Lab: Know YourNitrogen

Background Information (Teacher Only)

Start where you are, with what you have. Make something of it and never be satisfied.
~ George Washington Carver

Grade Level: 9-12

Estimated Time: Two 60-minute sessions **(See "Time Saving Adaptations" below to turn into 1 session)**

Purpose:

In this lesson, students will test for plant-available soil nitrogen and learn how farmers use this test to precisely match fertilizer to meet crop needs and reduce the amount of nitrogen left in the soil.

Materials:

- **For the Class:**
  - 2 kitchen sponges
  - 2 clear bowls
  - 2 clear cups
  - Water
  - Food coloring (red is best)
  - Measuring cup
  - Soil core sampling tubes (or shovels to dig uniform corns from the first 6" of soil)
  - A place to collect soil core samples
  - Electronic scales
  - Food or aquarium grade calcium chloride
  - 1 gallon of distilled water (add 6 g or calcium chloride to 1 gallon of distilled water to make the 0.01 M calcium chloride solution)

- **For each group:**
  - 1, 10-500 ppm nitrate test strip
  - 50 ml centrifuge tube
  - Quart size resealable bag
  - Waterproof marker
  - Nitrate test strip color chart

- **For each student:**
  - Summary of 2008-2009 Large Scale Irrigation and Nitrogen Fertilizer Management Trials in Lettuce
  - Nitrate Quick Test Procedure
  - Nitrate Test Strip Color Chart
  - Know Your Nitrogen Lab: Instructions and Data Sheet
  - Answers to Commonly Asked Questions

Vocabulary:

Lab: Know Your Nitrogen

Background Information (Teacher Only)

- *Conservation:* the wise use of resources, to conserve them for use by present and future generations
- *Crop rotation:* the successive planting of different crops in the same field over a period of years to maintain or improve soil quality and reduce pest problems
- *Fertilizer analysis:* the actual composition of a fertilizer as determined in a chemical laboratory using standard methods
- *Leaching:* downward movement of materials in solution through the soil
- *Water holding capacity:* The amount of water that a soil can hold before nutrients begin to leach out.

Background - Agricultural Connections

This lesson is part of the series called, *Fertilizers, Chemistry and the Environment*. These lessons introduce students to chemistry and environmental science concepts. Activities are modeled after real-life challenges that modern farmers face while producing our food, fiber and fuel. Labs are inquiry based and promote critical thinking skills. Other lesson are:

- *One in a Million*
- *Concentrate on the Solution*
- *Matter of Fact*
- *What's Your pH?*

Teacher Preparation and Pre-Lab Demonstration:

1. Prior to the lesson, place a slightly damp, but not saturated, kitchen sponge above a clear bowl. The bowl should be small enough so that the sides of the sponge suspend it slightly above the bottom of the bowl. Repeat with a second sponge and clear bowl. Prepare two separate cups of water, one containing ½ cup of water and the other containing one cup of water. Also have one bottle of red food coloring on hand.

2. Tell students that in this example the sponge represents an agricultural field. Just like a sponge, soil can only hold a certain amount of water. Explain that in this demonstration the red food coloring represents a fertilizer solution.

3. Ask for two volunteers to come to the front of the room. The volunteers represent farmers who irrigate their crops differently. Instruct each student to place two drops of food coloring in the center of their sponge. Now instruct the student with ½ cup of water to slowly pour the ½ cup of water onto the center of one sponge. Instruct the other student to slowly apply one cup of water to the center of the other sponge. Have students record their visual

Background Information (Teacher Only)

Students should observations about the process, and the amount of leachate that accumulates under the sponge, in a science journal or notebook. A class discussion should bring up the following points:

- The sponge, like soil, can only hold a certain amount of water. The phrase "water holding capacity" describes the ability of a particular type of soil to hold water against the force of gravity. Soil can only hold a limited amount of water.
- After the sponge reached its water holding capacity, the water moved through the sponge carrying the fertilizer with it. Today's farmers and scientists work together to implement nutrient management practices that protect the environment and apply the precise amount of nutrients and irrigation needed by the crop.
- Since water carries the fertilizer to the plant roots, it is important to understand how water travels through soil. Regulatory agencies, farmers, ranchers, and educational organizations are constantly working on research and monitoring projects to utilize the best nutrient management practices possible while growing healthy crops.

4. Explain that in this lab, students will carry out the same nitrate soil test used by farmers to measure soil nitrate levels in order to match fertilizer application rates to the needs of their crops. Students will:
   - test soil samples for available nitrogen; and
   - learn about best management practices to maximize nutrient utilization and environmental stewardship.

Procedure:

1. As a class, read the *Summary of 2008-09 Large Scale Irrigation and Nitrogen Fertilizer Management Trials in Lettuce* by Michael Cahn and Richard Smith, Farm Advisors, Monterey County (attached in Essential Files).
   a. This is a technical document and students may have difficulty understanding the terminology. The reason for including this reading in the lesson is to help students understand that fertilizer application is complex and involves a great deal of science.

2. As a class, discuss the article.

    a. **Were students surprised by the precision involved in modern agriculture?**

    b. **Make a concept map** on the board of all the things these farmers needed to know about their crop and their soil.

    c. **What skills would students need to run a lettuce farm like the one described in the article?** Add responses to the concept map on the board.

3. Tell students that they have earned a spot as an intern for the Cooperative Extension farm advisor in your county:

    a. "Your boss has given you an assignment to collect soil core samples from a local lettuce farm. You will need to collect numerous samples from the field and you have decided to enlist your classmates to help collect soil samples. Once you have collected your soil samples, you will return with them to the lab and will follow lab procedures that your boss has printed out for you."

4. Distribute the handouts for the *Know Your Nitrogen* lab and *Nitrate Quick Test Procedure*.

    a. Go over lab safety procedures and remind students to carefully read the instructions and gather the necessary materials before starting the lab.

    b. During the first day of the lab, demonstrate the correct method for soil sampling and draw a grid on the board to show where each group will sample the field. This will help ensure that a representative sample is collected. Lead students to the designated location to collect soil sample cores.

        - Depending on your location mapping out the site and creating a corresponding grid in the designated area would be a good way to help make sure students work in the correct location. (Wooden stakes and string would easily make a grid in a field)

5. In addition to collecting soil samples, we are also interested in soil drainage. Soil texture, shallow soil with fractured bedrock, and soils with a water table close to the surface all affect soil drainage. There are precise laboratory methods for determining soil porosity and soil drainage, however, we can do a quick assessment with a shovel and some water.

    a. Ask two students to volunteer to dig a hole that is one square foot wide by 12 inches deep, level on the sides and bottom.

    b. Once the hole is dug, students should fill it with water and let it soak in for an hour or so. When all the water has drained, the hole should be refilled with water and students should note the amount of time it takes for the water to soak in. If the water

drains faster than 4 inches per hour, the soil is highly porous. Soil with low porosity will drain less than one inch per hour.

c. Soil porosity is the amount of pore space occupied by water and gases in the soil. Ask students why farmers would be interested in soil porosity and soil drainage.

6. On the second day of the lab, students will follow the lab procedures for carrying out the *Nitrate Quick Test* on their soil samples.

7. After students have completed the nitrate soil test, ask them to write their nitrate level on the board in their assigned soil grid space. Discuss the class findings and provide any guidance the students may need before moving on to the lab questions.

Concept Elaboration and Evaluation:

- After conducting these activities, review and summarize the following key concepts:
  - Nitrogen is a macronutrient for the growth of plants. It is required in large quantities for healthy plant growth.
  - Growing plants removes nitrogen and other nutrients from the soil.
  - Nitrogen and other nutrients can be replaced in the soil through organic or inorganic fertilizers.

Variations:

- Experiment with drainage in different soil types. Have students collect soil samples and determine the soil texture using a field test, laboratory analysis, or soil map. Allow students to use different soil types in their experimentation. Discuss the role of percolation and the soil's water holding capacity in drainage.

ELL Adaptations:

- Write down key terms so students can see them and connect them to the spoken word. If appropriate, connect a visual to each term introduced.
- As a class, create a flow chart to illustrate the procedure for the *Know Your Nitrogen* lab. Address questions that come up during the illustration process and prior to starting the lab.

Time Saving Adaptations:

- Coming up with an area of land that is large enough to see distinctive amounts of nitrates that can be directly related to soil use may be difficult especially in urban areas. To get around this you can “collect” the soil samples yourself. This is handy if you want to ensure that there are variations to your nitrate levels. Additionally, this means you skip the soil collection portion of day 1 and reduce the length of the lab to one day.
  - Steps to take:

Background Information (Teacher Only)

- Create your grid and label your samples appropriately.
- Gather the requisite number of samples from soil sources in or around your school (a flower bed, potted plants, or purchase a bag of potting soil).
- Adjust the nitrate levels in your samples by adding ammonium nitrate in different concentrations to different samples.
- Make sure that you have a plan for how these samples are arranged in your "field".
    - Areas of your field with a lot of plant growth should have less nitrates than areas with little plant growth.

Enriching Activities:

- Have students research best management practices used by farmers to protect water quality, including buffer zones, denitrification beds, and conservation tillage. Have student groups make a poster about individual best management practices and present it to the class.
- Introduce students to the 4Rs of nutrient stewardship—the right source, right rate, right time, and right place. "The Right Way to Grow: 4R Nutrient Stewardship" is an 11-minute video which gives an overview of the 4Rs and explains how stewardship applies to large-scale agriculture producers as well as small farms. The video is divided into Part 1 and Part 2. The International Plant Nutrient Institute hosts a number of videos related to nutrient management on their YouTube channel, www.youtube.com/plantnutritioninst.

Suggested Companion Resources:

- Is There Ever Too Much of a Good Thing? (Activity)
- Everything is Chemical (Multimedia)
- Feeding the World and Protecting the Environment (Multimedia)
- How a New Evolutionary Map Could Help Farmers Eliminate Fertilizer (Website)
- Nitrogen & Agriculture (Website)
- Soil Health Education Resources (Website)

Sources/Credits:

This lesson was funded in 2011 by the California Department of Food and Agriculture's (CDFA) Fertilizer Research and Education Program (FREP). Chemistry, Fertilizer, and the Environment was designed to reinforce chemistry and environmental science concepts while educating students about the relationships between food, plant nutrients, farmers and the environment.

Executive Director: Judy Culbertson Illustrator: Erik Davison Layout and Design: Nina Danner

Author(s): Mandi Bottoms and Shaney Emerson

Organization Affiliation: California Foundation for Agriculture in the Classroom