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## *SOIL NITROGEN: The fate of soil Nitrogen and tools for optimizing plant uptake*

Soil Nitrogen (N) comes in many forms and must be carefully managed to optimize plant uptake. For simplicity, the following analogy is provided to compare a combustion engine to soil-N:

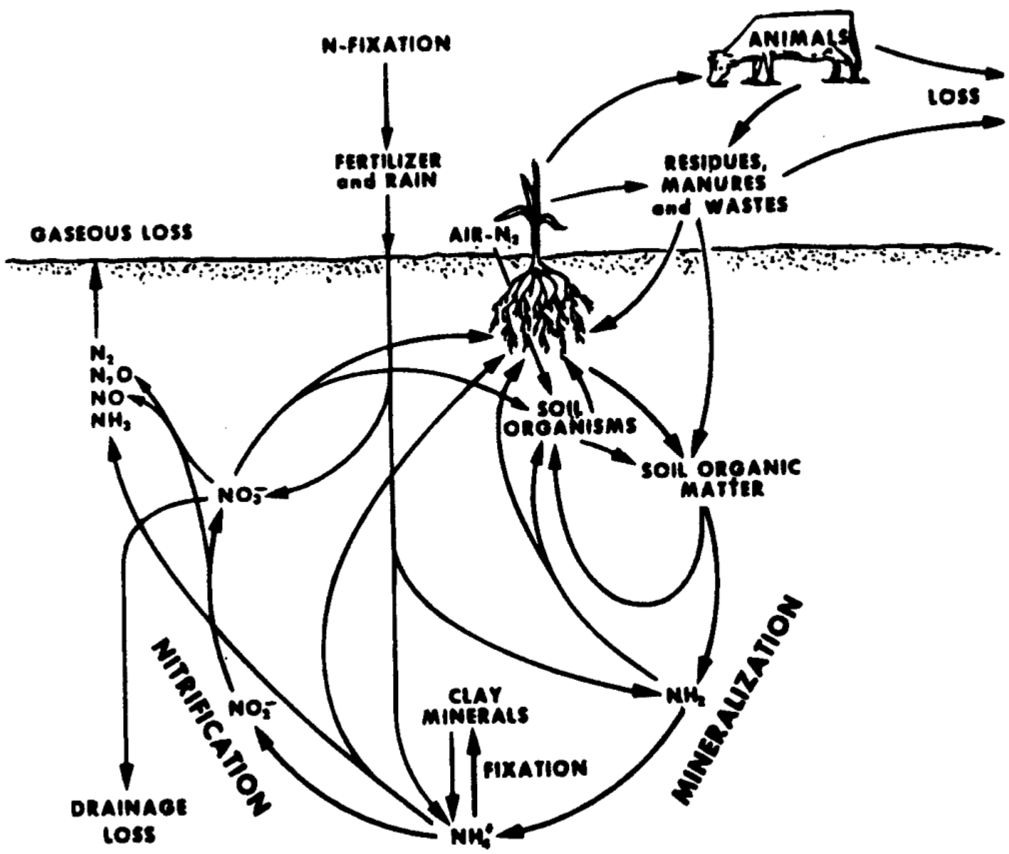
- **Nitrate (NO3)-N: Combustion chamber**: Nitrate-N to a plant is vaporized gasoline to a combustion engine. It is ready and available for the plant to metabolize as an engine is ready for a spark to generate an explosion for energy. Nitrate can be lost by denitrification, leaching, or absorption by surface plant matter and microbes as decomposition occurs. For sandy textured soils, the most common cause of soil Nitrate-N loss is by movement out of the root zone with soil solution, or leaching by rainfall.
- **Ammonium (NH4)-N: Fuel line**: Ammonium-N to a plant is gasoline in the fuel line for an engine. Ammonium-N can be in the combustion chamber but is more often in the fuel line for sandy textured soils. Ammonium-N is plant available, but is often converted to Nitrate-N by nitrification before the plant utilizes it. It is important to evaluate NH4-N in the soil if Ammonia based fertilizers are used or organic sources such as manure are managed for plant uptake.
- **Organic-N: Gas tank**: Organic-N to a plant is the gas tank to an engine. Organic nitrogen is not plant available but can be mineralized to NO3 or NH4, which is plant available. Organic-N is found in the soil organic matter, the breakdown of plant matter and organic sources of fertilizer such as manure. AgroLab's manure report will provide a breakdown of organic-N and the expected 1st year availability of N.
- **Total N in plant matter: Engine horse power**: Total Nitrogen in the plant is the result of adequate soil-Nitrogen as engine horse power is the result of a well run engine. Soil Nitrogen management can be evaluated by analyzing the plant tissue for total nitrogen. The plant-nitrogen is in complex forms, such as proteins and sugars, so the sample is combusted to measure the total nitrogen.

Six key biochemical processes make up an interlocked system known as the nitrogen cycle. These processes are:

Fixation
Immobilization
Ammonification
Nitrification
Denitrification
Leaching

Figure 1 shows the main portions of the nitrogen cycle. Additions to the system are through commercial fertilizers, crop residues, animal manures, and ammonium and nitrate salts brought down by rain. Certain microorganisms fix atmospheric N. Depletion is due to crop removal, drainage, erosion, and gaseous losses. Most of the N additions go through several reactions before removal can occur.

**Figure 1: The Nitrogen Cycle.**




Soil nitrogen derives from fertilizer and animal manure, or organic sources. Both sources undergo the same reactions that are involved in the biochemical releases from plant and animal residues. Fertilizer N will be in one or more of three forms:

a. nitrate
b. ammonia
c. urea

Urea-N ($CO(NH_2)$) is subject to ammonification, nitrification and utilization by microbes and plants. Ammonium fertilizers can be oxidized to nitrates, fixed by clay particles, or absorbed by plants and microbes

Soil nitrogen (N) is present in one of three major forms:

1) Organic - associated with soil organic matter or humus
2) Ammonium N fixed by certain clay minerals
3) Inorganic ammonium and soluble nitrate

### ***FIXATION***

Fixation of ammonium can occur through clay minerals or by organic matter. The negative charge of clay minerals attracts and traps the ammonium cation, making it relatively unavailable to plants or microbes. The addition of fertilizers containing free ammonia can react with soil organic matter to form compounds that resist decomposition, in a sense "fixing" the ammonia. Legume bacteria, Rhizobium, fix atmospheric nitrogen. Since the legume plants are able to use the nitrogen fixed by these bacteria, the relationship is known as symbiotic. These bacteria take free N from the soil air and synthesize it into plant useable forms. It is likely that N compounds produced within the bacterial cells are diffused out the cell wall and absorbed by the host plant.

### ***IMMOBILIZATION***

When fresh plant materials or crop residues are added to the soil, microorganisms begin to decompose this material. Microbial population increases soon after the addition of the fresh plant residue. If the plant material has a carbon:nitrogen (C:N) ratio greater than 25, the microbial population will use available soil nitrogen to decompose the residue. This process is referred to as immobilization of nitrogen. On the other hand, if the C:N ratio of the fresh plant material is less than 25, the microbial population will release additional available nitrogen.

### ***SOIL-N ANALYSIS***

The typical soil-N analyses include Nitrate-N and Ammonium-N. The analysis will provide a current availability of soil nitrogen. If multiple nitrogen applications occur during high demand nitrogen uptake, soil N analysis is the most accurate method to manage nitrogen. Otherwise, a current soil nitrogen analysis and other planning tools or calculation are typically used. Fall wheat soil nitrogen tests and corn pre-sidedress nitrogen tests are typical for optimizing plant demand. Soil N is reported as parts per million (ppm) and can be calculated to pounds per acre. The soil depth must be consistent and should represent the root zone for an accurate assessment. The calculation is (soil depth x .3 x ppm) = lbs/A. Should a 12 inch soil N analysis report 15ppm Nitrate-N and 10 ppm Ammonium-N, 12 x .3 x 15ppm = 54 lbs/A of Nitrate-N + 12 x .3 x 10ppm = 36 lbs/A of Ammonium-N; or a total of 90 lbs/A of soil-N. Note: the PSNT only accounts for soil nitrate-N when predicting total soil-N.

### ***Pre-Sidedress Nitrate Test (PSNT)***

A PSNT test is nothing more than a soil nitrate-N test and a calculation of the expected nitrate-N from mineralization and NH4 nitrification. The PSNT consist of 2 components:

1) The soil nitrate test of a representative area with a soil depth of 12 inches. The 12 inch sample is designed to account for the corn root zone and calculations are assuming a 12 inch sample.
2) A calculation of the expected nitrogen release from manure or other organic sources based on the amount of Nitrate-N found during sampling. For example: if a 12 inche PSNT test measures 25ppm, there is currently 90 lbs/A of Nitrate-N available in the soil and another 40-60 lbs/A is expected to mineralize as soil temperature increases. It is important to evaluate the amount of manure applied and the organic-N value when making a sidedress application decisions. The PSNT is a tool and should be one of several considerations when making nitrogen application decisions.

The following guideline is provided to interpret Soil nitrate tests used for PSNT calculations:

| YLD GOAL | PSNT (ppm NO3-N) | U of DE N REC | U of MD N REC | **AgroLab Gross N REC** |
|---|---|---|---|---|
| 125 | 5 | 125 | 40-80 | **130** |
| 125 | 10 | 125 | 40-80 | **120** |
| 125 | 15 | 95 | 40-80 | **96** |
| 125 | 20 | 70 | 40-80 | **62** |
| 125 | 25 | 0 | 0 | **24** |
| 125 | 30 | 0 | 0 | **0** |
| 150 | 5 | 150 | 40-80 | **156** |
| 150 | 10 | 150 | 40-80 | **144** |
| 150 | 15 | 115 | 40-80 | **119** |
| 150 | 20 | 85 | 40-80 | **83** |
| 150 | 25 | 60 | 0 | **44** |
| 150 | 30 | 0 | 0 | **5** |
| 175 | 5 | 175 | 40-80 | **180** |
| 175 | 10 | 175 | 40-80 | **167** |
| 175 | 15 | 135 | 40-80 | **140** |
| 175 | 20 | 100 | 40-80 | **103** |
| 175 | 25 | 75 | 0 | **62** |
| 175 | 30 | 0 | 0 | **21** |
| 200 | 5 | 200 | 40-80 | **204** |
| 200 | 10 | 200 | 40-80 | **189** |
| 200 | 15 | 150 | 40-80 | **160** |
| 200 | 20 | 115 | 40-80 | **122** |
| 200 | 25 | 85 | 0 | **79** |
| 200 | 30 | 50 | 0 | **37** |
| 200 | 35 | | | **0** |
| 225 | 5 | 225 | 40-80 | **228** |
| 225 | 10 | 225 | 40-80 | **211** |
| 225 | 15 | 170 | 40-80 | **181** |
| 225 | 20 | 140 | 40-80 | **141** |
| 225 | 25 | 100 | 0 | **97** |
| 225 | 30 | 50 | 0 | **53** |
| 225 | 35 | | | **15** |
| 225 | 40 | | | **0** |
| | -**Note: Subtract in-row starter N from Gross N recommendation;**<br>-**Note: For Yld Goals greater than 250, soil N should be tested prior to spoon feeding Nitrogen Fertilizer. Nitrogen uptake continues until black layer.** | | | |

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