NITROGEN USE EFFICIENCY: AGRONOMIC PERSPECTIVE

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Improving NUE

- What are we improving?
- Two types of NUE
  - The Scavenger
  - The Converter
- What is the goal?
An Understanding of Soil N

- The importance of understanding N in the soil helps us understand why NUE is such a loftily goal that has to include both
- Genetics
- Agronomics
N-Cycle

- OM
- 2 OM Processes
- 2 N Processes
- 3 Sinks
- 4 losses
- 5 additions
Organic Matter

- Central point of the Nitrogen Cycle
- In an acre furrow slice 1000 lbs N per 1% OM
- A continuous flow of N into and out of OM.
Organic Matter Processes

- Immobilization
  - $\text{NO}_3$ and $\text{NH}_4$ tied up into OM

- Mineralization
  - OM decomposed into $\text{NO}_3$ and $\text{NH}_4$

- High Carbon (straw) = Immobilization
- Low Nitrogen (alfalfa) = Mineralization
Nitrogen Processes

- **Amminization and Ammonification**
  - OM converted to $\text{NH}_4$
- **Nitrification**
  - $\text{NH}_4$ converter to $\text{NO}_3$
- **Ammonium + charge and Immobile**
- **Nitrate – charge and mobile**
Nitrogen Sinks

- Large Amounts of Nitrogen located in these pools.
  - Atmosphere: 78% N in the form of the diatomic gas $\text{N}_2$
  - Nitrate Pool
  - Microbial Sink
15.40 kg/ha
\[ \text{N}_2 \text{O}, \text{NO}, \text{N}_2 \]

10.80 kg/ha
\[ \text{PLANT AMINO ACIDS LOSS} \]

0.50 kg/ha
\[ \text{AMMONIA VOLATILIZATION} \]

0-40 kg/ha
\[ \text{LEACHING} \]

15.40 kg/ha
\[ \text{INDUSTRIAL FIXATION} \]

HABER BOSCH (1200°C, 500 atm)
\[ 3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3 \]

10.80 kg/ha
\[ \text{PLANT AND ANIMAL RESIDUES} \]

MATERIALS WITH N CONTENT > 1.5% (COW MANURE)
MATERIALS WITH N CONTENT < 1.5% (OW/HEAT STRAW)

0-50 kg/ha
\[ \text{AMMONIFICATION} \]

\[ \text{R-OH} + \text{ENERGY} + 2\text{NH}_3 \]

\[ \text{Heterotrophic Bacteria} (pH 6.0) \]
\[ \text{Fungi} (pH 8.0) \]

\[ \text{IMMOBILIZATION} \]

\[ \text{AMINIZATION} \]

\[ \text{ORGANIC MATTER} \]

\[ \text{NH}_3 \rightarrow \text{NH}_2\text{OH} \rightarrow \text{NH}_2\text{O} \rightarrow \text{NH}_3 \]

\[ \text{MICROBIAL PLANT SINK} \]

\[ \text{MINERALIZATION + NITRIFICATION} \]

\[ \text{NITRIFICATION} \]

\[ 2\text{NO}_3^- + \text{H}_2\text{O} + 4\text{H}^+ \]

\[ \text{NITRIFIER} + \text{O}_2 \]

\[ 2\text{NO}_2^- + \text{H}_2\text{O} + 4\text{H}^+ \]

Oxidation States:
\[ \text{NH}_2\text{NH}_2 \text{AMMONIA} -3 \]
\[ \text{NH}_3\text{+ AMMONIUM} -3 \]
\[ \text{N}_2 \text{DIATOMIC N} 0 \]
\[ \text{NO NITRIC OXIDE} 2 \]
\[ \text{NO}_2 \text{NITRITE} 3 \]
\[ \text{NO}_3 \text{NITRATE} 5 \]

\[ \text{DENITRIFICATION} \]

\[ \text{LEACHING VOLATILIZATION NITRIFICATION} \]

\[ \text{TEMP 50°} \]

\[ 0.40 \text{kg/ha} \]

ADDITIONS

\[ \text{OXIDATION REACTIONS} \]

LOSES

\[ \text{REDUCTION REACTIONS} \]

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4 Losses

- Leaching
  - $\text{NO}_3$ – follows water flow.

- Ammonia Volatilization
  - $\text{NH}_4$ at a pH $>7$ H is stripped off and $\text{NH}_3$ (gas) formed.

- Denitrification
  - $\text{NO}_3$ in waterlogged soil. Microbes strip O off

- Plant Loss
  - $\text{NO}_3$ and $\text{NH}_4$ converted to $\text{NH}_3$ in plant, in stress $\text{NH}_3$ gassed off.
pH and Temp are Drivers
Additions

- Lightning and Rainfall
- Biological N Fixation
- Decomposition
- Industrial Fixation
- Fertilization
Remember Organic Matter

- Organic Matter is the Driver
- Annual N need is determined by Mineralization and Immobilization
- Environment, temp and rainfall, drives Mineralization and Immobilization
Nitrogen Tradition?

We Solve your problems with a **Big Stick!!**
N Rate

- Stanford Eq.
  - JEQ Vol 2 No 2 1973 pgs 159-166
- \[ Nrate = \frac{(\text{Nupt} - \text{Nsoil})}{\text{Efficiency}} \]
- N rate from Three Simple numbers
- Nitrogen Uptake by plant
- Nitrogen Supplied by Soil
- Efficiency of Fertilizer
From the viewpoint of an Agronomist.

We have the data.

We have LOTS of data.

Are we using it effectively?

Or just looking the highest yields and N conc.
NUE plants –

- The Scavengers
  - Landraces
  - Poor yielders with good environment
  - Best yielders in limited environment
  - Rooting system…..

- Converters
  - Efficient internal use
  - Best quality in limited environment
NUE wheat, My Ideal

- For the Southern Great Plains
- A plant that can scavenge and converts N to grain well of course.
- Those alone miss the boat.
- N Responder
How to find a Responder

- The identification of a NUE can not be made without multiple N rates.
- Low rate, Mid Rate, Opt
- The least important rate is the optimum N rate.
Factors

- Isolate the highest yielding cultivars within the zero N and mod N.
- Isolate the greatest responders
  - Relative to Check. Mod/check.
- Incorporating Response will likely negate some of the Scavengers.