Feed Your Veggies

Principle of Plant Biology #2

Plants require certain inorganic elements for growth and play an essential role in the circulation of these nutrients within the biosphere.

Plants, like people, need adequate nutrition. When plants are not given proper nutrients, they don't grow well and are more likely to become diseased. Plants require large amounts of nitrogen, phosphorous and potassium, and smaller amounts of other nutrients including calcium, magnesium and iron.

Plants obtain their nutrients from the soil through their roots. Because plants remove nutrients from the soil, the soil must be regularly replenished. Nutrients are usually added back to the soil using chemical fertilizers or biological materials including compost and manure. Chemical fertilizers are mixtures of purified chemicals. They are sold as soluble, short-acting forms (powders or liquids) or as long-acting, slow-release pellets. Compost is a term used for a mixture of partially decomposed plant material. Besides adding nutrients back to the soil, compost also changes the physical and chemical properties of soil to help plant roots grow and take up nutrients. When the soil is too dense or sandy, the plant roots can't absorb fertilizers easily and so they wash out of the soil.

Over-use of fertilizers and fertilizer run-off are serious environmental problems. Too much fertilizer can damage plants, and can contaminate other soils and contribute to water pollution problems.

In the following activity, you will investigate how plants grow with different amounts of nutrients. What does a plant look like when it is grown without nutrients? What is the best way to apply nutrients to plants to promote growth and keep the plants healthy? Is it possible to give a plant too much fertilizer?

Real-world Connection:

Soil deficiencies are a major problem around the world. Plant growers can use fertilizers to correct these deficiencies, or in some cases they can grow different plants which are better adapted for soil conditions. Plant biologists study how plants use different nutrients and they develop new methods for dealing with nutrient deficiencies.

Activity: Effect of fertilizer on plant growth

Procedure:

1. Fill five pots with perlite.

2. Prepare five different watering solutions:
    a. Pure water (label as "0")
    b. ¼ strength fertilizer (label as "¼")
    c. Regular strength fertilizer ("1")
    d. Double-strength fertilizer ("2")
    e. Quintuple-strength fertilizer ("5")

3. Moisten the perlite in each pot with an equal volume of each watering solution. Plant 6 radish seeds (or other seeds) in each pot. Water each pot twice a week with an equal volume of the appropriate watering solution.

4. Each time you water, make careful notes about the appearance of the plants. Note when the seeds sprout, shoot height, number of leaves, leaf color and size, etc.

5. Was one concentration of fertilizer clearly the "best" or the "worst" in promoting plant growth?

Observations:

Observations (continued):

Student-Designed Experiments

Using the methods you learned in the activity above and the "Guide for Student Experimentation" below, design and carry out your own experiment. Question topics you might consider include the use of organic fertilizers such as compost, different types of soil, fast- versus slow-release fertilizers, different types of plants, etc. You might compare the results using larger plants in pots rather than starting from seeds, or try the experiment outside on a plot of ground if one is available.

Guide for Student Experimentation

Guidelines for Achieving Great Experiments

1. Ask a very specific, testable question.
2. Test a control for comparison (a group that does not receive the experimental treatment).
3. Use a sample size large enough to allow firm conclusions.
4. To understand a whole population, obtain a random sample of that population to avoid bias.
5. Replicate each part of the experiment (at least 3 times).
6. Hold all variables constant between trials except the variable being tested.
7. Collect quantitative data whenever possible.
8. Measure using metric units.
9. Gather data carefully and accurately.
10. Be objective and honest.

Introduction

Question:

Hypothesis:

Materials and Methods

Independent variable:

Dependent variable:

Experimental constants:

Control:

Protocol:

Results

Data collected:

Other observations:

Graph(s):

Discussion

Interpretation of data:

Conclusions:

Teacher's Guide to "Feed Your Veggies"

Links to National Science Education Standards

Grades 5-8:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Structure and function of living systems
- Diversity and adaptations of organisms
- Science and technology in society

Grades 9-12:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Matter, energy, and organization in living systems
- Science and technology in local, national, and global challenges

Materials

Per Group:

- Six plastic soda bottles for preparing fertilizer solutions
- Cups to measure liquid for watering
- Six plant pots per team, or planting trays, or plastic or styrofoam cups with small holes in the bottom
- 30 radish seeds

For class use:

- Liquid or powdered plant food (such as Miracle Gro or Schultz)
- Inert potting substrate such as Perlite or Vermiculite. Pre-rinse to remove dust by putting into a dishpan and covering with several inches of water, swish around a few times and pour off the water.
- Drain trays to place under pots (aluminum baking trays or cafeteria trays work fine). To avoid cross-contamination, put all the pots watered with the same solution on a single tray. Don't put all the pots of each group on a tray or the fertilizer will move between them.
- Growth area for plants - plant grow lights or a windowsill.

Teaching hints

1. **Obtaining and preparing material:** Radish seeds work particularly well in this experiment because they are small enough to use up their stored nutrients fairly quickly, and because they germinate quickly. Radish seeds will germinate in less than one week, and start producing leaves within two weeks. The effects of the different watering solutions should be apparent within three weeks of starting the experiment.
2. **Another experimental set-up:** Another way to set up the experiment is to place different numbers of slow-release plant food pellets into each pot, then water with pure water. The effects of too much fertilizer are less likely to be apparent though using this method.
3. **Composting:** This experiment provides a great way to talk to students about recycling food scraps by composting. Students can make their own mini-compost systems using soda bottles or plastic zip-lock bags. See http://www.bottlebiology.org/investigations/decomp_main.html for more information.
4. **Soil testing:** Interested students can test nutrient availability in their experimental

pots or in the soil near your school using a Rapitest soil test kit available from science supply companies and garden stores (and available on-line) for about $20.

5. **Successful student-designed experiments:**
   - Emphasize the "Guidelines for Achieving Great Experiments."
   - Before students design experiments, tell them how much time they will have.
   - Allow students to present their experiments and lead a short discussion about each one. Encourage other students to ask questions.

Web Resources

Investigating Plant Nutrition Using Fast Plants
www.fastplants.org/pdf/activities/WFPphysiology-06web.pdf

"The Effects of Different Levels of Minerals on Plant Growth" – Science and Plants for Schools
www-saps.plantsci.cam.ac.uk/worksheets/scotland/radish.htm

References

Hewitson, J. and Price, R. 1994. Plant mineral nutrition in the classroom. School Science Review 76: 45-55.

Lee, C.A. 2003. A learning cycle inquiry into plant nutrition. American Biology Teacher 65: 136-141.

Acknowledgements

Credits for figures are as follows: Shovel and roots, © iStockphoto.com / Diane Labombarbe; USDA NRCS scientist / Charlie Rahm. This work was funded by the Education Foundation of the American Society of Plant Biologists.