber N uptake**

- Kentdale
  - $R^2 = 0.98; y = 47.0 + 1.28 \times \frac{\text{GDD}_{590}}{\text{GDD}_{\text{total}}} = 0.24$
  - $R^2 = 0.98; y = 45.0 + 10.8 \times \frac{\text{GDD}_{590}}{\text{GDD}_{\text{total}}} = 0.21$

---

**SOIL NITRATE N AT HARVEST (kg ha$^{-1}$)**

- Residual NO$_3$-N at harvest (Mg ha$^{-1}$)
  - Winslow 2003
  - Winslow 2004
  - Brookside 2004
  - 60 kg NO$_3$-N

---

**SOIL NITRATE N AT HARVEST (kg ha$^{-1}$)**

- Residual NO$_3$-N at harvest (Mg ha$^{-1}$)
Vegetable Production, Soil Quality and Rotation Design

Four 5-year organic vegetable rotation sequences
Varying in green manure and soil amendment type and frequency
Commenced in 2006

Fertility status organic apples - Ontario

- Survey of soil fertility status on 18 organic and 2 conventional orchards in Ontario
- Plus leaf tissue comparison of trees in areas where sod dominates or not in 1 orchard

Soil Fertility- Organic orchards

- Soil (0-30cm) sampled (n~20) between tree trunk and drip line
- 50% of organic orchard soils were P (<12ppm) and K (<120ppm) deficient
- Soil inorganic N lower in organic compared to conventional

Leaf tissue analyses - Organic orchard

- N, Ca and Fe was lower in leaf tissue sampled from weak trees where sod dominant
- Study emphasizes importance of sod and floor management to maintain tree nutrition