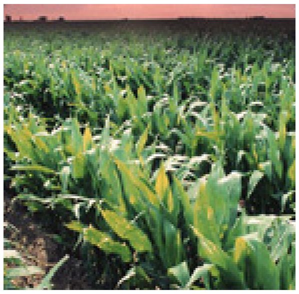
Nitrogen

Plants require N to grow roots, stems and leaves, and to reproduce. Nitrogen must be available continuously to feed the development of grains, fruits, nuts and vegetables essential to human nutrition. In a very real sense, N is necessary for all forms of plant and animal life. There is no substitute for it. Nitrogen is truly a superstar in food production.

Plants Have a Big Appetite for Nitrogen



The crops we cultivate for direct human consumption, as well as those grown to produce the beef, pork and poultry we eat, are heavy users of N. The following examples illustrate the massive demand for N which agricultural production must meet to provide adequate food to sustain an acceptable quality of life:

An average corn crop in North America will remove more than 6 billion pounds of N from our soils every year. That represents over 20 pounds for every man, woman and child!

Hay, grown to feed our livestock, removes 7.4 billion pounds of N from our meadows every year.

Wheat, which is the most commonly used small grain for human foods, such as breads and cereals, takes 2.4 billion pounds of N from our soils every year.

Fruits and vegetables are also big users of N. Bananas take up 400 pounds of N per acre, cocoa needs 416 pounds per acre and potatoes use nearly 300 pounds per acre. Sweet corn, oranges and bell peppers all take up more than 100 pounds of N per acre. Tomatoes, onions and pineapple take up 150 to 200 pounds.

Nitrogen Is Critical to Human Health

Nitrogen is a part of all proteins, animal and plant. That means it is vital to the human diet. Also, N is a component of RNA and DNA, the "blueprints" which pass genetic characteristics from one generation to the next. The very survival of humans, then, is dependent on the abundant presence of N in nature.

Nitrogen: Its Influence on Crop Health, Food Quality and Our Environment

Crop plants are marvelous food manufacturers, but they must have proper nutrition to fuel their food production factories. Otherwise, crop yields will be lower, the food produced will be of poor quality and low in nutritive value. Nitrogen is an important fuel in the food production chain.

An early sign of N deficiency in plants is the development of a pale yellowish-green color in the leaves. This symptom is the result of a slowdown in chlorophyll production. Nitrogen is a part of chlorophyll, so it is essential in its manufacture. Why is the production of chlorophyll so important? Because photosynthesis, the basic food production process in green plants, is dependent on the presence of chlorophyll. So, life can't proceed without N. That makes it a very important plant food.

Nitrogen is a "quality" nutrient. It is a part of the makeup of all plant and animal proteins. Therefore, the nutritive value of the food we eat is largely dependent on the availability of N for plant and animal growth.

Nitrogen helps protect our valuable water resources and increases our food supply. Healthy plants, adequately supplied with N, are better able to utilize available water from rainfall and soil moisture. A crop well fed with N can produce yields many times greater, on the same amount of water, than one starving for N. Also, a healthy, fast growing crop provides more ground cover to reduce the impact of rainfall and to slow runoff. This allows more water to soak into the ground, reducing erosion, increasing crop yield potential and protecting water quality.

How Does Nitrogen Behave in the Soil?

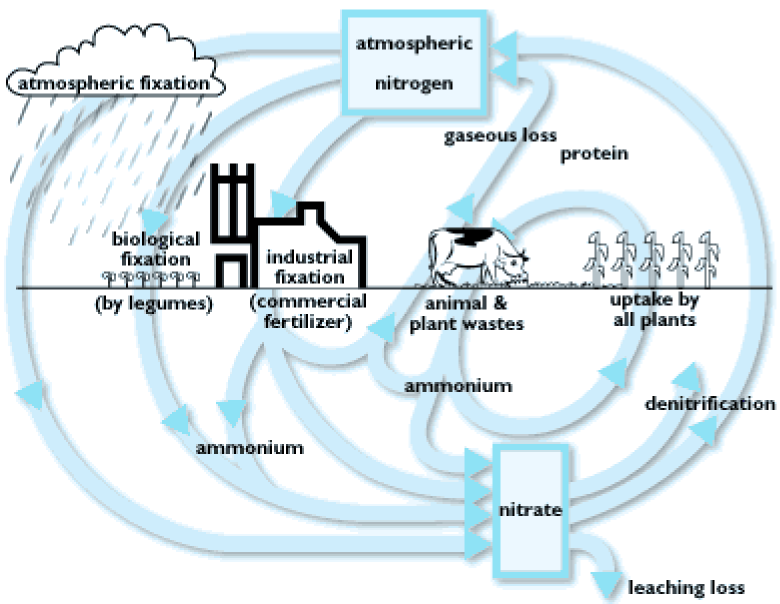
The only part of soil that supplies N to a crop plant is organic matter. None of the soil minerals contain N. Organic matter releases its N slowly. Release rate is controlled by such factors as soil temperature, soil moisture content and soil texture. In general, about 20 to 30 pounds per acre of N are released each year for each one percent organic matter in the soil. Not all of this N is available for crop growth because the rate of release might not be matched to uptake demands of the growing crop.

Since the N contribution to crop growth from the soil is dependent on the organic matter content of the soil in question, N management systems vary from area to area and are very site specific. Generalized recommendations regarding crop N requirements would result in poor N use efficiency and an increased danger of groundwater contamination.

As organic matter is broken down (mineralized) by soil microbes, N contained in its complex molecules is converted to more simple inorganic forms, ammonium and nitrate. Both the ammonium and nitrate forms of N are highly soluble in soil water and are readily available for plant uptake. The ammonium form is attracted to and held by soil particles, so it is not subject to movement down through the soil with water during periods of rainfall or irrigation. Nitrate, on the other hand, remains free and does move downward with soil water. This process is called "leaching" and can lead to nitrate accumulation in groundwater or loss of N by denitrification.

As soils are warmed by spring sunshine, the ammonium form of N in the soil, whether placed there in commercial fertilizer, manure, crop residues or released from organic matter, is subject to conversion to nitrate. This process is called “nitrification” and is carried out by certain soil microbes. Nitrification rate continues to speed up through spring and into the growing season. Most of the ammonium N not used by the crop is eventually converted to nitrate. The rate at which nitrification occurs is somewhat controllable, and holding the N in the ammonium form until the crop needs it can be helpful in reducing leaching potential.

The ammonium and nitrate forms of N are the only forms that can be used by plants. No matter what the N source, livestock manure, legumes, crop residues, organic matter or commercial fertilizer, the N content must be changed to one of these forms for plant use.



There is no net gain or loss of N in nature, as indicated in this illustration. Good management can help assure efficient use of N with minimum threat to the environment.

Where Do Plants Get Their Nitrogen?

From the Earth's Atmosphere.

The earth's atmosphere is nearly 80 percent N. There are about 75 million pounds of N in the atmosphere above each acre. This N, though in abundant supply, must be converted to a different form before plants can use it. The conversion can take place in the soil.

Some legume crops such as alfalfa, soybeans, garden peas and peanuts can convert atmospheric N to a form they can use. The process is called N fixation. It is carried out by certain groups of soil bacteria, and takes place in nodules that develop on legume roots. This kind of fixation is mutually beneficial to the crop and the bacteria and can account for significant quantities of available N being added to the soil. When non-legume crops such as corn or wheat are grown in rotation with legumes, they can benefit from some of the N from the legume that preceded them.

Legumes can convert from a few pounds to hundreds of pounds per acre of atmospheric N into a form crop plants can use. Some free living soil bacteria can also add usable N through fixation, but these amounts are quite limited.

In addition, some N is “fixed” each time there are thunderstorms. Electrical discharge (lightning) forms mineral N which enters the soil with precipitation and other atmospheric reactions.

From Soil Organic Matter

Productive soils in the US Corn Belt might contain as much as 3,000 pounds of N per acre. But most soil N is tied up in organic matter and becomes available to plants only when the organic matter is decomposed.

In colder climates, the organic matter decomposition rate is slow, and the amount of N available for crop use in a particular growing season is low. In warmer, more humid climates, soil organic matter levels are low because decomposition occurs rapidly, so levels don't build up. The N supplying power of those soils is also low.

From Animal Manures

Animal manures are another source of N. Where livestock are confined in large numbers, poultry buildings, dairies and feed lots, for example, the accumulation of manure is often significant. Although highly variable in N content, manure is a good source of plant food and can improve the physical condition of the soil when properly applied.

From Commercially Produced Fertilizer

It would seem that nature could easily provide the N requirements of plants. It could, if all N were available and in a form plants can use, but it's not. It is often not economical or practical to grow legumes in rotation with crops such as corn. Much livestock production is away from crop producing areas. Transportation of manure for any but short distances is prohibitively expensive. That's why commercially produced fertilizer is vital to food production. It provides what nature cannot, efficiently and economically.

Commercially produced N as a plant food had its beginnings following World War II. The industry developed rapidly in the 1950s and 1960s, and is a vital link in today's food production chain. Its base is the production of anhydrous ammonia, made by combining N from the atmosphere with hydrogen (H) from natural gas or other sources. Using ammonia, other N fertilizers are produced through a variety of processes.

Concerns for the environment have spotlighted commercially produced N use in the US in recent years. There is a misconception, promoted by some, that N use in production agriculture is increasing too rapidly, adding to the potential for groundwater pollution. In reality, N use has remained rather steady since the mid to late 1970s averaging 70-75 pounds per acre per year.

State laws require that N contents of commercially produced fertilizers be guaranteed by the seller. This protects the farmer and the environment. The farmer knows what he is buying and can shop for competitive prices. He also knows the exact rate per acre being applied and can match N rates to specific crop needs.

All commercial fertilizers contain their N in the ammonium and/or nitrate form or in a form that is quickly converted to the ammonium form once the fertilizer is applied to the soil. The N in animal manure, crop residues, cover crops or in legumes is in one of these two forms or converted to one of them before the crop can use it. The rate of conversion from these organic forms is less predictable because it is influenced by microbial activity and several soil and climatic conditions.

There are other materials that are also used for their N contents, but they are of little economic importance in crop production.

Choosing the correct N source should be based on several factors, including availability, price, crop being fertilized, timing of application, method of application, tillage system and others. But from a nutrient efficiency standpoint and as a potential groundwater problem, a pound of N is a pound of N, regardless of source, assuming that other management decisions are properly made for the chosen source.

Losses of Nitrogen from the Soil - How Does that Affect the Environment?

Soil N can be taken up and used by plants, tied up in decaying plant residues (organic matter), immobilized by reactions with some types of soil clays or lost in any of a number of ways.

Tremendous quantities of N are removed in the harvested portion of crops. Large amounts are lost annually from soils by erosion. Most soil N is present in organic matter in the surface layers, and that is the first part of the soil to be lost in both water and wind erosion.

Losses of soil N are natural processes governed by soil texture, amounts of rainfall or irrigation, amounts and types of plant residues returned to the soil and other conditions such as soil temperature. Regardless of how the N was originally added to the soil, bacterial actions eventually convert it to ammonium N and nitrate N.

If nitrate leaches below the soil levels where plant roots are using nutrients, the nitrate may eventually undergo nitrification or find its way into groundwater. Nitrate occurs naturally in groundwater, but high concentrations can result in a loss of nutrient N needed for crop production and become a potential health hazard.

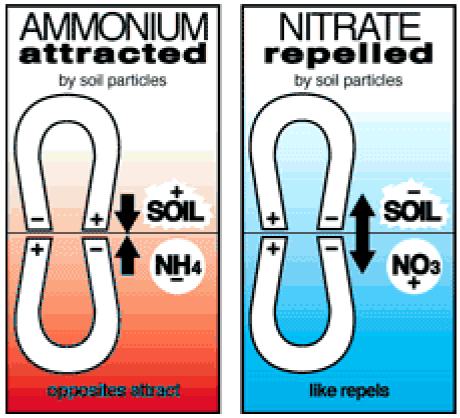
Another way N is lost from the soil is through the conversion of nitrate into inert, elemental N and other gases. Soil bacteria perform denitrification. Denitrification occurs when soil pores are saturated with water. Soil bacteria which decompose plant residues require oxygen. In the absence of adequate oxygen, forced out of the soil by excess water, the oxygen in nitrate is utilized by some bacteria with the N being released to the atmosphere. This is a significant mechanism of N loss from warm, wet soils and occurs regardless of the original N source.

From the Soil to the Atmosphere

Volatilization of ammonia gas can occasionally result in substantial N loss. This is particularly significant with animal wastes if they are applied to the soil surface without being mixed into the soil. Ammonia losses from N fertilizers are normally small. Where a potential loss exists, a source change or proper incorporation can eliminate the loss.

Controlling Nitrogen Losses from the Soil

Cultural practices can largely control N losses from agricultural soils. This is both economically and environmentally desirable. Reduced N losses mean more nutrient available for crops and lower nitrate levels in groundwater and streams.



Choosing the proper N rates for crops helps reduce the danger of unused nitrate leaching into water supplies. Excessive application of N increases farmers' costs, lowers profits and creates potential environmental hazards. On the other hand, too little N reduces yields and makes the entire system unprofitable. It can also lead to environmental damage because the production system breaks down, leaving unused N from fertilizer and the soil, for possible leaching.

Adequate supplies of phosphorus (P), potassium (K), sulfur (S),and other nutrients must also be available for highest N use efficiency to occur. Decisions on proper rates of N and other nutrients are site specific, requiring a correct yield goal, knowledge of nutrients available in the soil (soil test) and consideration of other best management practices (BMPs). These decisions are made by farmers in consultation with professional advisors and should not be subjected to generalized, legislated requirements.

Applying fertilizer N as close as possible to the time of actual crop use lowers the potential for nitrate leaching. Making multiple N applications has been recommended for many years by crop scientists and supply industries. It is widely practiced by farmers. Under some conditions, however, this may not be necessary because of low rainfall and little likelihood of leaching.

Certain compounds added to N fertilizers (N stabilizers or nitrification inhibitors) slow or delay the conversion of soil ammonium to nitrate or delay the conversion of urea to ammonia (enzyme inhibitor).

They can lower the potential for nitrate leaching. Eventually, however, the compounds themselves are broken down by soil bacteria and nitrification continues.

The agronomic BMPs used with soil and water conservation BMPs, terracing, filter strips, grass waterways, strip cropping and others, all increase N use efficiency. At the same time, they also reduce the potential for nitrate leaching, thus protecting the environment.

Summary

Nitrogen is essential to the growth and reproduction of all plants, human and animal life, an established scientific fact. Its use as a nutrient is critical to the very survival of mankind.

Both economic and environmental concerns should influence N management in production agriculture. A farmer must realize a fair profit to stay in business and provide a decent standard of living for a family. But it's also essential to recognize the environmental implications of a production system and management decisions.

One of the decisions the farmer must make is how to manage a crop N fertilization program. Is manure economically available for use? What is its analysis and how much can be applied and still maintain nutrient balance in the soil? Does the farm operation lend itself to rotations involving legumes to provide part of the N for grain crops? Is proper credit given to crop residues and soil organic matter? What about using a nitrification inhibitor? Should one consider growing a cover crop to protect land from erosion and to take up excess nitrate remaining in the soil after harvest of a grain crop? Matching commercial N sources, timing and rates to the operation?

There is scientific information available to answer all the above questions, to guide the farmer in management decisions regarding environmentally safe and economically sound use of N. From university research. From extension specialists and publications. From industry agronomists. From consultants, and others. The farmer does not have to guess.