Nitrous Oxide and Nebraska Crop Production

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Climate Change (global warming; climate weirdness)

- Is there a human factor?
- We will probably have to act on this even if we don’t believe that there is human influence
  - need to be informed
  - better to be proactive
Nitrous oxide ($\text{N}_2\text{O}$), water vapor, carbon dioxide ($\text{CO}_2$), and methane are gases in the atmosphere that absorb and emit heat (Infrared radiation) back to earth.

A ‘greenhouse effect’

Water vapor is the most important of these
  – not affected globally by human activity
  – Increases with higher temperatures
Nitrous oxide

- The CO$_{2e}$ of N$_2$O is 298 to 310. One ton of N$_2$O in the atmosphere = ~300 t CO$_2$
N$_2$O coupled to nitrogen application

Del Grosso et al., 2006
Nitrous oxide

• Agriculture
  – Main source of N$_2$O emission in US
  – Soil processes
    • denitrification
    • incomplete nitrification
  – animal manure

• 40-50% of N2O emission globally is from natural sources
Denitrification

• Reduces nitrate (NO\textsubscript{3}⁻) primarily to N\textsubscript{2}, but with some N\textsubscript{2}O emission

• Associated with
  – poor soil aeration
  – abundant decomposable organic material, e.g. fresh crop residues
  – Temperature sensitive

• Therefore, less with well-drained compared with poorly drained soil
Incomplete nitrification

• ammonium (NH$_4^+$) is converted to nitrite but not all nitrite (NO$_2^-$) is converted to nitrate (NO$_3^-$) with some N$_2$O emission
  – probably the main source of N$_2$O emission
  Nebraska crop production
  – Increased with
    • more soil NH$_4^+$ that undergoes nitrification
    • low soil aeration
    • warm temperature
Animal manure

- <10% of agricultural N\textsubscript{2}O emission
- much from urine-N with high protein diets
Emission from Nebraska Cropland

- $\text{N}_2\text{O}$ emissions in eastern Nebraska were found to be 4 - 5.5 lb $\text{N}_2\text{O}/\text{ac/yr}$
  - Less for rainfed
  - More for continuous corn
- 5 lb $\text{N}_2\text{O}/\text{ac} = \sim 1500 \text{ lb/ac}$
  $\text{CO}_2 = \text{CO}_2$ from $\sim 75 \text{ gal gasoline}$
Do we have some no cost or low cost opportunities?

- Potential for win-win-win solutions
Rotation vs monoculture

<table>
<thead>
<tr>
<th>Profit</th>
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Results of N$_2$O research

• Less with corn-soybean rotation compared with continuous corn in NE and IA studies
• Variable in others
• 3-6 wins; possibly no cost!!
## No till vs tillage

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**Results of N$_2$O research**

- §Var: often benefits depend on the level of risk of N loss to a process!!!
- Less emission with no-till in Colorado, but more in Canada
- Tillage effect varies
- 1-5 wins; often with no cost
Economic Optimal N Rate

N\textsubscript{2}O emission relative to yield
## Results of $N_2O$ research

- N rate is the best predictor of emissions
- 1-4% of applied N equivalent found to be emitted across Corn Belt
- Under study by UNL
- 6 wins; no cost!!!
Anhydrous NH$_3$ vs other N fertilizers

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Results of N$_2$O research

- MN studies:
  - 50% more emission with AA injected compared with urea broadcast and incorporated
  - more with AA compared with CaNO$_3$
  - more with urea than with UAN
  - Switch from AA; some other negative effects
## Injected vs surface

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### Results of N$_2$O research

- Mixed results: reduced emission with injection in MO, but increased in CO
- Inconclusive; under study by UNL
In-season N application

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Results of N$_2$O research

- Less emission expected with sidedress application and fertigation
- Under study by UNL
- Decreased emission with 4 to 6 wins, probably no loss of profit for situations of high risk of leaching or denitrification loss
Inhibitors, controlled release: also placement and type; continuous corn, CO

Cumulative N₂O-N flux, g N/ha

N rate = 202 kg N/ha

Urea, ESNssb, UAN, SuperU, ESN, UAN+AP, Check

Halvorson and Delgrosso, ARS
## Nitrification inhibitors

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### Results of N$_2$O research

- Use of a nitrification plus urease inhibitor reduced emission by 40% in CO
- Under study by UNL
- 3-4 wins; probably no loss of profit for situations of high risk of leaching or denitrification loss
## Controlled released N fertilizer

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### Results of N$_2$O research

- Reduction in emission varied across four studies with decreases up to 50%
- Under study by UNL
- 4 to 6 wins; effect on net profit will depend on
  - risk of N loss to one or more processes
  - the cost of controlled release N
Other practices

• Other practices have been found to have little or inconsistent effect on N$_2$O emission
  – Spring compared with fall application
  – Cover crops
Best no- or low-cost win-win-win N$_2$O opportunities

- Rotation
- EONR
- In-season N application
- Inhibitors where leaching or denitrification risk is high
- Controlled release fertilizer: depends on cost and potential for other losses
Variability in effectiveness and net cost

- Risk of $\text{N}_2\text{O}$ emission as well as N loss to different processes varies with field and management conditions
- We are developing an easy to use N management tool
  - assessment of N loss risk to different processes
  - evaluate effects of alternative practices
  - Using ‘saved’ money; need more money to complete
Opportunities

• Some N$_2$O reduction practices have multiple benefits, often with little or no loss in profit

• Good N loss risk assessments can greatly improve decisions on alternative practices