2 Rs:

Enough to
1) Increase Corn Yield,
2) Halve Nitrous Oxide, and
3) Reduce Drainage Nitrate

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4 Rs 4 nitrogen

- Timing
- Rate
- Source
- Placement

Biggest impact decision for corn, past 10 years.
Nitrogen timing in a wet year

Effect of N timing on corn yield (Urea + Agrotain)

- 140 pounds N
  - 2013 Missouri
  - 161 bushels applied in July
- 85 bushels applied in February
- 88 bushels applied in April

Do you ever make an N rate/source decision with a 75 bushel impact?
More than 40 cm rain
April-June 2015

• High risk of N loss to water and air
• Areas that wet in 2015 are shown in crosshatch
• We made maps like this one going back to 1900
More wet area in the central U.S.

Area with ≥ 40 cm of rainfall, April-June

99.99% certainty that size of wet area has changed
Nitrogen & drainage experiment

N treatments:
1. 155 pre-plant
2. Sensor-based when corn is knee-high
Variable-rate N based on crop sensors

Computer in cab reads sensors, calculates N rate, directs controller

Controller directs Capstan pulse unit to change fertilizer rate
Measurements

- Nitrous oxide flux
- Nitrate concentration in drainage water
- Corn grain yield
Results: N rate

Nitrogen rate vs N fertilizer system: 6-year average

Sensor-based at V7 155 pre-plant

p=0.63

average N rate, kg N ha$^{-1}$

- Orange: Sensor-based at V7
- Blue: 155 pre-plant
Results: Corn grain yield

Yield vs N fertilizer system: 5-year average

average yield, Mg ha$^{-1}$

- sensor-based at V7
- 155 pre-plant

$p=0.0003$
Results: $\text{N}_2\text{O}$

Nitrous oxide emissions vs N fertilizer system: 6-year average

- 53% reduction $p=0.0001$
- Due to N timing

Nitrous oxide emissions, kg $\text{N}_2\text{O}$-N ha$^{-1}$

- Sensor-based at V7
- 155 pre-plant
Time course of N$_2$O emissions

- Before sidedress N (green line): little flux from sidedress N plots, often large flux from preplant N plots
- After sidedress N: Flux from both systems is similar (slightly higher for sidedress N)
Results: Nitrate concentration in drainage water

Drainage nitrate vs N fertilizer system: 6-year average sensor-based at V7 and 155 pre-plant

Average nitrate concentration, mg L\(^{-1}\)

- Sensor-based at V7
- 155 pre-plant

35% reduction

p = 0.006
Variable-rate sidedress N: Impact

• $N_2O$ flux reduced 50% (reduced window for loss)
• Nitrate concentration in drainage water reduced 35%
• Total N use not changed
• Grain yield increased 10%
MORE about nitrogen

Ed. Schepers & Raun, ~1000 pages

Cliff Notes version, ~80 pages