# Comparing $N_2O$ emissions and N leaching losses from three fertilizer sources (synthetic, manure, & anaerobic digestate)

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## Introduction

- Biogas is a renewable energy source generated through anaerobic digestion[1,2]
- Anaerobic digestate (AD) is a by-product that may reduce N losses compared to raw swine manure (Manure) and synthetic fertilizers like urea-ammonium nitrate (UAN)
- The digestion process stabilizes organic matter and leaves behind a more recalcitrant organic N fraction that mineralizes slowly, leading to a more gradual release of nutrients[2,3]

**Hypotheses:**
H1) $N_2O$ Fluxes: UAN > Manure > AD
H2) Leachate TN: UAN > Manure > AD
H3) Plant N Uptake: AD > Manure > UAN

## Methods

- Growth chamber experiment with cereal rye (*Secale cereale L.)* in sandy loam soil
- **Treatments:**
  - Three fertilizer sources (UAN, Manure, AD)
    - Three N fertilization rates (45, 90, 134 kg N $ha^{-1}$) (**45N**, **90N**, **134N**)
    - AD from co-digested swine manure, cereal rye, and prairie biomass
  - Control with no fertilizer (**0N**)

**Table 1:** Chemical and physical properties of Manure and AD (n=4).

| Amendment | pH | Moisture (%) | Total N (%) | $NH_4^+$- N (mg/kg) | $NO_3^-$ - N (mg/kg) | Total C (%) | C:N Ratio |
|---|---|---|---|---|---|---|---|
| Swine Manure | 7.06 | 95.6 | 2.9 | 1633 | 6.4 | 41.3 | 14.1 |
| Anaerobic Digestate | 7.97 | 96. 5 | 4.6 | 1154 | 7.8 | 25.2 | 5.4 |

- **Measurements** (see photos)
  - Weekly $N_2O$ using LI-7820 $N_2O/H_2O$ Trace Gas Analyzer
  - Weekly total N (TN) leachate concentration ($NO_3^-$ and $NH_4^+$ coming)
  - Cereal rye biomass shoots and roots harvested at 84-98 d

## Results & Discussion

Results for 134N expressed relative 0N:
**H1)** $N_2O$ Fluxes: Manure 9.5x, UAN 2.4x, AD 0.5x (Figure 1)
**H2)** Leachate TN concentration: UAN 3.8x, Manure 1.8x, AD 1.5x (Figure 2)
**H3)** Plant N Uptake: UAN 9.9x, Manure 6.9x, AD 5.0x (Figure 3)

## Conclusions

- At all rates UAN had greatest plant N uptake, though risks moderate $N_2O$ loss and TN leaching.
- Manure had moderate plant uptake and TN concentrations, delayed but high $N_2O$ emissions.
- AD had low-to-moderate plant N uptake, but the lowest N losses.

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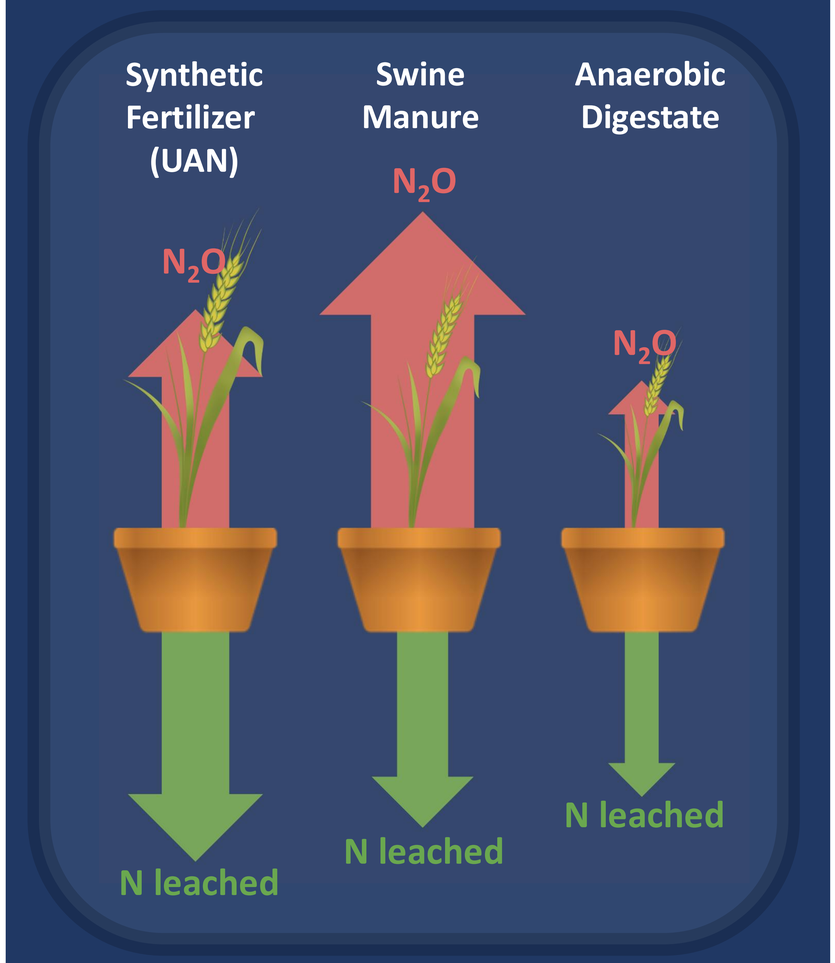
# Anaerobic digestate reduces N loss, but does not improve plant N uptake compared to other amendments

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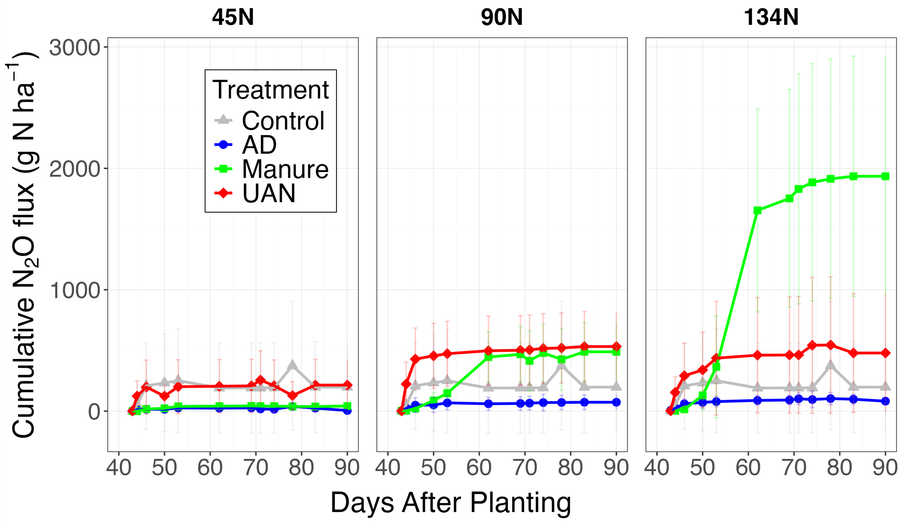


**Figure 1**. Cumulative $N_2O$ flux from day 43 to 98 after planting. Fertilization event on Day 43.

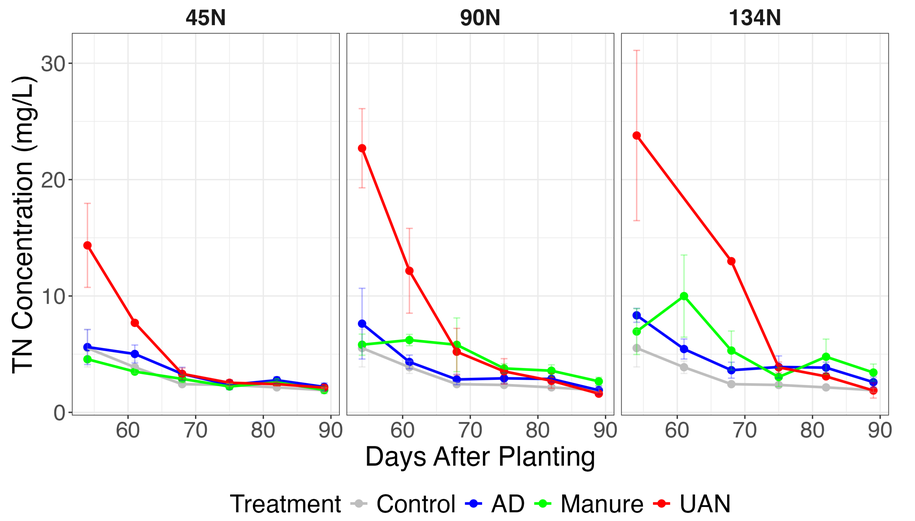


**Figure 2**. Total Nitrogen (TN) concentration of leachate day 43 to 98 after planting. Fertilization event on Day 43.

**Table 2:** Aboveground and belowground cereal rye biomass yield across fertilizer treatments. Values represent mean ± standard error (n=4).

| | Control | AD | | | Manure | | | UAN | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 45 | 90 | 134 | 45 | 90 | 134 | 45 | 90 | 134 |
| Total biomass (kg/ha) | 1476 ± 345 | 3885 ± 483 | 4429 ± 699 | 6138 ± 513 | 5206 ± 149 | 6371 ± 701 | 6371 ± 483 | 7148 ± 1077 | 7692 ± 909 | 7925 ± 807 |

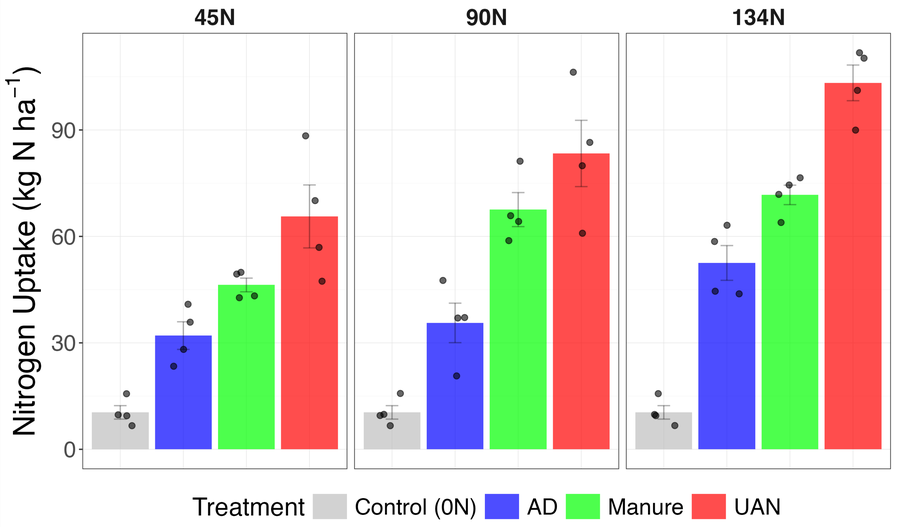


**Figure 3.** N uptake in aboveground and belowground cereal rye biomass across treatments.