Controls and Driving Factors of Nitrous Oxide Flux from Agricultural Soil

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Soil Factors affecting N₂O production and emission

The “Leaky Pipe Theory”

N₂O → N₂ → NO₃⁻ → N₂O

Labile C source

Mineralization → Nitrification → NO₃⁻ → Denitrification → N₂

NH₄⁺
Controls on $\text{N}_2\text{O}$ Emissions

- **Soil water content (water-filled pore space)**
  - Regulates diffusion of gases into and out of soil
  - Microbial activity

- **Carbon availability**
  - Residue or manure incorporation

- **Temperature**

- **Nitrogen availability**
  - N-fertilizer, organic matter mineralization
  - Residual nitrate
  - Reactive N is main driver of $\text{N}_2\text{O}$ increase in the atmosphere
N$_2$O in the Atmosphere

Source: IPCC, 2001
$\text{N}_2\text{O} \text{ in the Atmosphere}$

Observed and projected $\text{N}_2\text{O}$ concentrations
## Greenhouse Gas Emissions (GGE)

<table>
<thead>
<tr>
<th>Source</th>
<th>Tg CO₂ equivalents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net GGE in U.S.</td>
<td>6432</td>
<td>100</td>
</tr>
<tr>
<td>N₂O all sources</td>
<td>469</td>
<td>7</td>
</tr>
<tr>
<td>- N₂O Agricultural soil</td>
<td>365</td>
<td>6</td>
</tr>
<tr>
<td>N₂O emissions in California</td>
<td>?</td>
<td></td>
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</tbody>
</table>

Source: EPA 2005
Chambers used for static \( \text{N}_2\text{O} \) flux measurements in the field

Gas chromatograph
N$_2$O emissions tend to be event based

Kallenbach, 2008; Burger et al., 2005
N₂O Emissions in Winter?
Irrigation and Cover Crop Effects on $\text{N}_2\text{O}$ Emissions

Kallenbach, 2008
Interaction of Fertilizer Type & Tillage on N₂O Emissions

Venterea et al., 2005
N$_2$O emissions, Yield and Fertilizer N

N Fertilizer Rate vs. Yield

N Fertilizer Rate vs. N$_2$O Emission

McSwiney & Robertson, 2005
Hypothetical Model
Applied Fertilizer N vs. N$_2$O Emission Factors

Emission Factor (%) vs. kg N ac$^{-1}$
Hypothetical Model
Applied Fertilizer N vs. N$_2$O Emission Factors
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Applied Fertilizer N vs. N₂O Emission Factors

N₂O Emission Factor

Emission Factor (%)

kg N ac⁻¹

0 100 200 300
Conclusions

• Controls and drivers of N$_2$O emissions are well known, but the magnitude of the emissions is difficult to predict

• Optimizing N fertilizer use efficiency is probably also the best strategy to minimize N$_2$O emissions

• Actual N$_2$O flux measurements in California cropping systems will provide improved emission estimates and information on mitigation potential