Constraining soil-emitted GHGs from crop production on the Canadian semiarid prairies

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Constraining Soil-Emitted GHGs from crop production on the Semiarid Canadian Prairies

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Seasonal Pattern of soil-emitted $\text{N}_2\text{O}$

Spring Thaw

First soil ``wet up`` following N application

$\mu$g $\text{N}_2\text{O-N} \text{ m}^{-2} \text{ h}^{-1}$

- April
- June
- July
- Aug

N applied
Emission factor as a function of local climate

Soil $\text{N}_2\text{O} = \text{Ninputs}_{\text{N}_2\text{O}} \times \text{“modifiers”}$

\[
\text{Ninputs}_{\text{N}_2\text{O}} = (\text{Fertilizer } \text{N} + \text{Residue } \text{N} + \text{Manure } \text{N}) \times \text{EF}
\]

$\text{EFeco} = \text{EF calculated specifically for each ecodistrict}$

$\text{EFeco} = \text{0.022 P/PE - 0.0048}$

EFeco < 0.0016 were set = 0.0016
EFeco > 0.017 were set = 0.017

(Source: Rochette et al., 2008)
Estimating $\text{N}_2\text{O}$ Emissions: Canadian Semiarid Prairies

$\text{Soil}_\text{N}_2\text{O} = \text{Ninputs}_\text{N}_2\text{O} \times \text{“modifiers”}$

Modifiers = Tillage, slope position, irrigation, soil texture

Reference situation = “a non-irrigated soil located in well-drained portions of the landscape under conventional tillage practices”

~ 80-90% data collected from Hard Red Spring Wheat
Crop Mix: Canadian Semiarid Prairies

• 2014 Estimated Seeded Acreages for Saskatchewan
  ➢ 38% spring wheat, (24% hard red spring wheat)
  ➢ 36% oilseeds (31% canola)
  ➢ 17% pulses (lentil, field pea, chickpea)
  ➢ 7% summerfallow & “misc.”

• Current Crop Sequences:
  ➢ Oilseed-Cereal or Pulse-Cereal
  ➢ Oilseed-Pulse-Cereal or Fallow-Oilseed-Cereal
Case Study: Pea-Canola Frequency Study

- Field experiment established in 1998

- Treatments with various crop sequences of field pea (*Pisum sativum* L.), wheat (*Triticum aestivum* L.) and canola (*Brassica napus* L.)

  - **W [±N]** - hard red spring wheat grown each year with or without added N
  - **P** - pea grown every year
  - **P-W** - pea-wheat
  - **C-W** - canola-wheat
  - **P-C-W** - pea-canola-wheat

- All phases of each rotation present each year
Pea-Canola Frequency Study

- Nitrogen (urea) side banded at 75, 65 and 7.5 kg N ha\(^{-1}\) for canola, wheat, and pea, respectively

- Plexi-glass non-flow through, non-steady state chambers (22 cm × 45.5 cm and 15 cm high)

- The annual precipitation was 385, 285 and 637 mm in 2008, 2009 and 2010 respectively. (30-yr mean = 360 mm)
Cumulative $\text{N}_2\text{O}$ and Yield-Scaled $\text{N}_2\text{O}$ from selected crop-residue combinations  Scott, Saskatchewan, Canada

<table>
<thead>
<tr>
<th>Residue Type</th>
<th>Crop Grown</th>
<th>Direct $\text{N}_2\text{O}$ 3-year cumulative (g $\text{N}_2\text{O}$-N ha$^{-1}$)</th>
<th>Residue Type</th>
<th>Crop Grown</th>
<th>Yield-Scaled $\text{N}_2\text{O}$ 3-yr Cumulative (g C/g $\text{N}_2\text{O}$-N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>W</td>
<td>2120 a</td>
<td>P</td>
<td>W</td>
<td>0.33 a</td>
</tr>
<tr>
<td>W</td>
<td>C</td>
<td>1440 b</td>
<td>P</td>
<td>C</td>
<td>0.28 ab</td>
</tr>
<tr>
<td>W</td>
<td>W</td>
<td>1360 b</td>
<td>P</td>
<td>P</td>
<td>0.28 ab</td>
</tr>
<tr>
<td>W</td>
<td>P</td>
<td>1270 bc</td>
<td>W (+N)</td>
<td>W (+N)</td>
<td>0.22 bc</td>
</tr>
<tr>
<td>W (-N)</td>
<td>W (-N)</td>
<td>1110 bc</td>
<td>W (-N)</td>
<td>W (-N)</td>
<td>0.21 bc</td>
</tr>
<tr>
<td>P</td>
<td>W</td>
<td>1120 bc</td>
<td>P (-N)</td>
<td>C</td>
<td>0.20 bc</td>
</tr>
<tr>
<td>P</td>
<td>C</td>
<td>1100 bc</td>
<td>W (-N)</td>
<td>W</td>
<td>0.16 c</td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>990 c</td>
<td>C</td>
<td>W</td>
<td></td>
</tr>
</tbody>
</table>
Cumulative $N_2O$ and Yield-Scaled $N_2O$ on a rotational basis: Scott, Saskatchewan

<table>
<thead>
<tr>
<th>Rotation</th>
<th>N$_2$O Loss</th>
<th>3-yr cumulative (g N$_2$O-N ha$^{-1}$)</th>
<th>Yield scaled N$_2$O Loss</th>
<th>3-yr cumulative (g C / g N$_2$O-N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-W</td>
<td></td>
<td>1780 a</td>
<td></td>
<td>0.31 a</td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>1360 ab</td>
<td></td>
<td>0.28 ab</td>
</tr>
<tr>
<td>P-W</td>
<td></td>
<td>1190 bc</td>
<td></td>
<td>0.22 bc</td>
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<tr>
<td>W (-N)</td>
<td></td>
<td>1110 bc</td>
<td></td>
<td>0.21 c</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>990 c</td>
<td></td>
<td>0.17 c</td>
</tr>
</tbody>
</table>
Summary

- On the Canadian semiarid prairies the magnitude of emissions largely governed by N inputs and soil water status
- Crop sequence/crop type does influence “per area” and “yield-scaled” emissions
- Including a pulse in the crop sequence benefits the overall rotation on both “per area” and “yield-scaled” emissions
- Including an oilseed, particularly canola, in the crop sequence “costs” the overall rotation on both “per area” and a “yield-scaled” emissions
Future Needs...

- What is the influence of crop type (e.g. winter wheat), particularly long-term influence?
- Spring thaw period – who’s doing what, when and why?
- Can we manage cropping systems to stimulate $\text{N}_2\text{O}$ consumption?
- What is the appropriate intensity metric to assess emissions?
- Continued development of models, particularly for scenario testing
- Concerted, integrated effort to identify/develop mitigation and “environmentally optimal” crop production strategies
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