FFF Review

Effective Nitrogen Management

N-use efficiency/environmental satety hinge on how well this mobile nutrient is managed.

How essential is nitrogen to plant growth? A corn crop will take up to 215 lbs of N in a growing season. Soybeans 315 lbs. Alfalfa as high as 450 lbs. Clearly, it is a critical component. N is a part of every living cell. Plants require large amounts of it for normal growth. How well it is managed in a farm operation will determine whether or not a crop is successful.

In this article, we will look at the nature of nitrogen and how it behaves. Understanding nitrogen and how it works goes hand in hand with good N management.

Versatile

Nitrogen plays many roles in promoting plant growth.

Yield booster. Plants take up most of their N as the ammonium (NH_4^+) or nitrate (NO_3^-) ion. Some direct absorption of urea can occur through the leaves, and small amounts of N are obtained from materials such as water soluble amino acids. Except for rice, most agronomic crops take up most of their N as nitrate, which is the most common source found in soils. However, research has shown that crops use substantial amounts of NH_4 if it is present in soil. Certain corn hybrids have a high requirement for NH_4^+-N that helps boost yields. Wheat has also shown the benefits of NH_4^+ nutrition. One reason for the higher yields is that NO_3^- reduction in the plant requires energy (NO_3^- is reduced to NH_4^+, then converted to amino acids inside the plant). This energy is supplied by carbohydrates, which otherwise could be used in grain formation.

Enhances photosynthesis. Nitrogen is necessary for chlorophyll synthesis and, as a part of the chlorophyll molecule, is involved in photosynthesis. Green pigment in chlorophyll absorbs light energy needed to initiate photosynthesis. Chlorophyll helps convert carbon, hydrogen, and oxygen to simple sugars. These sugars and their conversion products stimulate most plant growth increase. Lack of N and chlorophyll means the crop will not use sunlight as an energy source to carry on essential functions.

Increases protein. Nitrogen is also a component of vitamins and energy systems in the plant. It is an essential component of amino acids, which form proteins. Thus, N is directly responsible for increasing protein content.

Deficiency signs

We've just seen what nitrogen can do. Now we'll look at what happens when it is lacking in plants.

Yellowing. Adequate N produces a dark green color in the leaves by a high concentration of chlorophyll. Nitrogen deficiency results in chlorosis (yellowing) of the leaves because of declining chlorophyll. This yellowing starts first on oldest leaves, then develops on younger ones as the deficiency becomes more severe.

Stunting. Slow growth and stunted plants are indications of N deficiency.

Less tillering. Small grains and other grass-type plants tiller less when N is in short supply.

Fewer leaves. Inadequate N leads to low protein in seed and plant vegetative parts. Deficient plants usually have fewer leaves.

Higher moisture. Corn supplied with insufficient N will have a higher moisture content than corn adequately fertilized with N.

Early maturity. Certain crops such as cotton may reach maturity earlier than plants with adequate N.

Water use efficiency

Anytime a missing nutrient increases plant yield when it is applied, water use efficiency is also increased. In a Minnesota study, for example, corn plants taking up the same amount of water showed yield increases of 66 bu/A after N rates applied at planting were doubled from 100 to 200 lbs/A. Applying the 200-lb/A rate through irrigation in eight 25-lb/A increments, added another 34 bu/A.

In a Colorado study, 150 lbs/A of N on corn gave a little over 2 bu/A more per inch of water under wet conditions and almost 2.75 bu/A more per inch of water under dry conditions.

Thus, applying optimum rates of N— not too much nor too little—has resulted in improved water use efficiency while minimizing potentially negative effects on the environment.

Nitrogen cycle

The amount of soil N in an available form is small. Most soil is tied up in organic form. Very little is found in the rocks and minerals from which soils were formed. Most all soil N originated in the earth's atmosphere

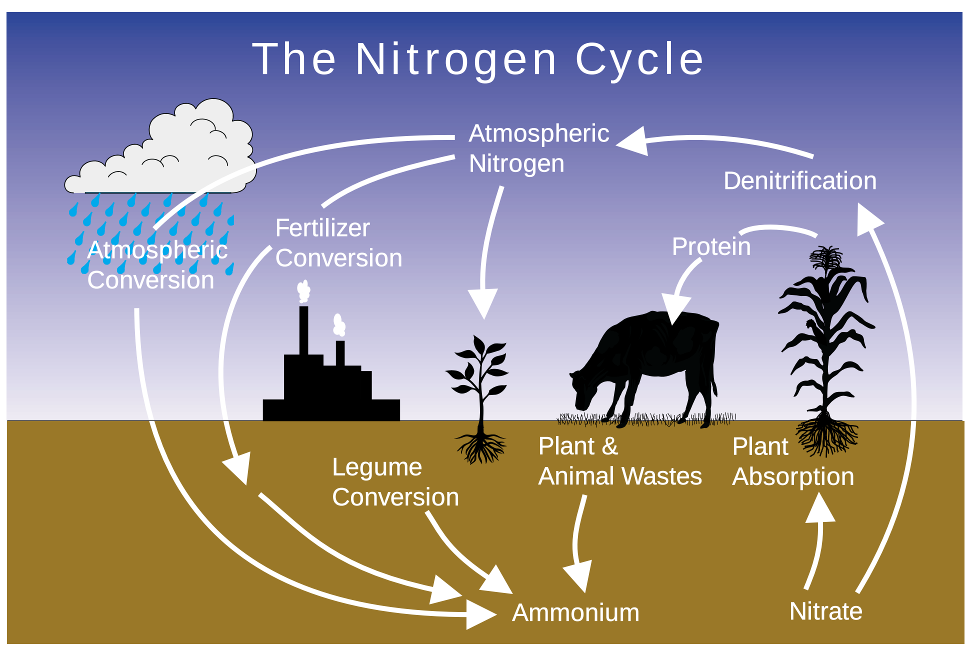

Figure 1. Diagram of nitrogen cycle

(Figure 1), which contains nearly an unlimited supply.

About 80 percent of the air we breathe is nitrogen (N_2). Each acre of the earth's surface is covered by about 37,000 tons of N, but this N_2 is an inert gas. It must be combined with other elements before plants can use it. N occurs in the soil in three major forms:

Organic N is part of soil organic matter and is unavailable to growing plant. Organic N may represent up to 98 percent of the total N in the soil.

Ammonium N (inorganic N) is often fixed by clay minerals and is slowly available to plants. It is held by soil particles and does not leach readily.

Ammonium and nitrate ions (inorganic N) or soluble compounds constitute the N form plants use. Nitrate ions may leach and move with soil water.

Conversion

Two biologically mediated processes affect the amount of plant-available N.

Mineralization. The process by which unavailable organic forms are converted to available forms is defined as mineralization. It occurs as microorganisms decompose organic materials for their energy supply.

As the organic matter is decomposed, the organisms use some of the energy released, plus part of the essential nutrients in the organic matter. When the organisms have used all the nutrients they need, the excess (such as N) is released into the soil for plant growth.

Immobilization. Nitrogen can also be converted from inorganic to organic forms. The process is called immobilization and is the reverse of mineralization. It occurs when crop residues high in carbon and low in N are incorporated into the soil.

Mineralization and immobilization occur simultaneously in soils. Whether the soil shifts toward an organic or inorganic N pool depends largely on the C/N ratio of the decomposing organic materials. When immobilization of soil N exceeds mineralization, there may be practically no N available for growing crops *unless* N fertilizers have been applied in a band near the roots.

As microorganisms vigorously decompose the new energy supply in these crop residues, they need N to build protein for their body tissues. Unless residues are relatively high in N, organisms take up inorganic N from the soil to get needed N. So the inorganic N in the soil is converted into organic N in microbial proteins, unavailable for plant growth. But much of this N is gradually returned to the available form as bacterial bodies decompose.

Destabilization

Under conditions favoring plant growth, much of the NH_4^+-N in soils will be converted to NO_3^--N by certain nitrifying bacteria. This process is called nitrification (Figure 2). The process is important because: 1) nitrate is readily available for use by crops and microorganisms, 2) nitrate is highly mobile in the soil and may leach, 3) nitrate can be lost through denitrification.

Denitrification (Figure 3) usually occurs in soils high in organic matter, under extended periods of waterlogged conditions (absence of oxygen) and as temperature rises.

Soil conditions that have the greatest influence on nitrification or denitrifica-tion are: pH, moisture, temperature, aeration, and plant residues.

Stabilization

An important part of fertilizer N management is to apply proper rates and sources, place the N for best use efficiency, and time applications when crop needs are greatest. Nitrification inhibitors and slow-release forms of N also help.

Nitrification inhibitors block the conversion of NH_4^+ to NO_3^- by deactivating nitrifying bacteria for varying periods of time, sometimes up to three months. Ample data are available showing that inhibitors increase yields, especially in sandy soils, under wet conditions, or where N has been applied in the fall or early spring.

Slow-release N is made by reacting urea with formaldehyde to form com-pounds only slightly water soluble. Its cost often prohibits use on field crops. ❑

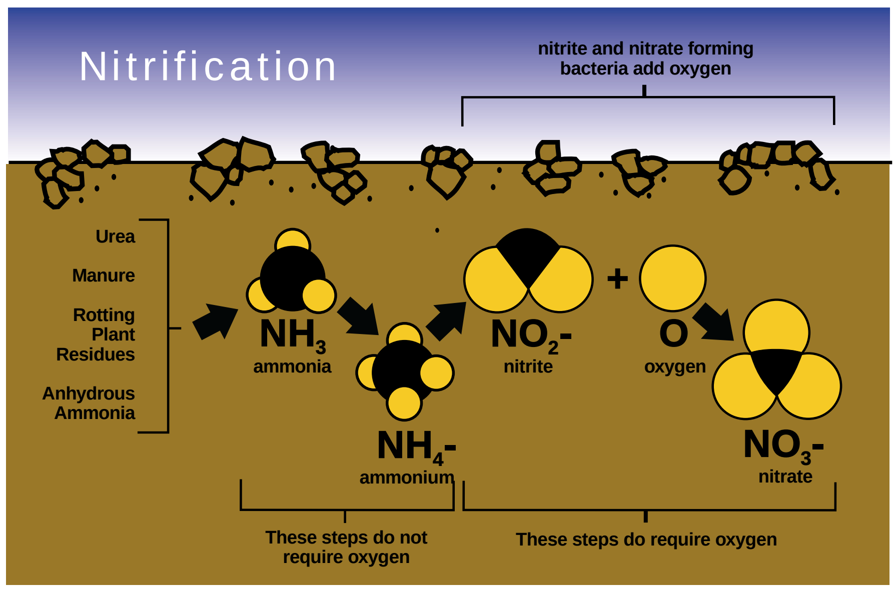

Figure 2. The process of nitrification

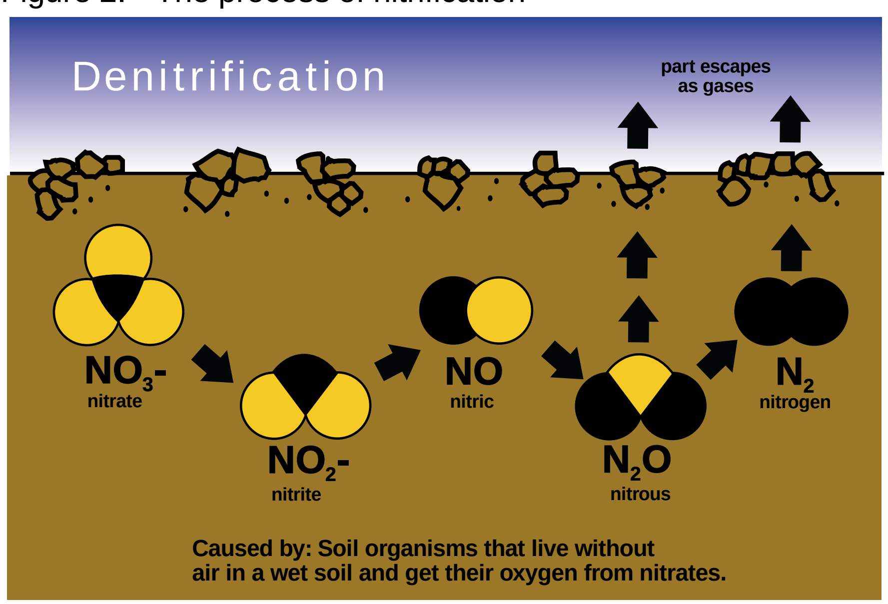

Figure 3. The process of denitrification