Module 2: Nitrogen Management

To view the chapter for this topic click here.

Introduction

- Nitrogen (N) is essential for plant growth:
  - part of every living cell
  - component of all amino acids (proteins and enzymes) and nucleic acids
  - component of chlorophyll
- Nitrogen deficiency in plants appears as chlorosis or yellowing mainly in older leaves (mobile nutrient).
- Nitrogen nutrition affects yield, but also crop quality.
- Nitrogen has interaction implications with efficient use of other nutrients.

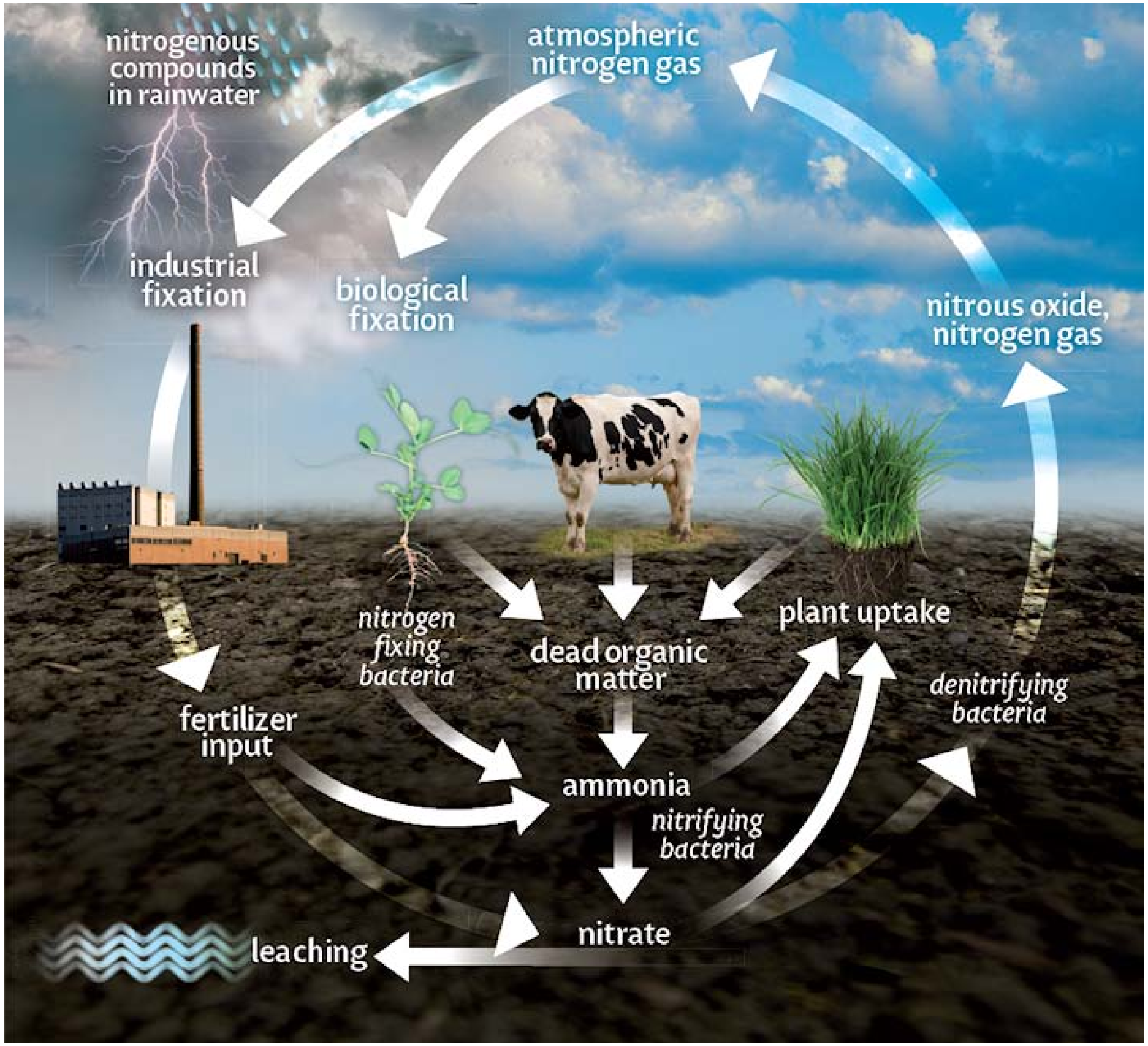
Basic Nitrogen Processes in the Soil-Plant System

- Nitrogen soil processes
  - *Mineralization*: organic N conversion to NH_4^+
  - *Nitrification*: NH_4^+ conversion to NO_3^-
  - Immobilization: inorganic N conversion to organic N

- Nitrogen gains
  - *Biological N fixation*: plant-microbe symbiotic supply of plant available N
  - *Fertilization*: supplements soil plant-available N
  - *Organic additions*: increases organic matter and potentially plant-available N

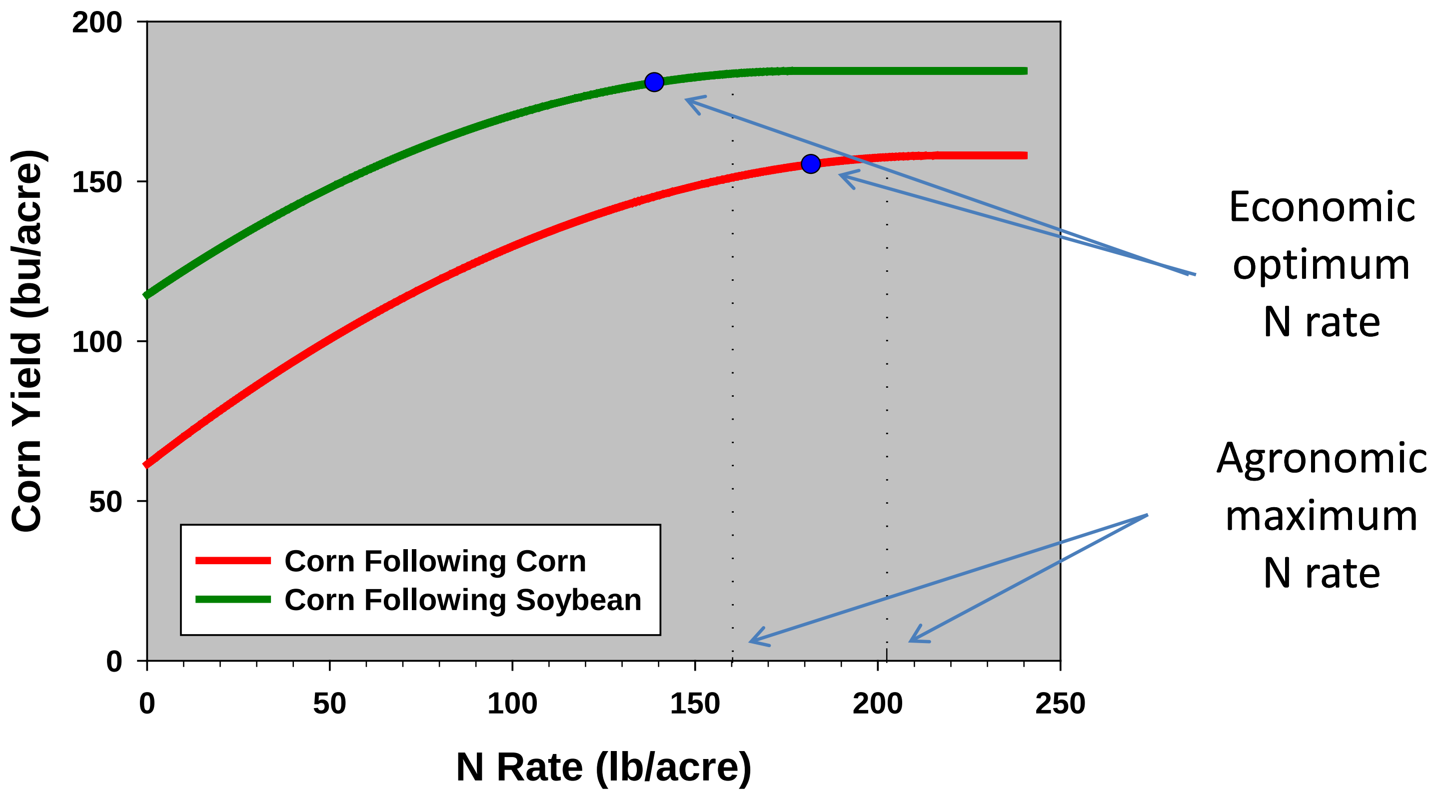
- Nitrogen losses
  - *Crop removal*: reduction in soil N with crop harvest
  - *Leaching*: NO_3^- loss with water drainage and potential water quality issues
  - *Denitrification*: NO_3^- loss by microbial conversion to N gases with potential air quality issues
  - V*olatilization*: ammonia loss from soil surface with potential air quality issues
  - *Erosion*: organic matter loss with water runoff and potential water quality issues

The Nitrogen Cycle in Agroecosystems



From Rothamsted Research, www.rothamsted.ac.uk

Nitrogen Fertilization Rate Determination and Economic Response



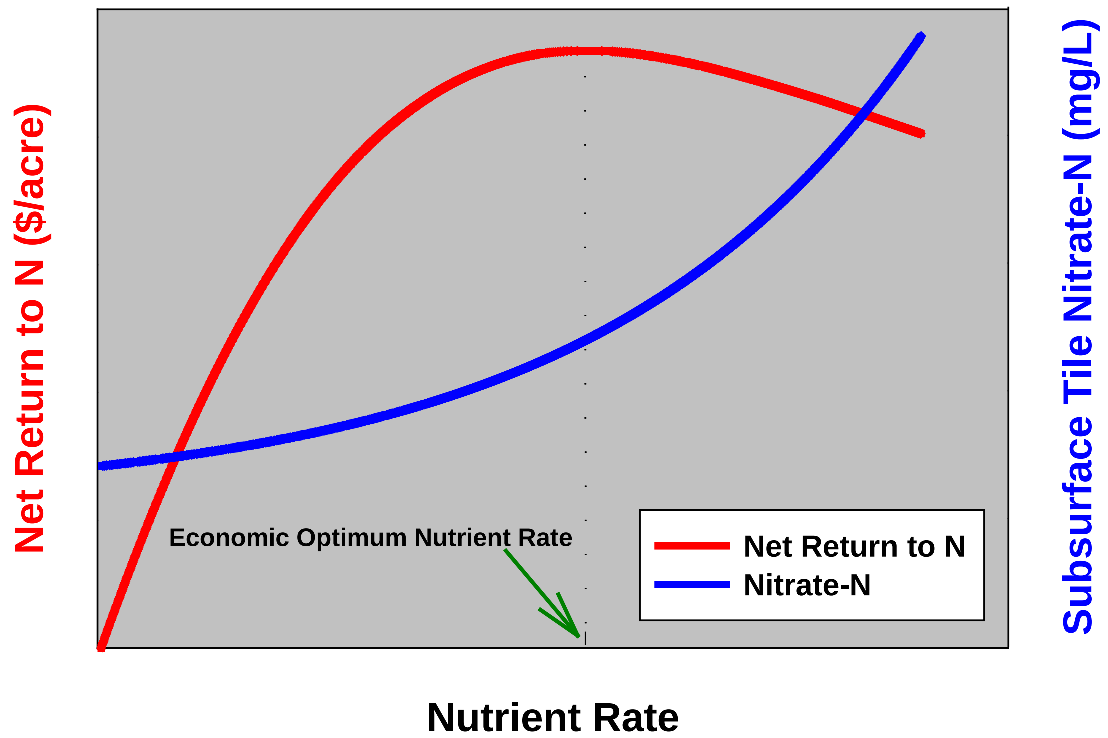
Nitrogen rate response of corn following corn and corn following soybean in Iowa. J.E. Sawyer, Iowa State University.

Nitrogen Rate: Economic and Environmental Issues

- Applying “more than enough N” is not environmentally safe or cheap “insurance”.

- Farmers need to critically determine N rates because of:
    - High N fertilizer costs
    - Potential economic loss
    - Environmental impacts

Nitrogen Fertilization Rate Determination and Economic Response

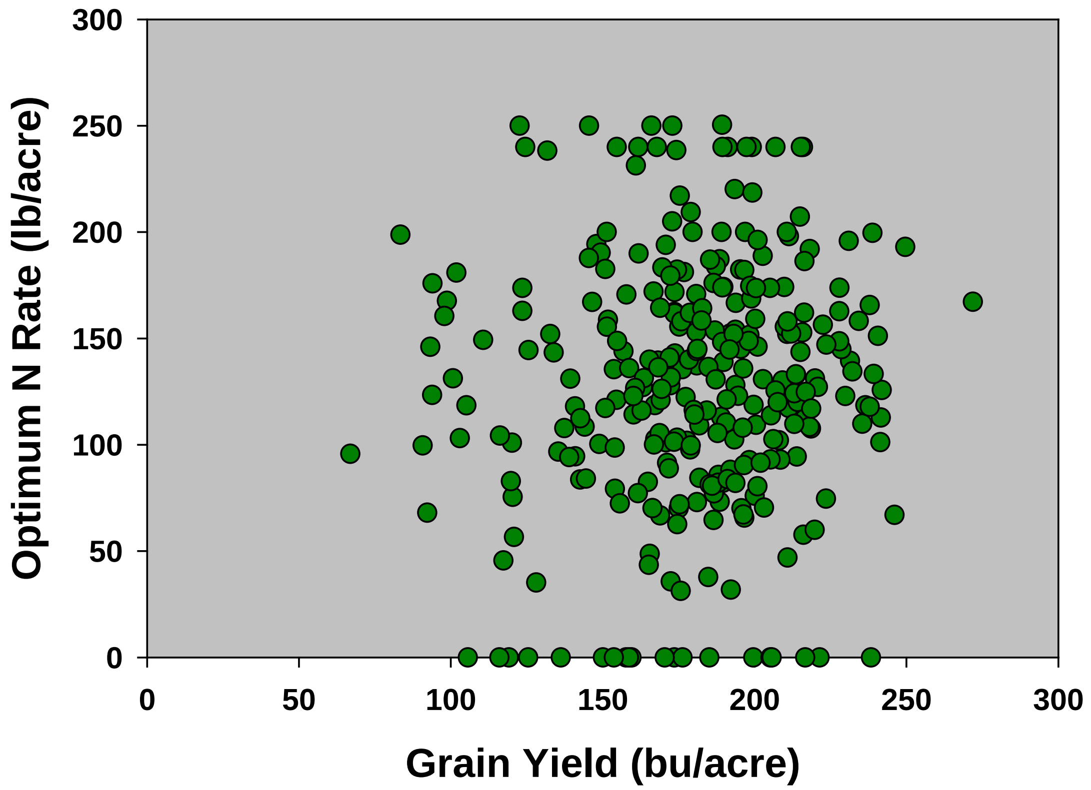


Importance of using optimum N rates for greatest profit and minimizing nitrate-N loss (via subsurface tile drainage).

Rate Determination and Economic Response

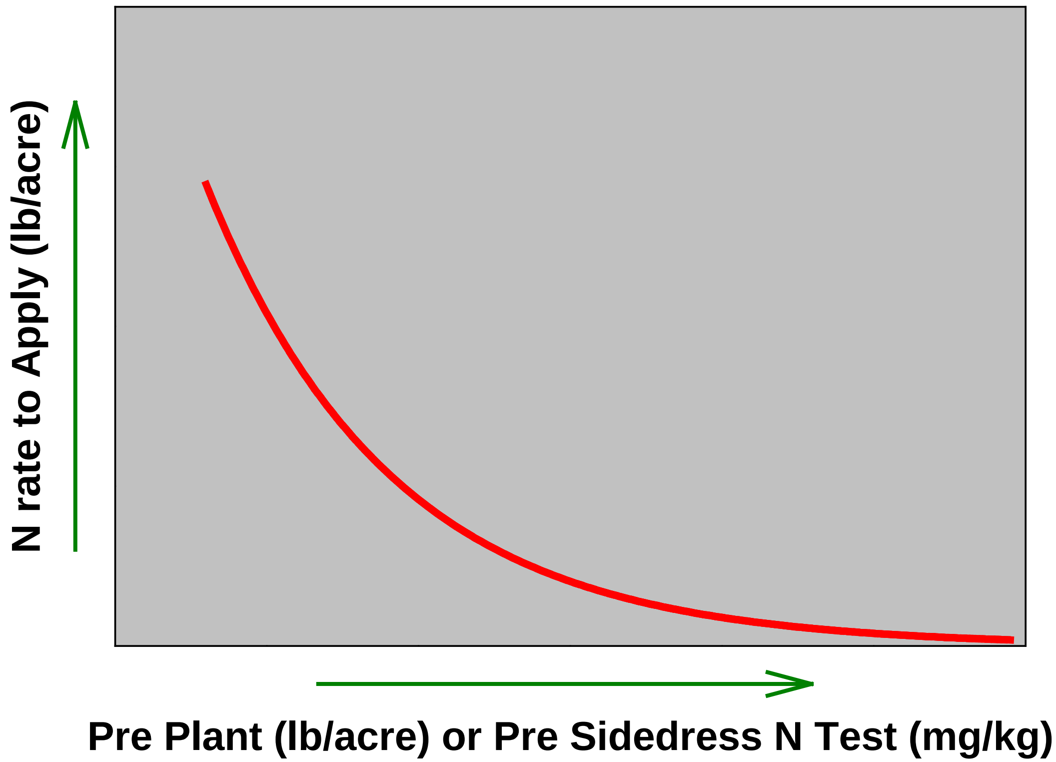
- Nitrogen recommendations have been based on yield-goals for many years in the Midwest USA and other regions.
- Expected crop yield is the criterion for determining N rates.
- In the Midwest USA there is poor correlation between site-year crop yield and economic optimum N rate.
- Use a new approach with N response data-driven recommendations sensitive to measured N response and N and grain prices.
- In the Midwest USA called the MRTN (Maximum Return To N).

Nitrogen Rate Determination and Economic Response



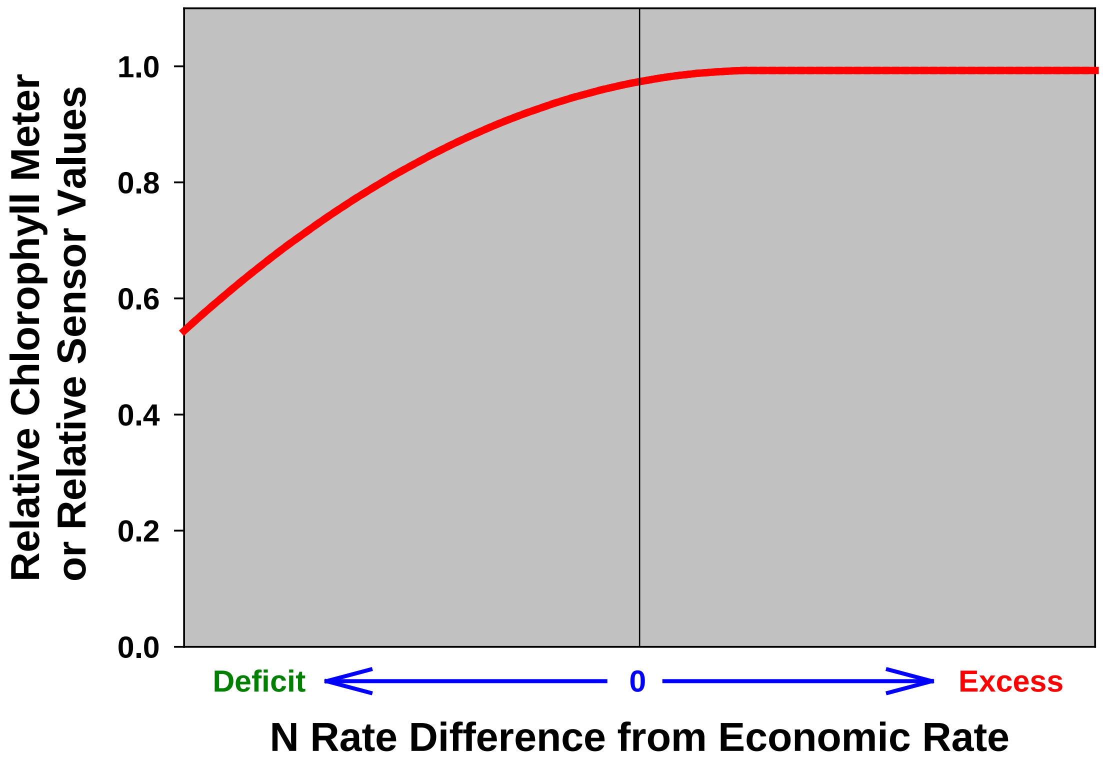
Relationship between the economic optimum N rate and corn grain yield level. Data from corn after soybean in Iowa. J.E. Sawyer, Iowa State University.

Nitrogen Diagnostic Methods: Pre-plant and Pre-sidedress Soil Sampling



General relationship between N fertilization rate and pre-plant or pre-sidedress soil nitrate-N content.

Nitrogen Diagnostic Methods: Chlorophyll Meter and Crop Canopy Sensors



Relative crop canopy sensor value as related to the differential from the economic optimum N rate in corn.

Nitrogen Variable Rate Technology

- Soils differ within fields and that can result in significant yield variation.

- Fields are divided into management units where the fertilizer application may differ.

- Diagnostic tools for N VRT
    - intensive soil sampling
    - soil and crop remote sensing
    - aerial images
    - yield mapping
    - crop modeling

Nitrogen Application Timing

- The demand for N by a crop is associated with the growth rate.
- Ultimate goal of N management is to time N fertilizer applications to match crop uptake needs.
- Application timing can play a critical role in optimizing N use efficiency.
- Fall N application increases risk of loss.
- Nitrification inhibitors with fall-applied N can improve effectiveness where fall application is an acceptable practice.

Nitrogen Application Timing

- Spring applied N is generally more effective than fall application.

- Fall application is only suggested for regions where:
  - winters have frozen soils
  - rainfall is low
  - soils without excessive drainage

- Benefits from sidedress and split N applications are greatest where there is a high risk of N loss between preplant timing and crop N use.

- Sidedress also allows for use of in-season soil tests and plant N stress sensing.

- Yield reductions due to delayed applications can be minimized by applying some N at planting.

Nitrogen Sources

- *Manure*
  - Mix of organic and inorganic N forms
  - Liquid or solid typically with low nutrient concentration
  - Sampling and laboratory analysis are always recommended
  - Significant time may be needed to provide plant available inorganic N

- *Anhydrous ammonia* (NH_3) (82 % N)
  - Relative low cost and high N concentration
  - Care should be taken when transporting and applying
  - It can be applied pre-plant or sidedressed in row crops
  - Soil moisture content should not be too dry or too wet
  - Shallow placement may result in early season crop seedling or root damage
  - For small grains, knife spacing needs to be close enough to avoid deficient strips
  - Addition of a nitrification inhibitor with late fall application may be beneficial

Nitrogen Sources

- *Urea* ($CO(NH_2)_2$) (46 % N)
    - It converts quickly to ammonium
    - In no-till, ammonia volatilization from surface application is a concern
    - A urease inhibitor can help reduce volatile loss with surface placement

- *Urea-ammonium nitrate solution* (UAN) (28-32 % N)
    - Widely used as a broadcast and injected product
    - It can be banded on the soil surface which reduces volatilization

- *Ammonium nitrate* (NH_4-NO_3^-) (34 % N)
    - Both N portions are immediately available for plants
    - There is no volatile loss potential from surface application on most soils
    - It’s use has been decreased due to safety regulations (explosive)

- *Slow and controlled release N sources*
    - Products with varying chemical structures that slow conversion or release timing of plant available N

Nitrogen Application Placement

- *Injected or banded*
  - To avoid volatile losses and odors
  - To match crop row spacing
  - To avoid crop injury that may occur with broadcast
  - To have a high N starter available for early growth

- *Broadcast*
  - Uniform distribution of N across the soil
  - Often applied pre-plant or prior to emergence
  - After crop emergence can cause crop injury with some products

- *Fertigation*
  - It allows for multiple applications throughout the season
  - Especially useful on coarse textured soils
  - Timely rains may reduce the need for irrigation

Management Practices for Nitrogen Fertilization

- Management practice concepts to help address P use for the right nutrient source, at the right application rate and time, and in the right place
- Rate
  - Selecting the appropriate N rate is highly important for achieving economic and environmental goals.
  - Recommended rates should be based on research-derived responses to N application.
  - Soil preplant and presidedress testing for nitrate can be used to adjust application rates.
  - Plant sensing tools are used to access cereal crop N stress and adjust in-season N rates.
  - Nitrogen rates should be specific for the crop rotation and previous crops.

Management Practices for Nitrogen Fertilization

- Source
  - Many N fertilizers and manures can be used successfully if management is correct for the source.
  - In situations with high probability for N loss, controlled release fertilizers can avoid loss by physically protecting applied N.

- Placement
  - Nitrogen placement should be optimal for plant uptake and avoidance of volatile loss.
  - In dry conditions, N placed within the root zone can enhance crop uptake.
  - Nitrogen application with irrigation can be useful to supply N during crop N uptake.

Management Practices for Nitrogen Fertilization

- Timing
  - Maximizing crop N uptake reduces potential for loss.
  - N application timed with crop uptake increases nutrient use efficiency
  - Spring application is generally more effective than fall.
  - Nitrification inhibitors can slow conversion of fall-applied anhydrous ammonia.
  - Yield reductions due to delayed sidedress applications can be minimized by applying some N at planting.
  - In season N applications can avoid loss conditions that may occur before planting.

Summary

- Proper N management is essential for many reasons:
  - to supplement soil N supply in order to meet crop needs
  - to optimize crop production and profitability
  - to improve N use efficiency
  - to reduce impacts of N on air and water quality
  - to avoid increased regulation

- Nitrogen management is more complex in humid regions than in drier areas.

- Nitrogen management goals:
  - apply N at optimal economic rates
  - select an application timing to minimize N leaching and denitrification
  - use diagnostic tools to aid in rate determination and adjustment
  - use the appropriate N source and placement for each production system
  - use precision agriculture technologies when appropriate