Global, National, and Local Trends of Nitrogen Use Efficiency in Agriculture

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The Haber-Bosch process is one of the greatest public health boons in human history.

The shape of things to come

Mo Fo; Lo Po
Nitrogen: A Very Leaky Element

N inputs:
- synthetic N fertilizers
- manure
- & natural N fixation

Consumed Animal Products: 4%
Consumed Crops: 14%

Atmosphere

Crop production

Animal production

Groundwater & surface waters

Agriculture

N inputs: synthetic N fertilizers, manure, & natural N fixation
\[ \text{NUE} = \frac{\text{outputN}}{\text{inputN}} \]

\[ \text{Surplus} = \text{inputN} - \text{outputN} \]

Data Source: FAOSTAT, FAOFertiSTAT
Zhang et al., in preparation
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What are the technical, economic, and social impediments and opportunities for increased nitrogen use efficiency in crop and animal production systems?
Mixed economic signals

- **N** fertilizer costs are high enough for many farmers to want to improve NUE.
- But most also agree that the economic risk of applying too little N is high.
- **N** application provides an important economic margin of safety, like relatively inexpensive insurance.
Estimated costs for adopting several currently available management practices across the Ceder Creek Watershed, Iowa, for a 35% load reduction, implemented over a 20 year period. The total cost is $71 million per year, or $7.78 kg\(^{-1}\) N removed yr\(^{-1}\), or $42 ha\(^{-1}\) yr\(^{-1}\) (from Dan Jaynes, USDA-ARS, and Mark David, Univ. Illinois).

RECOMMENDATIONS:

- Develop partnerships & networks between industry, universities, governments, NGOs, crop advisors, and farmers to demonstrate the most current, economically feasible, best management practices.

- Provide improved, continuing education to private sector retailers and crop advisors through professional certification programs by university and government extension.

- Provide science-based recommendations through trusted sources of information to help reduce the perception of risk and the perceived need to apply additional N for “insurance” purposes.
Retailer & Conservationist Survey

Purpose of the Survey
Nutrient stewardship is an important issue facing agricultural producers because of costs, effect on crop yields, and environmental benefits. Five organizations have partnered to create a survey to:

- Identify areas for focusing and targeting outreach
- Better quantify existing implementation of 4R practices
- Identify opportunities for retailers and conservationists to work cooperatively to help ensure that the agricultural community leverages the full power of voluntary nutrient stewardship.

Sponsoring Organizations

NCFC
National Council of Farmer Cooperatives

The Fertilizer Institute

Agricultural Retailers Association

National Association of Conservation Districts

Certified Crop Adviser
Results – 4R Awareness and Working Relationships

◆ 4R Awareness
  – Retailers:
    ✦ 2% first learned of 4Rs in Survey
    ✦ Knowledge of 4R - 7.2 (scale of 1-10)
  – Conservation Districts:
    ✦ 37% first learned of 4Rs in Survey
    ✦ Knowledge of 4R - 4.6

◆ Awareness of each other
  – Retailers:
    ✦ Awareness of district activities – 5.4
    ✦ Awareness of technical/financial assistance – 4.6/4.9
  – Conservation Districts:
    ✦ Awareness of retailer activities – 3.3
    ✦ Awareness of technical/financial assistance – 8.9/8.9
And the Survey Says…..

Most recommended practices by retailers

- Aerial photography
- Ag drainage practices
- Applying buffer strips
- **Auto steer (71%)**
- Band fertilizer placement
- Conservation tillage
- **Mapping soils/yields (69%)**
- Crop rotation
- Nutrient injection
- Manure testing
- Mapping sensitive areas

- Planting cover crops
- PSNT
- **Split nutrient applications (80%)**
- Plant tissue testing (75%)
- **Soil fertility testing (98%)**
- Use N Stabilizers (91%)
- Use P efficiency products
- Proper nutrient source (75%)
- Nutrient budgets
- **VRTX nutrient application (86%)**
- Yield maps analysis (73%)
- Grassed waterways
And the Survey Says…..

Most recommended practices by conservationists

- Aerial photography
- Ag drainage practices
- **Applying buffer strips (65%)**
- Auto steer for application
- Band fertilizer placement
- **Conservation tillage (71%)**
- Mapping soils/yields
- **Crop rotation (49%)**
- Nutrient injection
- **Manure testing (48%)**
- Mapping sensitive areas
- **Planting cover crops (75%)**
- PSNT
- Split nutrient applications
- Plant tissue testing
- **Soil fertility testing (74%)**
- Use N Stabilizers
- Use P efficiency products
- Proper nutrient source
- Nutrient budgets
- VRT nutrient application
- Yield map analysis
- **Grassed waterways (55%)**
Nitrogen Use Efficiency in Nebraska’s Central Platte Valley

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Corn yields (green line) have increased in Nebraska, while N fertilizer application rates (blue line) have remained steady, indicating an increase in NUE. From Nebraska Dept. of Ag – Ag Statistics, Natl Ag Statistics Service, and Univ. of Nebraska-Lincoln
Central Platte Natural Resources District
Groundwater Management Area (GWMA)

First GWMA in Nebraska, established in 1988 following passage of enabling legislation.
Central Platte NRD Groundwater Management Area (GWMA)

**Phase I** (0-7.5 ppm NO$_3$-N)

- Fall & winter N application banned on sandy soil.
- N application allowed on heavier-textured soils after November 1.
Central Platte NRD GWMA

**Phase II** (7.6 – 15 ppm NO$_3$-N)

- No N fertilizer application allowed until after March 1.
- Annual soil and irrigation water tests required.
- Lab analysis and nutrient accounting is required if manure is to be applied.
- Legume credits must be considered.
- Certification by the NRD every 4 years.
- Measurement of irrigation water applied to each field.
- Annual reporting to the NRD of crop grown, N credits, recommended N rate, nitrification inhibitor use, soil & water analyses, N fertilizer and water applied, and crop yield.
Central Platte NRD GWMA

**Phase III** (> 15 ppm NO$_3$-N)

- All requirements of Phase II, plus –
- Split N application, or use of a nitrification inhibitor, or sidedress application.
Trends in the Central Platte Valley

Average of values from producer reports in GWMA, representing ~ 300,000 acres

\[ y = -0.1523x + 321.41 \]

\[ R^2 = 0.82403 \]

\[ y = -2.1092x + 4289.4 \]

\[ R^2 = 0.63118 \]

Policies, regulations, incentives, & outreach should be tailored to local conditions, administered and enforced by local entities.

Average of values from producer reports in GWMA, representing ~ 300,000 acres
Farmers lose, environment loses

Farmers win, environment loses

Farmers lose, environment wins

Farmers win, environment wins

NUE

- 0.63
- 0.67
- 0.71
- 0.75
The Kansas City Consensus on Nitrogen Use Efficiency 2013

In August 2013, agronomists, environmental scientists, extension agents, crop advisors, economists, farmers, and other agricultural experts gathered at a conference in Kansas City, Missouri, to discuss a vexing challenge: How can we promote better management of nitrogen fertilizers and manures in order to reduce unintended environmental impacts of nitrogen pollution, while still enabling modern agriculture to meet the growing demand for affordable food and biofuels?

Existing knowledge and technology, although imperfect and incomplete, are already advancing the dual goals of making agriculture productive and environmentally sustainable. Unfortunately many economic and social barriers stand in the way of more widespread adoption by farmers of existing and emerging technologies. In the meantime, concerns about environmental pollution, from nitrate in drinking water to toxic algae in waterways, are increasing pressures to reduce nitrogen losses from agricultural fields. View the complete consensus statement at http://nitrogennorthamerica.org/pdf/KansasCityConsensus_Final_Nov_2013.pdf