Nutrient Use in Agriculture:
Managing Nutrients for Economics and the Environment

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May 14, 2008

Who We Are:
The Fertilizer Institute

- TFI represents the nation’s fertilizer industry including producers, importers, retailers, wholesalers and companies that provide services to the fertilizer industry.
Who We Are:
TFI Mission Statement

• TFI seeks optimum plant nutrition for an abundant, economical, safe and nutritious food and fiber supply.
• We also seek to encourage farmers and their advisers to responsibly protect and improve air and water quality.

Presentation Overview

I. The Global Food Crisis
II. What are Nutrients
III. Managing Agricultural Nutrients for Economics and Environment
   a. Nutrient Management Planning
   b. Toolbox
IV. Review of Factors Driving Nutrient Use
   a. Bioenergy Production
   b. Energy Costs
   c. World Fertilizer Demand
The Global Food Crisis

“The squeeze on the supply of fertilizer has been building for roughly five years. Rising demand for food and biofuels prompted farmers everywhere to plant more crops. As demand grew, the fertilizer mines and factories of the world proved unable to keep up.”

“Shortages Threaten Farmers’ Key Tool: Fertilizer”
Essential to Improved Soil Fertility

• For arid and semi-arid regions results show that nutrient limitations set a stronger ceiling on yield than water availability.

• In much of Africa, fertilizer use is low. With improvements in soil fertility and water management, yields in West African rain-fed agriculture can double or quadruple.

• Developing country fertilizer use
  - Sub-Saharan Africa 9 kg/ha
  - Latin America 73 kg/ha
  - South Asia 100 kg/ha
  - East and Southeast Asia 135 kg/ha
  - Western Europe and U.S. >250 kg/ha

What is a Plant Nutrient?

N
Nitrogen (N) is a primary building block for all organisms. It is essential to making proteins, helps keep plants green and is a critical component of soil structure.

P
Phosphorus (P) is a component of DNA and it also plays vital roles in capturing light during photosynthesis, helping with seed germination, and helping plants use water efficiently. Plants also use phosphorus to help fight external stress and prevent disease.

K
Potassium (K) plays an important role in plant’s water utilization and also helps regulate the rate of photosynthesis. Other aspects of plant health include the growth of strong stalks, protection from extreme temperatures, and the ability to fight stress and pests.

Green Revolution

World Cereal Production – Area Saved Through Improved Technology, 1950-1998

Global trends in cereal and meat production

Global total use of nitrogen and phosphorus fertilizers.

Increased use of irrigation

Total global pesticides production

SOURCE: Timan et al., 2002

N in Soil OM
Schulten & Schnitzer, 1997
Nitrogen Use Efficiency (NUE)

Nitrogen-use efficiency is the proportion of all nitrogen (N) that is removed in harvested crop biomass, contained in recycled crop residues and incorporated into soil organic matter and inorganic N pools. Nitrogen not recovered in these N sinks is lost from the cropping system and thus contributes to reactive N external to the agroecosystem.

Source: Cassman et al., 2002

Grain Yield and Plant-N Accumulation

Figure 3. Relationship between grain yield and plant-N accumulation in aboveground biomass at physiological maturity in maize and rice.

Data sources: for rice, data obtained from on-farm and research station experiments conducted across a wide range of agroecological environments in Asia from 1995 to 2000 (n = 1650); for maize, data obtained from on-farm and research station experiments conducted across a wide range of agroecological environments in the North-Central USA from 1995 to 2000 (n = 479). Blue lines indicate the boundary of maximum dilution of N in the plant (maximum physiological efficiency), whereas the black lines depict the average physiological efficiency as obtained from nonlinear regression for the entire data set for maize and rice.
Trends in maize grain yield, use of N fertilizer and partial factor productivity from applied N fertilizer (PFP_N, kg grain yield kg^{-1} N applied) in the United States.

Source: Cassman, et al., 2002

Every Farm and Field is Different

We are growing more with less

Source: Computed by TFI from USDA data
Managing Nutrients in Agricultural Systems is Complex...

The Nitrogen Cascade

Nutrient Removal to Fertilizer Use Ratio for US Grain Corn

Improvement: %

N: 42%
P: 106%
K: 85%

Corn Yield: 52%

Source: USDA-NASS; PPI
**Nutrient Use Efficiency Improving**

Nitrogen and Phosphate Use per Bushel of Corn Produced

- Corn yields increasing at ≈1.7 bushels/ac per year
- N Fertilizer rates have been stable since 1980
- Result: NUE has increased by 33% from 1980 to 2000
Nitrogen Check Yields and Net Returns in University Corn Studies in Iowa and Illinois

<table>
<thead>
<tr>
<th>Previous crop</th>
<th>Region</th>
<th>No. of sites</th>
<th>N check, % of opt. yd</th>
<th>Net return to N, $/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>IA</td>
<td>147</td>
<td>71</td>
<td>188</td>
</tr>
<tr>
<td>Soybean</td>
<td>Central IL</td>
<td>148</td>
<td>58</td>
<td>281</td>
</tr>
<tr>
<td>Corn</td>
<td>IA</td>
<td>73</td>
<td>44</td>
<td>326</td>
</tr>
<tr>
<td>Corn</td>
<td>Central IL</td>
<td>53</td>
<td>49</td>
<td>315</td>
</tr>
</tbody>
</table>

At risk: $60 to $90/A of input costs
30% to 55% of total yield
$200 to $300/A net income from one input

Millennium Development Goals

Fertilizer is part of the solution...

- **Goal 1**
  Eradicate extreme poverty and hunger

- **Goal 7**
  Ensure environmental sustainability

- **Goal 8**
  Develop a global partnership for development

Source: http://www.un.org/millenniumgoals/
Mitigating Environmental/Economic Risks

- Economic penalty for over or under estimating need or for nutrient loss is much greater with today’s higher prices … greater risk
- Tools for Mitigating Risk
  - Precision input application, enhanced efficiency N sources
  - Guidance systems
  - Soil testing and plant analysis, soil or plant imaging
  - On-farm strip trials, omission plots
  - Other forms of decision support including simulation models
  - Investing in determination of right source, rate, time and place for nutrients … risk management tools

Source: Fixen, IPNI, EPA Integrated N SAB presentation, April 10, 2008

Right Product, Time, Rate and Place Paradigm

Right Product

Right Time

Right Rate

Right Place
Decision Making for Nutrient Application

Right Nutrients

- Select appropriate nutrients and on farm nutrient sources for the cropping system.
- Soil Testing
- N, P, K and micro-nutrient data
- Enhanced fertilizer efficiency
- Nutrient management planning
Soil and Plant Testing

Ask the question with soil testing…

Is there a full tank of Nutrients, or are we running on empty?

Right Time

- Application Timing
- Controlled Release Technologies
- Inhibitors
- Fertilizer Product Choice
Right Place

- Application method
- Incorporation of fertilizer
- Buffer strips
- Conservation tillage
- Cover cropping

Right Rate

- Soil testing
- Yield goal analysis
- Crop removal balance
- Nutrient management planning
- Plant tissue analysis
- Record keeping
- Variable rate technologies
- Site-specific management
Managing Fertilizers in Agriculture

- The North American fertilizer industry has a long history of partnering with its farmer customers and the more than 13,000 Certified Crop Advisers (CCAs) to ensure maximum crop productivity, while protecting water quality, soil quality and the environment.

Consultants and Extension
Reduce Complexity
What are Certified Consultants?

A CCA works with producers to:

Maximize Crop Production and Minimize Environmental Risk!

- Passes 2 CCA Exams
- 2 yrs. field experience with a BS Degree

Or

- 4 yrs. field experience without advanced degree.
- Supporting references
- Sign the CCA Code of Ethics

Once Certified:

- Each CCA is required to earn 40 hours of continuing education / 2 years.

What is the goal of a Certified Consultant?

Maximize Crop Production and Minimize Environmental Risk and Costs

- Determine the amount of nutrients in the soil that will be available for plant uptake.
- Determine the amount of nutrients needed to produce the desired crop.
- Manage Nutrient:
  - Source
  - Placement
  - Application Timing
Nutrient Management
Tool Box

- **Tool 1: On Site Evaluation**
  - Identify environmental concerns
- **Tool 2: Geographic Information**
  - Aerial photos
  - Soil type maps
  - Global Positioning Systems (GPS)
- **Tool 3-6: Soil, Manure, and Plant Tests**
  - **Soil**: Amount of nutrients available is obtained from the soil test.
  - **Plant**: Amount of nutrients needed to produce the desired crop.
  - **Manure**: Amount of nutrients available in manure
- **Tool 7: Nutrients**
  - The nutrient source, timing, and placement can influence crop nutrient efficiency and the potential for nutrient loss.
- **Tool 8: Management practices**
  - Tillage, crop rotation, planting rates, seed selection are all practices that can influence how we manage nutrients.
- **Tool 9: Planning Software**

GPS/GIS

Having precise location information allows soil and crop measurements to be mapped.
Precision agriculture allows you to place the nutrients where you need them.

- Maximize crop returns with a minimum amount of inputs.
- The environment is protected because only the precise quantity of inputs is applied when and where needed.

“Do the right things in the right place at the right time and in the right way”

Modern Corn and Soybean Production, Horst R.G et al.

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Practice adoption varies across practices and crops, 2001-03

<table>
<thead>
<tr>
<th>Standard practices</th>
<th>Percent of farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation tillage</td>
<td></td>
</tr>
<tr>
<td>Crop rotation</td>
<td></td>
</tr>
<tr>
<td>Resistant seed</td>
<td></td>
</tr>
</tbody>
</table>

| Decision aids                       |                  |
| Soil/tissue test                    |                  |
| Pest scouting                       |                  |
| Soil mapping                        |                  |

| Management-intensive practices      |                  |
| Variable application                |                  |
| Nitrogen management                 |                  |
| Pest management                     |                  |

Note: Nonfamily farms are excluded.
Source: 2001-2003 ARMS, Phase III.
What is going on with fertilizer prices?

Index of Fertilizer Prices Paid by Farmers, Jan 1995-Nov 2007

Natural Gas Required to Produce a Ton of Anhydrous Ammonia

1983 to 2006 => 11% increase in efficiency
Average Annual Natural Gas Costs ($)

Source: Spot-delivered-to-pipeline price, Natural Gas Week.

Rising Energy and Feedstock Costs

PRODUCTION COST IMPACTS

Ammonium Phosphates

Direct => higher energy prices

=> higher sulfur prices

Indirect => higher ammonia prices

Potash

=> higher electricity and natural gas prices
World Fertilizer Demand
Fertilizer Nutrient Demand, FY95/96 and FY00/01

- United States: 20.7 million short tons nutrient demand in FY95/96, drop in use of 1.4 million nutrient tons over 5 years.
- Rest of World: 131.3 million short tons nutrient demand in FY95/96.
- World: 150.1 million short tons nutrient demand in FY95/96, growth of 4.2%.

Source: IFA, TFI.

World Fertilizer Demand
Fertilizer Nutrient Demand, FY00/01 and FY05/06

- United States: 21.2 million short tons nutrient demand in FY00/01.
- Rest of World: 150.4 million short tons nutrient demand in FY00/01.
- World: 171.6 million short tons nutrient demand in FY00/01, growth of 13.7%.

Source: IFA, TFI.
Practice adoption reflects farm and operator characteristics

Percent of farms in each type

<table>
<thead>
<tr>
<th>Retirement/retired, lifestyle</th>
<th>Standard practices</th>
<th>Decision aids</th>
<th>Management-intensive practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retire/medium, retired</td>
<td>90</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Retire/medium, retired</td>
<td>80</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>Retire/medium, retired</td>
<td>70</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Retire/medium, retired</td>
<td>60</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

Note: Nonfamily farms are excluded.
Source: 2001-2003 ARMS, Phase III.
Summary of Toolbox

– On Site Evaluation
– Geographic Information
– Soil Testing
– Right Nutrients
– Right Timing, Placement and Rate
– Field Management—Rotations, Tillage, etc.
– Planning Software