31st Annual NATIONAL NO-TILLAGE CONFERENCE

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Tips for Improving Nitrogen Use Efficiency

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Agenda

- **Review of Nitrogen Dynamics**
- Introduction of the OODA LOOP
- Deconstruction of the 4R's to improve Nitrogen Use efficiency
- Nitrogen Stabilizers
- How to measure NUE

Grower Challenges / Opportunities

Utilization: 50%

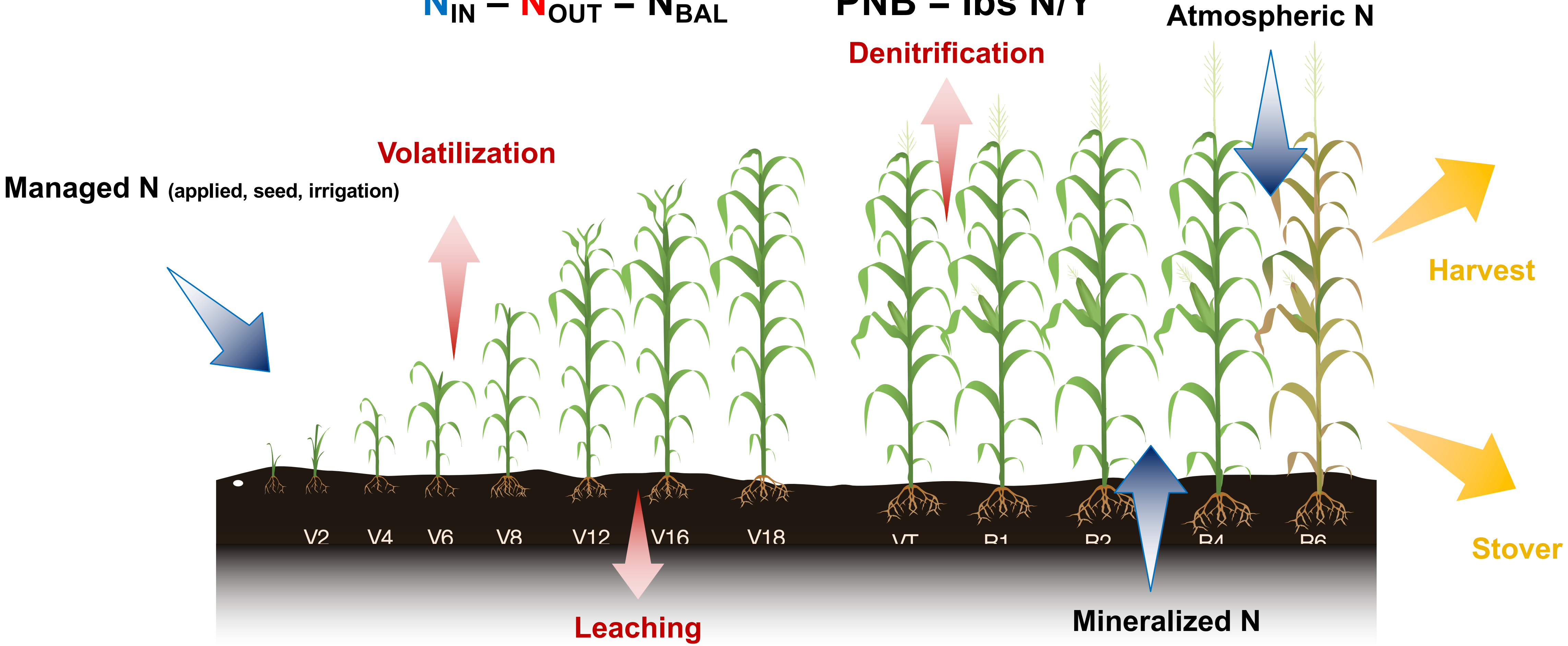
of Nitrogen **available** to the plant is underutilized

…while Nitrogen is the 3rd largest investment the grower makes

https://www.360yieldcenter.com/2015/03/five-tips-for-smarter-nitrogen-management/

Nitrogen Balance

$N_{IN} - N_{OUT} = N_{BAL}$ PNB = lbs N/Y



What Does Nitrogen Do?

- Important in cellular functions
- Increasing protein content
- Critical for enzyme formation
- Essential part of the chlorophyll molecule and is necessary for photosynthesis

FAST FACTS

Nitrogen is essential for plant growth and is part of every living cell

How N is Uptaken?

- Organic Vs. Inorganic P
  - Inorganic forms = nitrate & ammonium
  - Organic = urea & free amino acids
- Mass Flow Nutrient Uptake
  - dissolved nutrients into a plant as the plant absorbs water.
  - responsible for most transport of nitrate, sulfate, calcium and magnesium
- Mobile in both soil and plant

Nitrogen Losses

Volatilization

Most common in warm, dry conditions

Nitrification

Conversion of Ammonium N to Nitrate N

Denitrification

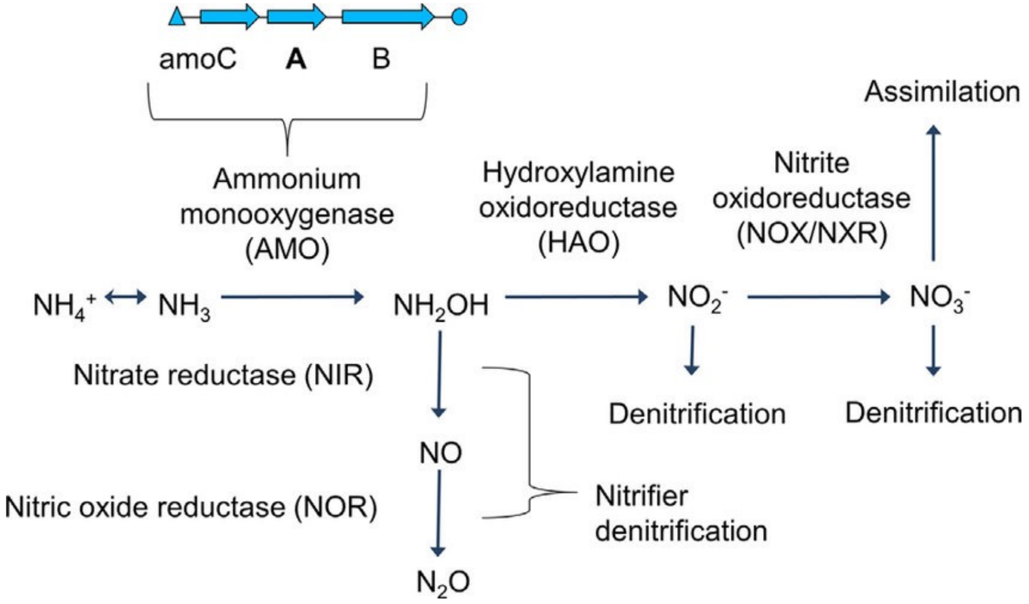
Most common when Nitrate is present, and soil is saturated with water (anaerobic)

Factors Influencing Volatilization

High Risk Conditions	Low Risk Conditions
Moist Soil or Heavy Dew	Dry Soil
High Soil pH (>7.0)	Low Soil pH (<6.0)
High Soil Temperature (>70^{o}F)	Cool Soil Temperatures
Crop Residue, perennial thatch or sod	Bare Soil
Low CEC, OM Soils	High CEC, OM Soil
Poorly buffered soils	Highly Buffered Soils

Factors Influencing Nitrification

- Aerobic reaction
- Soil OM and Clay content
- Soil Temperature
- Soil Moisture near Field Capacity is Optimum
- Tillage system
  - Less tillage=Higher Risk



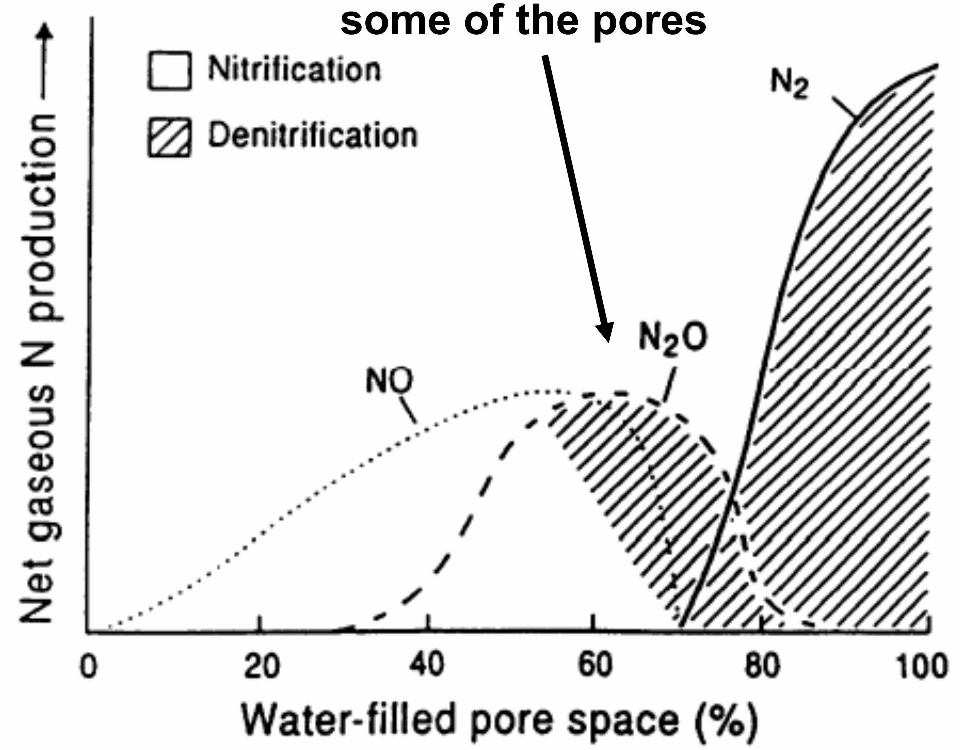
Factors Influencing Denitrification

- Anaerobic reaction
- Above field capacity to saturated soils
- Warm soils
- Available Nitrate

Denitrification Reaction Sequence

NO_3^-	→	NO_2^-	→	NO	→	N_2O	→	N_2
Nitrate		Nitrite		Nitric Oxide		Nitrous Oxide		Nitrogen Gas

Soils don't have to be completely saturated only some of the pores

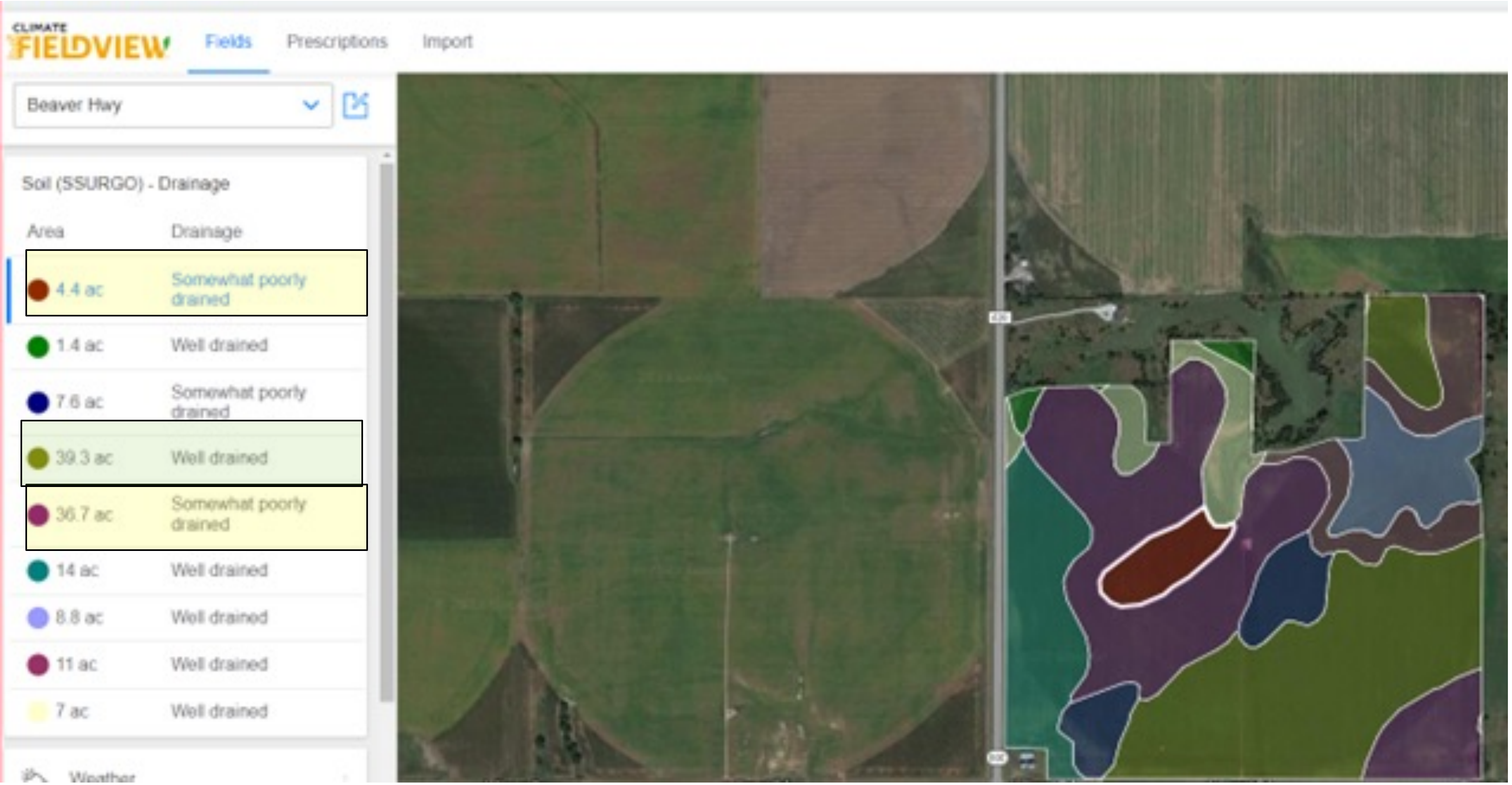


Nitrogen Loss Risk

High Risk

Low Risk

High Risk



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What is the OODA Loop

Observe
- Gather information quickly
- Collect internal and external data

Orient
- Make sense of information
- Spot errors in thinking
- Orient to take advantage of these gaps

Decide
- Decide best course of action

Act
- Implement your decision
- Implement fully or test hypothesis

The 8 Steps

Observe

- **Clarify the problem**
- **Break down the problem and identify performance gaps**

Orient

- **Set improvement target**
- **Determine root causes**

Decide

- **Develop Strategy**

Act

- **Execute strategy**
- **Confirm results and process**
- **Standardize successful processes**

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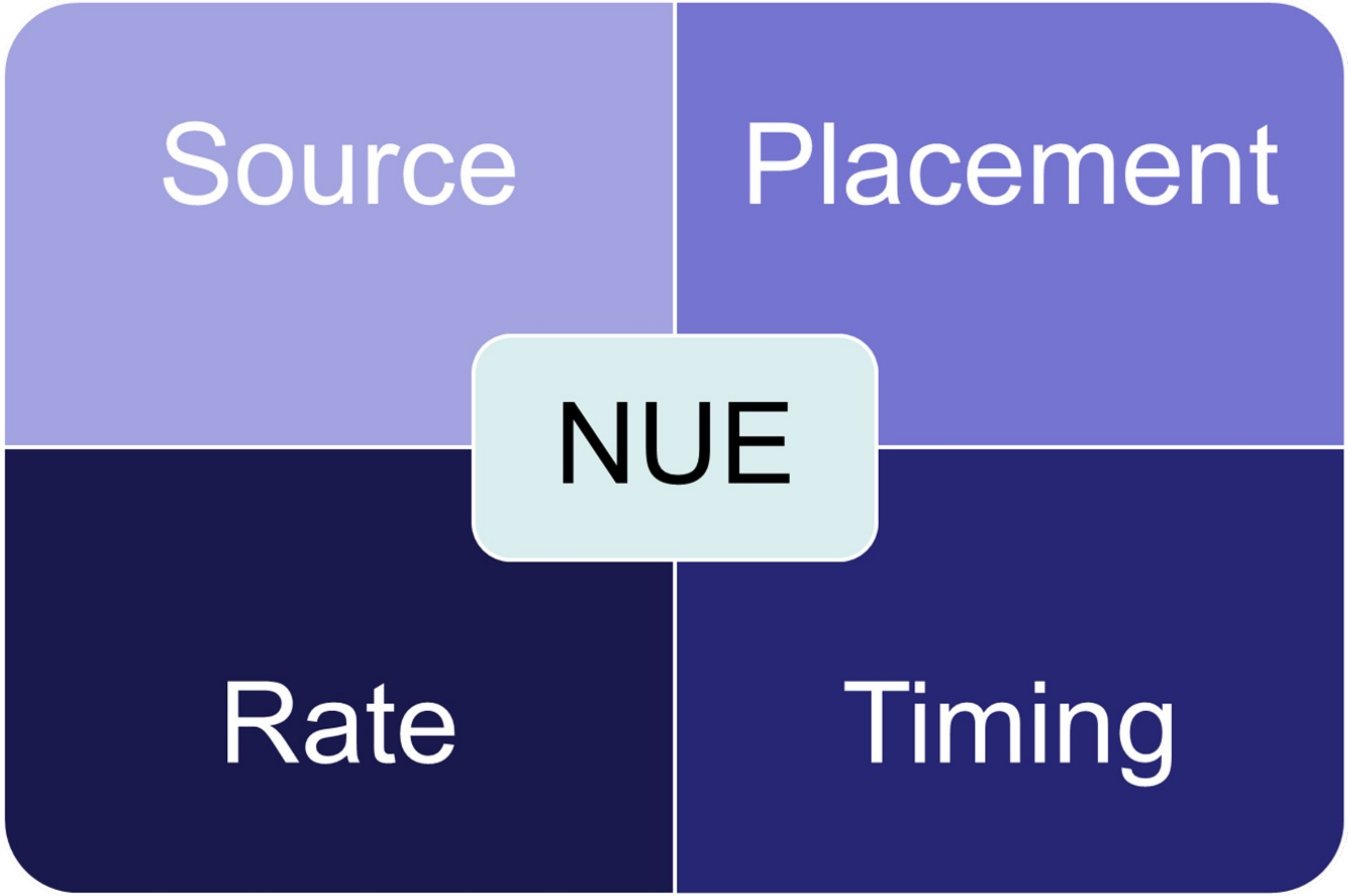

Source
Placement
NUE
Rate
Timing

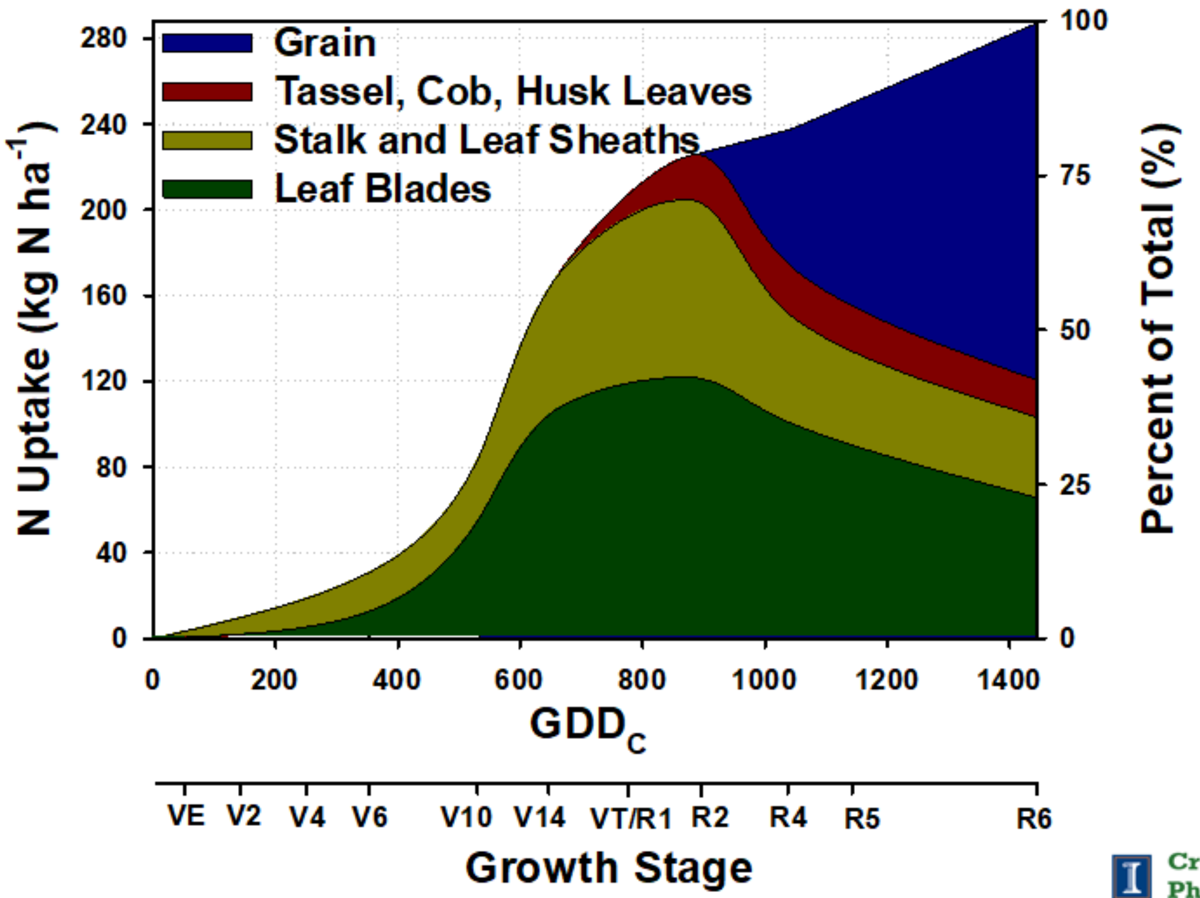
Source

- Highly driven by local availability and economics
- Generally speaking a unit of N is a unit of N
- Each source has its own advantages and disadvantages
  - The key is leveraging them correctly
- NUE can be improved regardless of Source

Placement

- Less Critical than other nutrients due to Nitrogen’s Mobility
- Eventually Placement becomes the “Next” change
- Requires equipment replacement
- NUE can be improved regardless of Placement

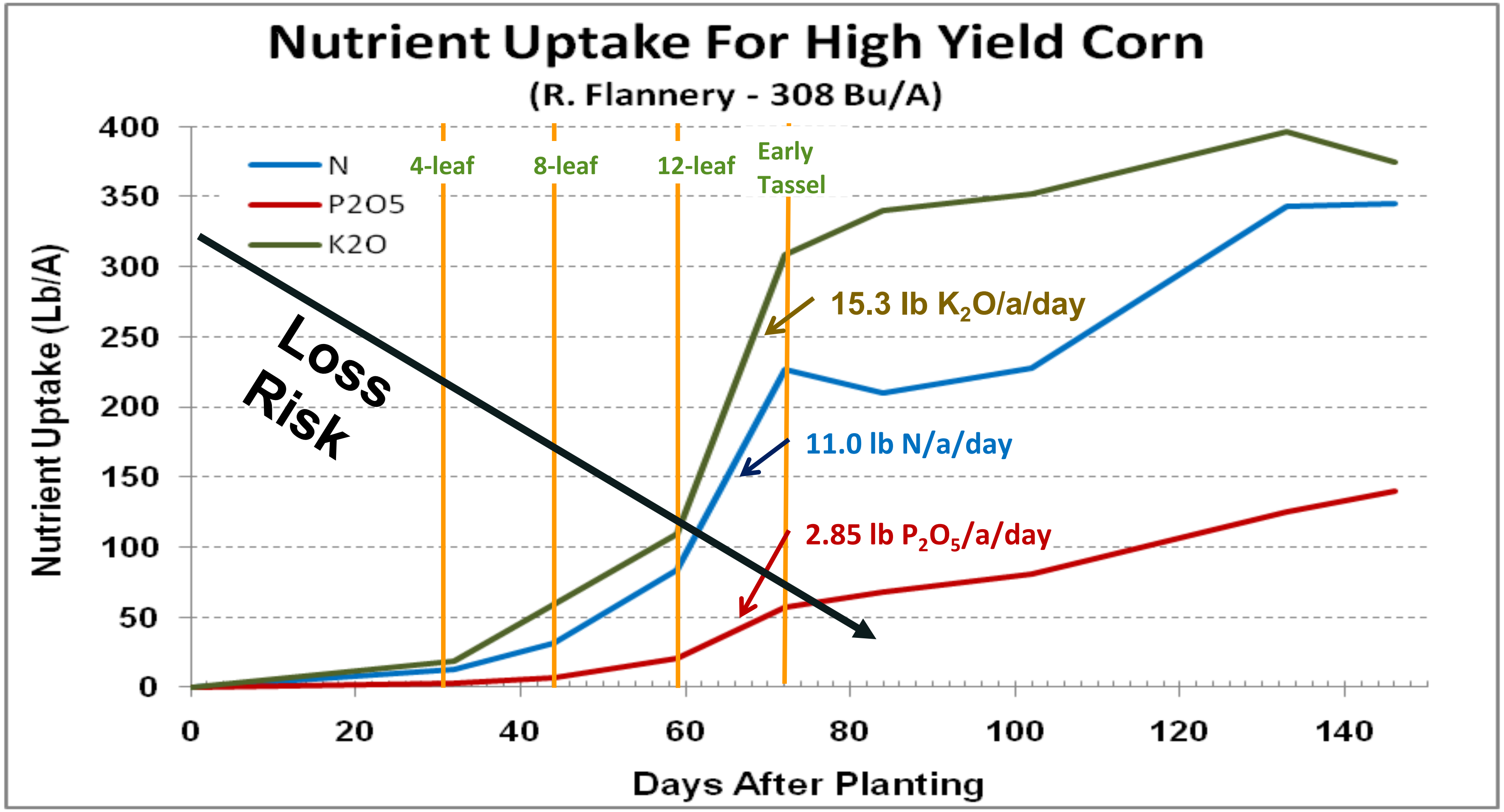
Timing



6 hybrids representing transgenic insect protection grown in Champaign and DeKalb, IL in 2010 with yields of 220-240 bu/ac

Crop Physiology

Timing



Nutrient Uptake For High Yield Corn
(R. Flannery - 308 Bu/A)
Nutrient Uptake (Lb/A)
Days After Planting
N
P2O5
K2O
4-leaf
8-leaf
12-leaf
Early Tassel
Loss Risk
15.3 lb K2O/a/day
11.0 lb N/a/day
2.85 lb P2O5/a/day
0
50
100
150
200
250
300
350
400
0
20
40
60
80
100
120
140

Timing

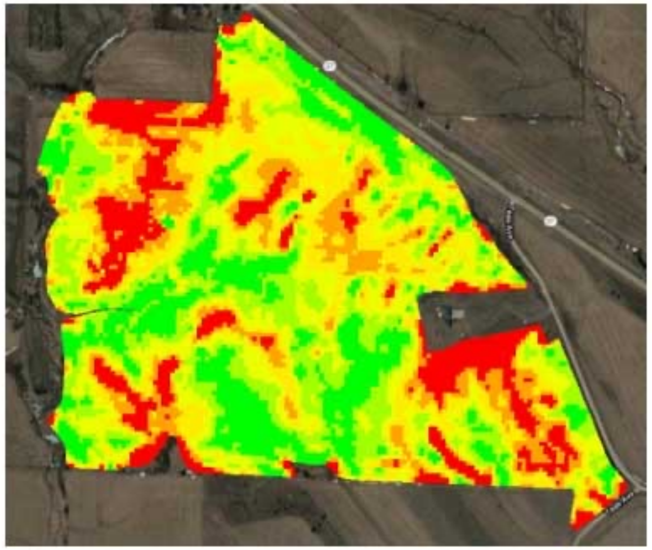
- Largest risk is Large pools of N applied long before uptake
- Timing allows us to match the “Sink-Source”(Supply-Demand) relationship
- Timing strategies like Split applications also allow for “real-time” yield goal adjustments
- Changes in timing do pose their own set of risk

Rate

- Optimum Rate is dynamic so we need to think in “Optimum Range”
- Optimum Rate maximizes the utilization of ALL Nitrogen Sources
- Rate adjustments can be made when there are changes to timing using multiple tools
- Improvements will be small 5-7%

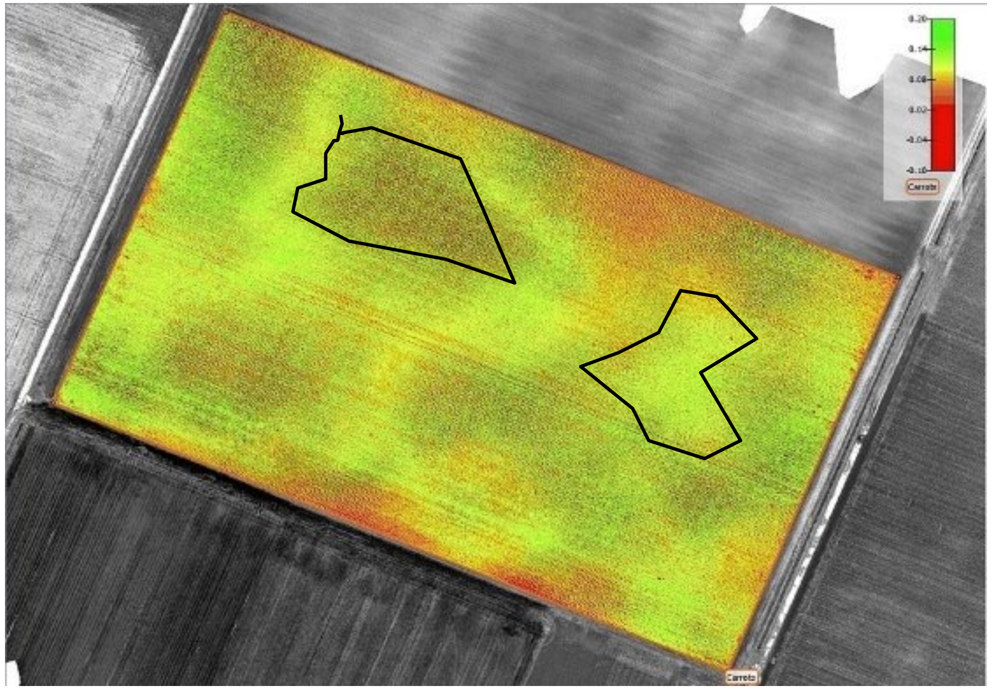
Rate

- VRN helps us match Right rate to the Right Placement
- VRN prescriptions can be written using single layers of data like Soil type all the way to using complex layering of data to create management zones
- Management Zones May contain data from
  - Normalized Yield Maps
  - Soil Type, drainage and Elevation
  - Historical in-season Imagery
- The Key is to do what makes sense to you



Rate

- In-season Imagery allows us to make changes in final Nitrogen applications based on the current status of the crop.
- NDRE is becoming more commonly used to estimate the Nitrogen status of the plant.
- Imagery in conjunction with Zone based tissue and soil samples creates a complete picture to determine the best rate.
- Future technologies will enable application equipment to do this in real-time.



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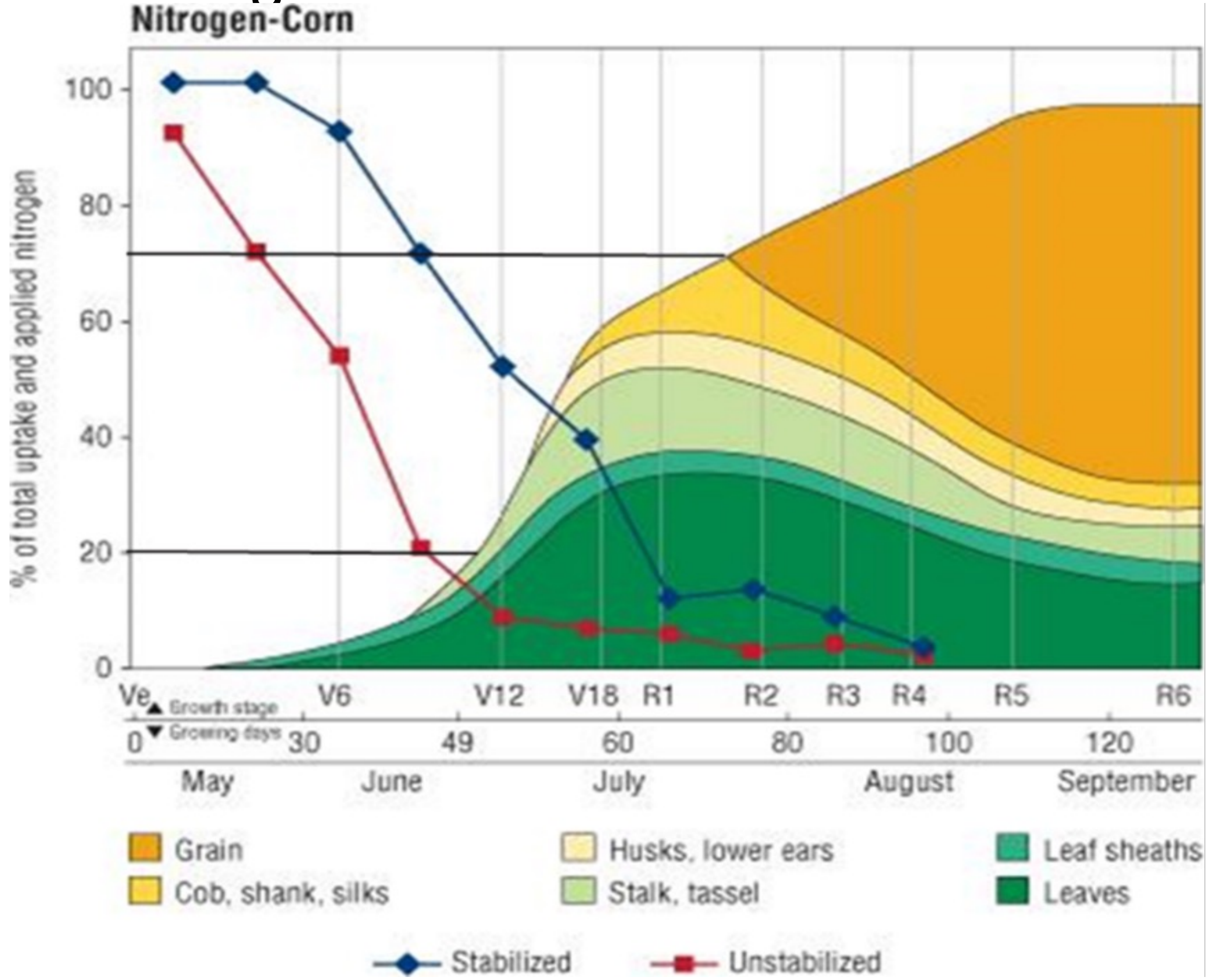
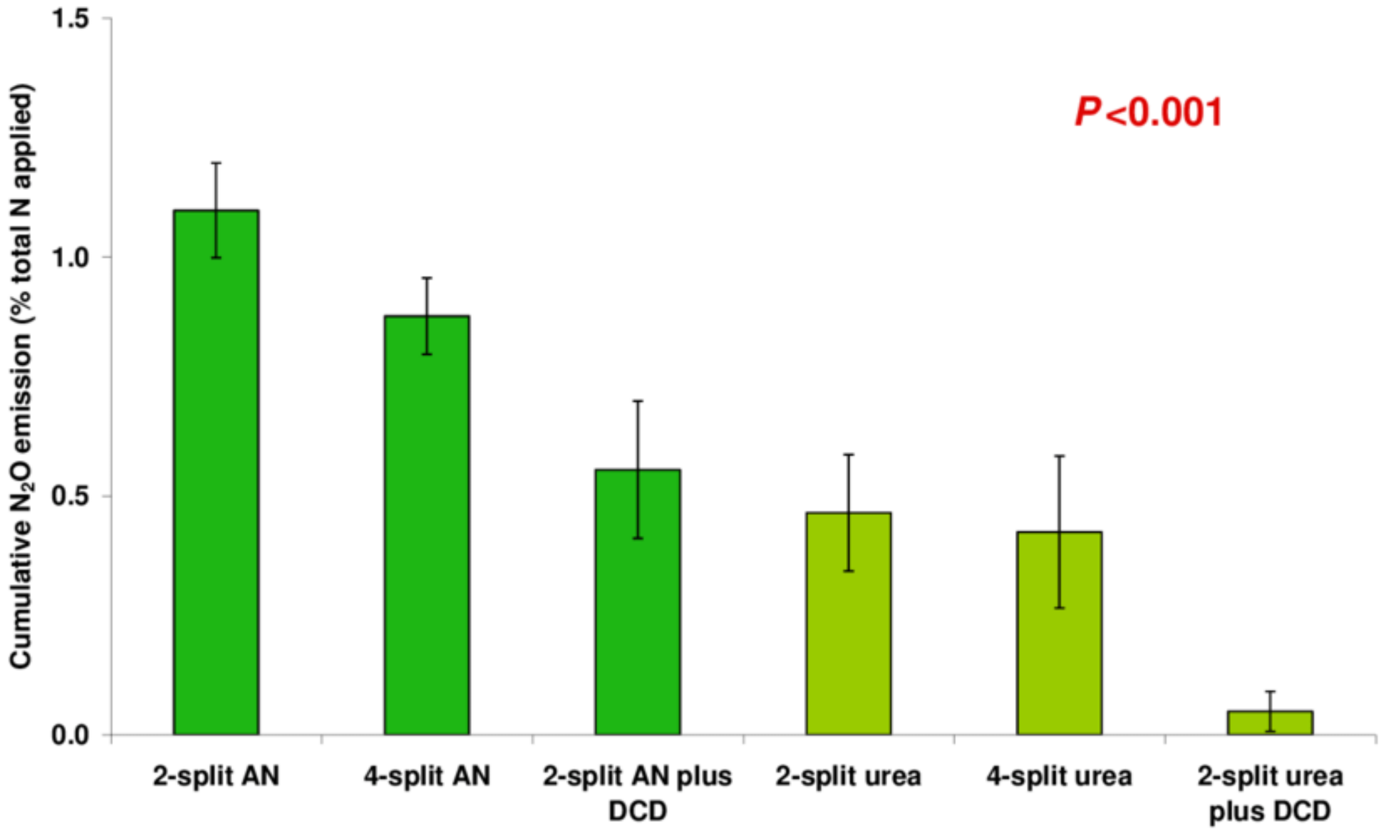
Weather is unpredictable and soil types may vary within a small area. Up 50% your applied nitrogen is at risk of being lost through volatilization, leaching and denitrification.

Nitrogen Stabilizers and nitrification



Nitrogen Stabilizers and Nitrous Oxide Reduction



https://www.researchgate.net/figure/Annual-nitrous-oxide-N2O-emission-following-ammonium-nitrate-AN-and-urea-fertiliser_fig1_284727942

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NUE Metrics

NUE Term	Calculation	Reported Example
PFP-Partial Factor Productivity of applied nutrient	Y/F	Unit of Yield per unit of Nutrient
AE-Agronomic Efficiency of applied nutrient	$(Y-Y_0)/F$	Unit of Incremental Yield per unit of nutrient
PNB-Partial Nutrient Balance (Removal to use Ratio)	U_H/F	0 To greater than 1 Depends on native soil fertility a maintenance objectives
RE- Apparent Crop Recovery Efficiency of applied Nutrient	$(U-U_0)/F$	0.1-0.9 scale dependent on Nutrient

F-amount of Nutrient Applied
Y-yield of harvested portion of crop with applied nutrient or treatment
Y_O- yield of control with NO applied nutrient or treatment
U_H-nutrient content of harvested portion of crop
U-total nutrient uptake in the aboveground crop biomass with nutrient or treatment applied
U_O total nutrient uptake in the aboveground crop biomass with NO nutrient or treatment applied

Thank You!