

Plant Nutrients—Nitrogen

Information compiled by the Western Plant Health Association

Plant Utilization – Nitrogen is one of the 17 chemical elements required for plant growth and reproduction. Nitrogen is in chlorophyll, a green chemical which allows plants to capture energy from the sun and make food for themselves in a process called photosynthesis. It is also the basic element of plant and animal proteins, including the genetic material DNA and RNA, and is important in all phases of plant growth.

Production – Nitrogen is an abundant element on and around Earth. Approximately 78% of the Earth's atmosphere is nitrogen gas (N_2). As with all plant nutrients, however, nitrogen must be in specific forms to be utilized by plants. Converting N_2 into nitrogen plants can use is called nitrogen fixation. Most often, nitrogen gas is converted into plant available nitrogen by using complex chemical processes or nitrogen-fixing bacteria.

Most manufactured nitrogen fertilizers begin as ammonia. At temperatures of 400°C - 500°C and great pressure, nitrogen from the air and hydrogen from natural gas combine to produce ammonia. The ammonia can be used directly or further processed into other nitrogen fertilizers. Legumes, such as beans and alfalfa, grow specialized nodules on their roots. *Rhizobia*, nitrogen-fixing bacteria, live in these root nodules and convert atmospheric nitrogen into nitrogen plants can use. Farmers take advantage of this unique symbiotic relationship by periodically growing legumes in nitrogen-deficient soil to naturally boost nutrient levels.

Forms – In the soil, nitrogen exists in different forms, which interact with one another and with plants, animals, and microorganisms. Most crops use nitrogen rapidly, therefore, farmers and home gardeners often supply nitrogen to the plants in a variety of ways, including the application of manufactured fertilizers, applying composts and manures, and growing legumes in rotation with other crops.

Plants absorb nitrogen in the forms of nitrate (NO_3^-) or ammonium (NH_4^+) ions, both of which are water-soluble. Nitrate ions are absorbed quickly by plant roots, but leach easily. Ammonium ions are attracted to soil particles and move slowly through the soil to plant roots. Commercial fertilizers, both dry and liquid, are available with various combinations of nitrate and ammonium ions, enabling farmers to manage their nitrogen application. Crop advisors monitor crops to ensure the crops receive optimum amounts of nitrogen.

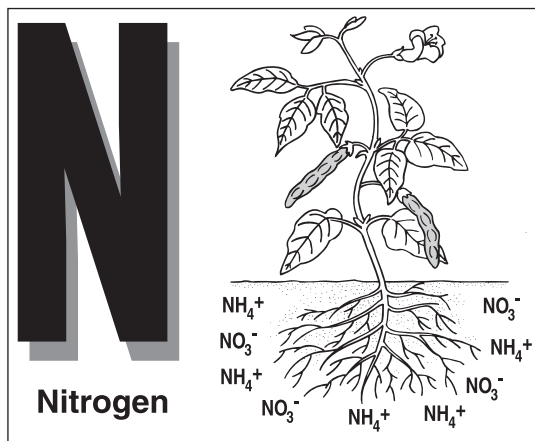
History – Americans have fertilized their crops with nitrogen for centuries. Early colonists used animal manure, fish scraps, cottonseed meal, and tobacco stems as nitrogen fertilizer. Later, Americans imported nitrate of soda from Chile, rotated crops with legumes, and used ammonium sulfate—a by-product of steel production. Many of these are still used today.

The process of synthesizing ammonia is considered one of the greatest chemical engineering feats of all time. The process was first demonstrated in the laboratory in 1884, but it was not commercially feasible until 1913 in Germany. The first American ammonia plant was built in 1921. Nitrogen fertilizer production was minimal until

after World War II, when the demand for food increased with an increase in human population. Improved nitrogen management is the focus of intensive research at both public and private research facilities.

Top Producing Regions – China is the world's largest producer of nitrogen and phosphate fertilizers and Canada produces more potash fertilizer than any other country. Although the U.S. is the third largest producer of nitrogen fertilizers, we still import more nitrogen fertilizer than any other country. Natural gas is a major feedstock for production of ammonia. During this same period, 27 U.S. ammonia plants closed. Since 2008, four new ammonia plants have opened but the U.S. remains dependent on nitrogen imports. More than 60% of imported anhydrous ammonia is from Trinidad. Globally, wheat receives the largest share of nitrogen fertilizer at 18%, however, in the U.S. nearly half (49%) of all nitrogen fertilizer is applied to corn.

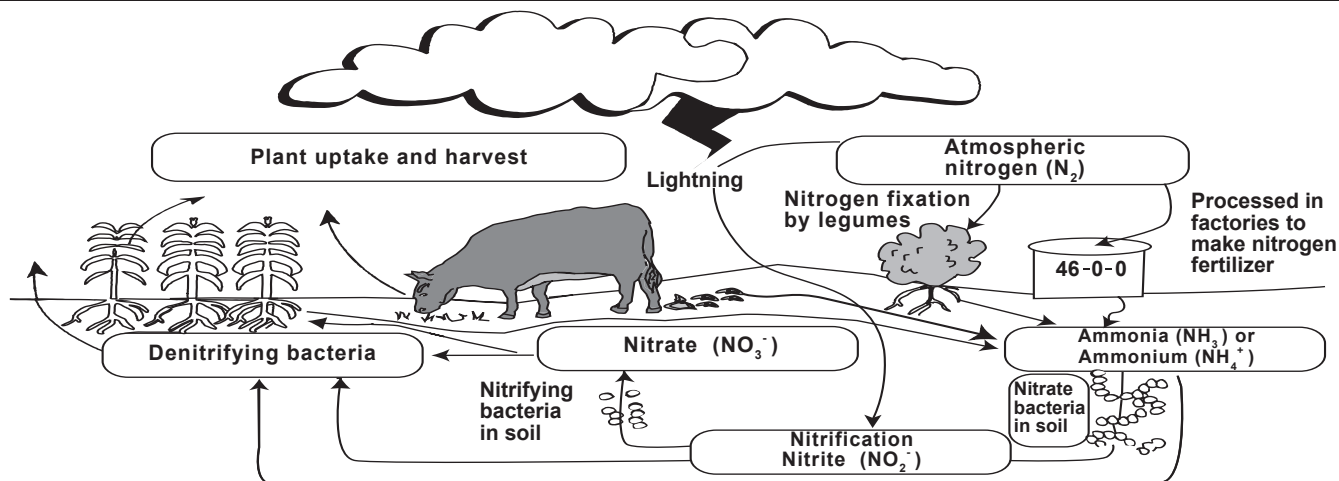
Economic Value – Fertilizer manufacturers, wholesalers, importers, brokers, retailers, and the businesses that serve them support 487,000 American jobs with a total annual economic impact of \$130 billion. The fertilizer industry creates over 30,000 jobs in California, paying workers more than \$2 billion in wages. Fertilizer, which is responsible for half of the world's food supply, helps keep U.S. farmers profitable by helping them grow in excess of \$366 billion worth of crops every year.



For additional information:
California Fertilizer Foundation
(916) 574-9744
Website: www.calfertilizer.org



Nitrogen Activity Sheet



Lesson Ideas

- Compare and contrast the nitrogen and water cycles.
- Make a poster of the nitrogen cycle using magazine pictures.
- Chart and compare the growth of plants which are fertilized with varying amounts of nitrogen fertilizer.
- Compare fertilizer labels for nitrogen content.
- Make compost at your school using garden, fruit, and vegetable lunch waste.
- Identify plants which are legumes. Research how these plants make nitrogen available to other plants.
- Draw a picture of a plant and the plant's need for nitrogen.
- Research the procedures and chemical equations used in ammonia fertilizer production.
- Compare and contrast the nitrogen content of various organic fertilizers, including steer manure, chicken manure, and fish emulsion.
- Locate nitrogen on the periodic table of elements. Learn about its physical and chemical properties.

Fantastic Facts

1. Ammonia is the basic chemical ingredient in commercial nitrogen fertilizer production.
2. The color green is associated with plants which contain a sufficient amount of nitrogen.
3. Legumes, such as beans and alfalfa, contain microorganisms in their roots that convert nitrogen into a form other plants can use.
4. NO_3^- and NH_4^+ are the two forms of nitrogen that plants can absorb through their roots.
5. The United States is the world's top importer of nitrogen.
6. Nitrate (NO_3^-) is a form of nitrogen that can leach rapidly, depending on environmental factors.

Lesson Plan: Let's Make Manure Tea

Introduction: Substances added to improve the nutrient content of soils are called fertilizers. Fertilizers can be natural or man-made (synthetic). Animal waste is sometimes used as a natural fertilizer.

Objective: Students will make a liquid fertilizer called "manure tea" from steer manure. Students will design and perform an experiment to determine the optimum dilution of this nitrogen-rich fertilizer.

California Standards: NGSS: 3-5-ETS1-3, MS-LS1-5, MS-ETS1-3

Materials: Store-bought steer manure (3 or 4 cups), coffee filter, five-gallon bucket with lid, water, string, index cards cut in half, stapler, tablespoon, corn seedlings and other supplies for student-designed experiment.

Procedure:

1. Write the term "manure tea" on the board. Obtain student ideas for its definition. Also discuss that plants need certain

nutrients for successful growth and reproduction.

2. Have each student make a manure tea bag by placing two tablespoons of manure into a coffee filter and stapling it shut. Staple a string to one end and 1/2 of an index card to the other end of the string. Have students create and draw labels for their "brands" of tea on the index cards.
3. Hang the tea bags in a covered five-gallon bucket that is full of water. Let the bags steep overnight. Record observations.
4. Design and perform a class experiment that will determine the optimum manure tea concentration for growing corn. Brainstorm variables to control and potential failure points.
5. At the conclusion of the experiment, compare and identify the most successful design solutions. Discuss how their newly-gained knowledge can relate to large-scale agriculture.