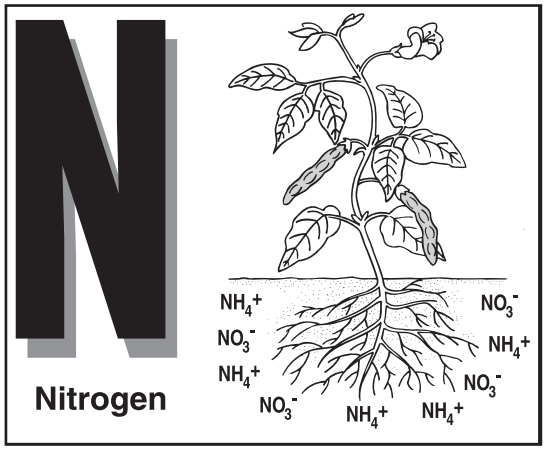
Natural Resource Fact Sheet

Plant Nutrients–Nitrogen

Information compiled by the California Fertilizer Foundation

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 periods of rapid plant growth.



Production – Nitrogen is an abundant element on and around Earth – about 78 percent 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 400ºC - 500ºC 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.

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 (NO_3^-) or ammonium (NH_4^+) ions which are both 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 the 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 scrap, cottonseed meal, tobacco stems, and even Peruvian bat guano 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. 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 quite small 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 produces the most nitrogen fertilizer in the world and the U.S. is the world's largest importer of nitrogen. All nitrogen fertilizer used in California is imported. Since natural gas is required for producing nitrogen fertilizer, the high natural gas prices caused the 26 U.S. ammonia plants to permanently close in 1999. Much of the imported nitrogen fertilizer comes from Trinidad, where gas costs are lower and producers have easy access to the U.S. Gulf.

China is the world's largest nitrogen fertilizer consumer, using 31 million tons in 2006, approximately 32% of the world's total production. India is the second largest consumer of nitrogen fertilizer, followed by the U.S. which consumes 12 million tons annually. Wheat receives the most nitrogen fertilizer in the world (17% of total); however, corn is the crop that receives the largest amount in the U.S. (45% of U.S. total).

Economic Value – The economic value of the nitrogen industry is difficult to assess. Many people have businesses associated with replenishing agricultural soils with nitrogen, including those whose livelihoods depend on providing compost bins, soil amendments, and tools. It is known that ammonia production brings in $4 billion to the United States economy annually and shows the large economic impact fertilizer production and distribution play in the economy of the United States.

For additional information:
California Fertilizer Foundation
4460 Duckhorn Drive, Suite. A
Sacramento, CA 95834
(916) 574-9744 Fax: (916) 574-9484
E-mail: pame@healthyplants.org
Web Site: www.calfertilizer.org

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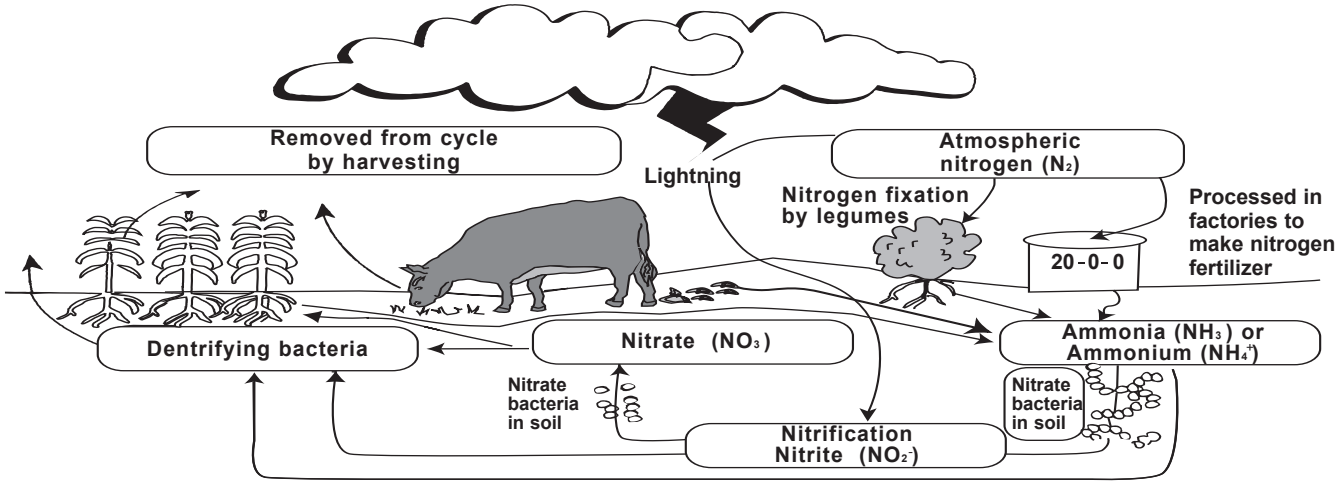
Nitrogen Activity Sheet



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 the Elements. Learn about its physical and chemical properties.

Nitrogen Fun Facts

1. What chemical is the basic ingredient in commercial nitrogen fertilizer production?
2. What color is associated with plants which contain the appropriate amount of nitrogen?
3. What kinds of plants contain microorganisms on their roots that convert nitrogen into a form other plants can use?
4. What are the two basic chemical formulas that show the forms in which plants can absorb nitrogen through their roots?
5. List one of the world's top importers of nitrogen.
6. What form of nitrogen leaches rapidly?
7. Which states produce ammonia in the United States?

1) Ammonia 2) Green 3) Legumes, such as beans and alfalfa
4) NO_3^- and NH_4^+ 5) United States 6) Nitrate (NO_3^-) 7) None

Lesson Plan: Let's Make Manure Tea

Introduction: Substances added to improve the nutrient content of soils are called fertilizers. In this activity, students will make a liquid fertilizer called "manure tea" out of steer manure. The students will then design and perform an experiment to determine the optimum dilution of this nitrogen-rich fertilizer.

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 ½ 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. At the conclusion of the experiment, discuss how their newly-gained knowledge can relate to large-scale agriculture.

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This is one in a series of fact sheets composed by the California Foundation for Agriculture in the Classroom (CFAITC). For additional educational materials: CFAITC, 2300 River Plaza Drive, Sacramento, CA 95833-3293 (916) 561-5625 ✣ (800) 700-AITC ✣ Fax: (916) 561-5697
E-Mail: cfaitc@cfbf.com ✣ Web Site: http://www.cfaitc.org ✣