# Animal, Plant & Soil Science

## D3-5

# Characteristics and Sources of Nitrogen

# Interest Approach

- A month or more before the lesson is to be taught, sow corn seeds in two pots containing an inert medium, such as sand, vermiculite, or perlite. Water one pot when needed with just water and the other with a soluble fertilizer. In time, the corn that isn't given fertilizer will show signs of nutrient deficiency. Display the two pots at the start of the lesson and ask the students why the plants look different.

# Objectives

- 1 Identify the forms of nitrogen and describe their characteristics.
- 2 Identify and describe the symptoms of nitrogen deficiency and nitrogen toxicity.
- 3 Describe the nitrogen cycle and explain how it influences the availability of nitrogen to plants.
- 4 Identify plants capable of nitrogen fixation and describe factors that influence nitrogen fixation.
- 5 Identify and describe natural and synthetic fertilizer sources of nitrogen.

# Terms

- ammonia volatilization
- autotrophs
- biogeochemical cycles
- denitrification
- fixed
- immobilization
- inoculation
- leach
- legumes
- mineralization
- nitrification
- nitrogen assimilation
- nitrogen cycle
- nitrogen fixation
- rhizobia

# What are the forms of nitrogen and the characteristics of each?

- I. Nitrogen is absorbed by plants in greater amounts than other fertilizer elements. It is essential in the production of proteins that contribute to vegetative growth. Nitrogen comes in many forms, including atmospheric nitrogen and nitrogen in organic compounds.

# What are the forms of nitrogen and the characteristics of each?

- A. Atmospheric nitrogen is gaseous nitrogen found in air.
- 1. The atmosphere consists of 75 to 80 percent nitrogen. However, most of this nitrogen is unavailable for plant use.
- 2. Legume plants are capable of absorbing atmospheric nitrogen.

# What are the forms of nitrogen and the characteristics of each?


- B. Organic matter is a major source of nitrogen in soil. About 99 percent of all the nitrogen in soil is found in organic matter.

- 1. Soil microorganisms break down large organic compounds. The byproducts include inorganic nitrogen ions in the forms of ammonium ($NH_4^+$) and nitrate ($NO_3^-$). These ions are available for plant growth.

# What are the forms of nitrogen and the characteristics of each?

- 2. Nitrogen from organic matter is released very slowly, and little or no nitrogen is released when soil temperatures drop below 32°F.
- 3. Whether it is applied as a fertilizer or whether it is from organic matter, nitrogen is absorbed in the form of nitrate (NO3 -).

# What are the symptoms of nitrogen deficiency and nitrogen toxicity?

- II. Although the atmosphere is 75 to 80 percent nitrogen gas, nitrogen is the most common nutrient deficiency seen in plants. N2 gas contains a triple bond that is extremely hard to break. As a result, the molecule is almost inert. Nitrogen is one of the most important nutrients required for plant growth and development. Optimal levels of nitrogen promote fast vegetative growth.

# What are the symptoms of nitrogen deficiency and nitrogen toxicity?

- A. Nitrogen is a component of amino acids and, thus, proteins and enzymes.

- 1. It is an essential part of chlorophyll. There are four nitrogen atoms in each molecule of chlorophyll.
- 2. Nitrogen stimulates carbohydrate utilization and promotes root growth and development.
- 3. Nitrogen also regulates the uptake and utilization of other nutrients.

# What are the symptoms of nitrogen deficiency and nitrogen toxicity?

- B. Early signs of nitrogen deficiency are lighter green leaf color and slowed growth. As the deficiency advances, the lower or oldest leaves turn yellow and drop from the plant. The plant exhibits stunted and slow growth and a poor root system.

# What are the symptoms of nitrogen deficiency and nitrogen toxicity?

- C. Excess nitrogen causes rapid soft tissue growth. The plant leaves turn darker green and sometimes become thickened and brittle.

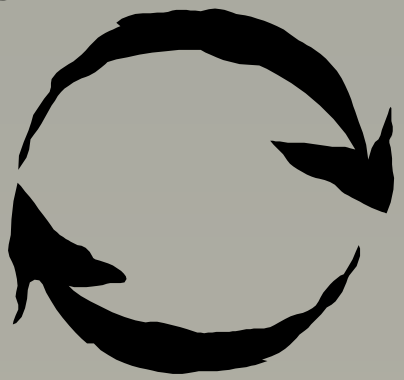
- 1. Ammonium toxicity symptoms can vary from crop to crop. Leaf margins may curl. Chlorosis, or yellowing in varying patterns, develops, followed by necrotic spots.
- 2. This situation occurs under cool growing conditions.

# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- III. Nitrogen continually changes from usable nitrogen to atmospheric nitrogen. This flow of nitrogen between the abiotic (non-living) and biotic (living) parts of the environment is called the ***nitrogen cycle***. The largest proportion of nitrogen at any given time is found in the biomass or in dead organisms. The nitrogen cycle is one of many ***biogeochemical cycles***. Biogeochemical cycles involve the recycling of nutrients throughout the ecosystem. The water cycle is another well-known example of this process. The key concept is that no nitrogen is lost or consumed in the environment, but rather it changes form and moves between the abiotic and biotic components of the environment and is recycled.

# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- A. ***Nitrogen fixation*** is the conversion of atmospheric nitrogen into oxidized forms that can be assimilated by plants. Before plants can use it, nitrogen must be removed from the atmosphere through nitrogen fixation or through the manufacture of chemical fertilizers.



# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- 1. Nitrogen fixation is a natural process in which rhizobia bacteria in root nodules of legumes convert nitrogen to a nitrate form.
- 2. Legumes typically do not need nitrogen fertilizers because they make their own nitrogen supply. The rhizobia "fix" atmospheric nitrogen (N2) by converting it to ammonia (NH3 +). A compound is referred to as ***fixed*** if it resists decomposition.

## What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- B. The positive charge of ammonium causes it to easily bond to clay soils, making it unavailable. However, a two-step process known as ***nitrification*** is carried out by soil bacteria, in which ammonium (NH4 +) from organic matter or chemical fertilizers is converted to nitrate. Ammonia is converted to nitrite (NO2 -) and then to nitrate (NO3 -). The negatively charged nitrate becomes part of the soil solution and is absorbed by crops.

## What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- 1. Nitrates ***leach***, or pass through, soils readily and may erode, primarily through water runoff.
- 2. Nitrite is toxic to higher plants, but the conversion from nitrite to nitrate occurs so quickly that no nitrite buildup in the soil or plant roots occurs.
- 3. High nitrite levels in water can cause illness especially in children.

# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- C. Plants absorb nitrogen as inorganic nitrate ions (NO3 -) and, in a few cases, as ammonium (NH4 +) or amino (NH2 +) ions. Nitrogen absorbed by the plant is reduced to N2 -, NH-, or NH2, which is then synthesized into more complex compounds, amino acids, and proteins. ***Nitrogen assimilation*** is the incorporation of nitrogen into organic cell substances by living organisms.

## What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- D. ***Immobilization*** is the conversion of nitrogen from an inorganic or mineral form to an organic form. This process occurs naturally during initial decomposition, or nitrogen can be immobilized during chemical fertilizer composition to make it available to the plant at a later time.

# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

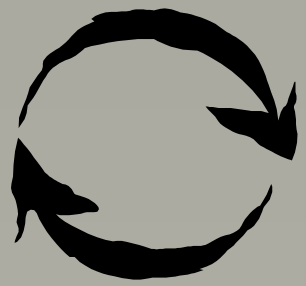
- E. Most natural soil nitrogen is in the organic form, meaning that it is combined in some manner with carbon.

- 1. Manures, decomposing organic matter, and urea are all forms of organic nitrogen. These must be oxidized before plants can use them.
- 2. The transformation of organic matter to the inorganic or mineral form ($NH_4^+$, $NO_2^-$, or $NO_3^-$) is called ***mineralization.***

# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- F. To complete the nitrogen cycle, nitrogen can be removed from the soil by the uptake of nitrogen by the plant, by losses due to leaching, or by denitrification.

- 1. ***Denitrification*** occurs when nitrates are converted to nitrogen gas (N2) under wet soil conditions. The nitrogen is then lost to the atmosphere.



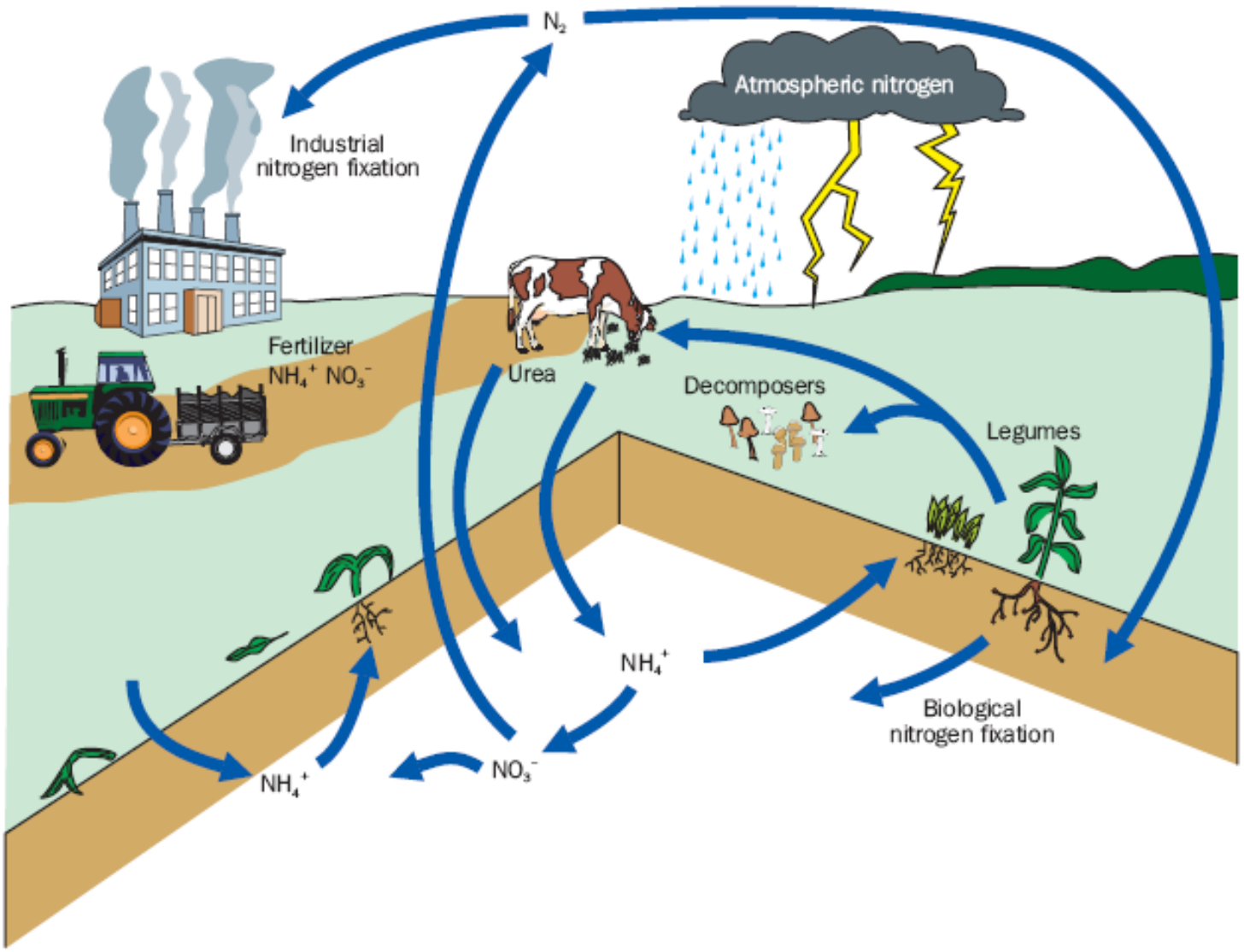
## What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- 2. Some forms of nitrogen convert to ammonia gas ($NH_3$). The ammonia gas can move from the soil to the atmosphere in a process called ***ammonia volatilization.*** Ammonia volatilization commonly takes place with organic forms of nitrogen, such as urea. Urea may originate from animal manure and urea fertilizers and, to a lesser degree, from the decay of plant materials.

# What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?

- a. Ammonia volatilization occurs mostly when soils are moist and warm and the source of urea is on or near the soil surface. It also happens with alkaline soils.
- b. To reduce the rate of ammonia volatilization, apply manure and urea fertilizers when soil and air temperatures are cool. It is also helpful if rain occurs soon after application and if the materials are mixed with the soil shortly after application.

# THE NITROGEN CYCLE



# What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

- IV. Legumes, such as beans, peas, alfalfa, clover, chickpea, and soybeans, are able to take in nitrogen through their roots. ***Legumes*** are plants that are members of the family *Leguminosae*. A symbiotic relationship that exists between bacteria and legume plants is utilized to convert nitrogen gas (N2) to ammonium ions (NH4 +) that are usable to plants.

## What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

- A. ***Rhizobia*** are aerobic bacteria found naturally in soils. The soil bacteria enter the plant through openings in the root hairs and extend into the cortex of the rootlets. This causes the growth of nodules to occur and is where nitrogen fixation occurs.

# NODULES ON PLANT ROOTS

## What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

- 1. Rhizobia cause excessive growth in the form of nodules on the cortex of the roots of legumes. The cortex is an outer layer of tissue in the roots of dicotyledonous plants, located between the stele and the epidermis.
- 2. Rhizobia are autotrophic bacteria. ***Autotrophs*** are organisms that create their own food rather than obtaining it from other organisms. They get their energy from the oxidation of mineral constituents, as well as from carbohydrates from their host plant.

## What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

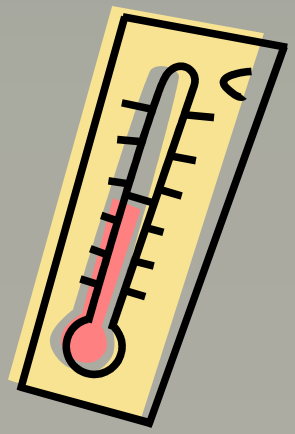
- B. Seeds are inoculated with rhizobia to increase the bacterial populations in the soils of leguminous plants. ***Inoculation*** is the bulk treatment of leguminous seeds with rhizobia.

## What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

- 1. Increased rhizobia populations will "fix" more nitrogen, making more nitrogen available to the plant.
- 2. The increased supply of nitrogen by rhizobia lessens the need for supplemental nitrogen and generally increases the yield and quality of crops.
- 3. However, these bacteria are crop specific, with certain strains affecting only certain crops.

## What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

- C. There are several factors that affect rhizobium activity.



- 1. As soil temperature increases, soil bacteria become more active. This explains why nodules are not present in legumes during the winter months. Research has also shown that nodules slough off immediately after crop harvest and then begin to return several days after harvest.

## What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?

- 2. Rhizobia populations are increased by soil moisture, soil oxygen, and soil aeration.
- 3. Soil with a pH of 6.0 to 8.0 supports the greatest rhizobia populations.
- 4. Also, the greater the exchangeable calcium in the soil, the greater the soil bacteria populations.

# What are natural and synthetic fertilizer sources of nitrogen?

- V. Nitrogen is a major requirement for plants to grow rapidly and maintain a healthy green color. Leguminous crops are able to use atmospheric nitrogen rather than rely on the application of fertilizer. Use of legume plants in crop rotations is important for sustainable agriculture programs. Nitrogen fertilizer is expensive to produce and, thus, is an expensive input for farmers. Nitrogen fertilizers may be organic or inorganic.

# What are natural and synthetic fertilizer sources of nitrogen?

- A. Organic sources of nitrogen include animal tankage, fish meal, dried blood, guano, and manure. These materials provide a small percentage of nitrogen for agricultural purposes.

# What are natural and synthetic fertilizer sources of nitrogen?

- B. Most inorganic nitrogen fertilizers are produced by the synthetic fixation of atmospheric nitrogen. Inorganic sources of nitrogen are available in two forms. They are ammonium or ammonium forming and nitrate.

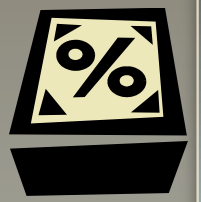
# What are natural and synthetic fertilizer sources of nitrogen?

- 1. Ammoniacal sources of nitrogen include anhydrous ammonia, urea, ammonium nitrate, and ammonium sulfates.
  - a. Anhydrous ammonia contains 82 percent nitrogen. It must be stored under high pressure as a liquid and applied below the soil surface.

# What are natural and synthetic fertilizer sources of nitrogen?

- b. Urea contains 46 percent nitrogen. It is available as solid or liquid fertilizer. It is quickly converted to ammonium carbonate when applied to the soil. The ammonium carbonate decomposes into ammonia and carbon dioxide. High temperatures, high soil pH, and low rainfall increase ammonia loss.
- c. Ammonium nitrate contains 33.5 percent nitrogen. It is in solid form and is composed of one half ammonium form and one half nitrate form.
- d. Ammonium sulfate has 20 percent nitrogen and 24 percent sulfur. It is often a byproduct from the manufacture of coke and nylon.

# What are natural and synthetic fertilizer sources of nitrogen?




- 2. Nitrate sources include sodium nitrate, calcium nitrate, and potassium nitrate.
  - a. Sodium nitrate is a naturally occurring product that contains 16 percent nitrogen. It is expensive and is generally not used in mixed fertilizers.
  - b. Calcium nitrate consists of 15.5 percent nitrogen and 19 percent calcium. It is commonly used with horticultural crops.
  - c. Potassium nitrate contains 14 percent nitrogen and 44 percent potash. Its primary use is as a sidedressing for tobacco, citrus, and horticultural crops.

# REVIEW

- 1. What are the forms of nitrogen and the characteristics of each?
- 2. What are the symptoms of nitrogen deficiency and nitrogen toxicity?
- 3. What is the nitrogen cycle and how does it influence the availability of nitrogen to plants?
- 4. What plants are capable of nitrogen fixation, and what factors influence nitrogen fixation?
- 5. What are natural and synthetic fertilizer sources of nitrogen?