How does the planting of legumes affect the growth and productivity of pumpkins?

PROJECT PUMPKIN (gr 3-5)

Nutrient Management 2

(ILS 6D, 10A, 10B, 11A, 12A, 12B)

Overview

This curriculum explores the relationship between people and the food they eat. By growing pumpkins in a garden plot, the curriculum takes teachers and students through six features of sustainable agriculture that separate it from conventional farming. If the entire curriculum is completed, students will gain an understanding of sustainability and people's place in the food chain.

Sustainable Agriculture, for the purpose of this curriculum, shall be defined as "a system of food production, supported by consumers, where farming operations, practices and technologies work in harmony with the natural systems that sustain life on earth."

Suggested Grade Level

This curriculum is designed for 3rd through 5th grade levels. The topics covered can be built upon in complexity throughout that age range.

Approximate Time

Session 1 requires 30-40 minutes; session 2 requires 30-40 minutes and must be completed by Sept 15. Session 3, which must be done about a month after session 2, takes 30-40 minutes. Session 4 requires 45 minutes and must be done a full year after completing sessions 1-2 (the following school year).

> **Teacher note:**
> This lesson involves an experiment that **requires over a full calendar year** – from September until the following October. Therefore, it may require teacher cooperation, multi-age or looping classes.

Objectives

1. The students will conduct a long-term experiment to determine the effect of nitrogen on pumpkin plant productivity.
2. The students will learn that a cover crop of leguminous plants may be used to restore nitrogen to garden and agricultural soils.
3. The students will compare the effects of soil that has had a cover crop to one that has not, using pumpkin productivity as the indicator.

Activity Abstract

Students will plan an experiment to test the effects of nitrogen-fixing legumes on pumpkin growth and productivity. Students will plant a leguminous cover crop that will demonstrate how these plants restore nitrogen to the soil. They will plant the cover crop

in a test field to be used later for a pumpkin crop. **This long-term project will take a over a year to complete.**
Help with plowing/tilling the fields is recommended!

Background Information

You have seen commercial fertilizers display the three major chemicals on their packaging. It might look like this: 5 - 10 - 5. This stands for: Nitrogen - Phosphorous – Potassium, which are abbreviated as "N", "P" and "K" respectively. The numbers represent the percentage of that chemical element in the fertilizer. Depending upon the growth stage of your pumpkin, you should seek higher or lower levels of these chemicals.

Nitrogen. Apply higher concentrations of Nitrogen in the early growth stage. It provides for leaf, root and vine growth. High levels of nitrogen result in a lush, green plant that might not produce fruit but plenty of leaves. Of the three major chemicals, nitrogen can also provide the most damage as it can burn your plants. Avoid direct contact to leaves and vines since this can also result in a wilting of the plant due to burning. Too much nitrogen also can reduce or delay the emergence and number of flowers and fruit. If your plant seems to be thriving and is a healthy green, yet has no flowers, stop adding nitrogen for a week or two and the plant will redirect its energy from plant growth to fruit set and development.

The nitrogen cycle (See Appendix A for diagram)

Despite the fact that the earth's atmosphere is 78% nitrogen, free gaseous nitrogen cannot be used by higher plants. They depend on nitrogen that is present in the soil. To enter living systems, nitrogen must be "fixed" (combined with oxygen or hydrogen) into compounds that plants can use, such as nitrates or ammonia. A certain amount of atmospheric nitrogen is fixed by lightning and by some cyanobacteria (blue-green algae). But most nitrogen fixation is performed by soil bacteria of two kinds: those that live free in the soil and those that live enclosed in nodules in the roots of certain leguminous plants (e.g., alfalfa, peas, beans, clover, soybeans, and peanuts). For our purposes we will address only those attached in nodules to the roots of legumes. Bacteria that live in the roots of legumes are of the genus Rhizobium.

At any particular moment a large degree of the total fixed nitrogen will be locked up in the biomass or in the organic matter containing dead remains of organisms. So, the only nitrogen available to support new growth will be that which is supplied by nitrogen fixation from the atmosphere or by the release of ammonium or simple organic nitrogen compounds through the decomposition of organic matter. Some of other stages in this cycle are mediated by specialized groups of microorganisms and are explained below.

Legume symbioses. The most familiar examples of nitrogen-fixing symbioses are the root nodules of legumes (peas, beans, clover, etc.). In these leguminous associations the bacteria usually are Rhizobium genus, although the root nodules of soybeans, chickpea and some other legumes are formed by small-celled rhizobia termed Bradyrhizobium. Rhizobia can be found free-living in the soil, but they cannot fix nitrogen in the free state, nor can the legume root fix nitrogen without Rhizobia.

These rod-shaped bacteria enter the roots chiefly through the tiny root hairs. They work their way to the inner root tissues where they stimulate the growth of tumor like nodules. Inside these nodules the bacteria develop into forms called bacteroids, which live in a symbiotic (mutually beneficial) relationship with the green plant. The bacteroids take carbohydrates from the plant for energy to fix nitrogen and synthesize amino acids; the plants take the amino acids contained within the nodule to make plant tissue. Scientists do not yet understand the exact biochemistry of nitrogen fixation within the nodule.

After harvest, legume roots left in the soil decay, returning organic nitrogen compounds to the soil for uptake by the next generation of plants. It is estimated that more than 300 pounds of nitrogen per acre can be fixed by fields of alfalfa and other legumes. For this reason crop rotation in which a leguminous crop is rotated with a nonleguminous one is a common practice for maintaining soil fertility.

Animals in turn consume the plants and convert plant protein into animal protein.

Materials

- Two designated areas for field testing pumpkin productivity (this can be one large garden divided in half, or two separate gardens. However, they should have the same soil type, sun, etc.)
- Leguminous seeds for display -- red clover, alfalfa, soybeans, lentils, peanuts
- Leguminous seeds appropriate to the area's growing season for planting (alfalfa, soybeans, red clover for Illinois)
- Assorted garden tools such as shovels, rakes, hoes, cultivators
- Magnifying lenses
- Knife and microscope (optional)
- Scales, tape measure, data recording sheet (See appendix B)
- Soil thermometers
- Soil testing kit to test for nitrogen levels.

Procedure (Session 1)

1. **Tap prior knowledge.** Ask students what they know about the importance of nutrients in plant growth. Review information from the Nutrient Management Activity 1, the "Pumpkin Patch" game (if played). Why do some gardens produce different yields of the same plant? What are some ways that soil can be improved so that yields improve? What do they know about legumes?
2. **Share with a neighbor**. Have a selection of leguminous seeds available as examples for display. Write the activity question (on the top of page 1 of this activity) on the board. Use seed observations and info the student gained from the Nutrient Management Activity 1 to help answer the question**.** Generate a brainstorm list from this question on the chalkboard.
3. **Introduce scientific principle.** Explain that students will be conducting a long-term experiment to answer their activity key question.
4. Review the scientific method. Steps include defining the problem, generating a hypothesis, creating a procedure for a controlled experiment, collecting and analyzing data, and reaching a conclusion. The key question is the problem, so that's done!
5. Have students generate a hypothesis and record it so you can refer to it later.
6. Identify the variables in this experiment and come up with the best method to test. What will be your control and experimental variables?

7. In groups, design the experiment so that there is only one thing that changes (presence, or lack of leguminous cover crop producing nitrogen in the soil. That means the types of plants, garden lay-out, soil, and care all have to be the same for both plots.)
8. As a class, review the procedure and decide on one experimental design. Agree on how they will measure results. Will it be number of pumpkins grown, size and weight of pumpkins? Other suggestions? Discuss charts and graphs that could represent the data, once collected.
9. Create teams or a system for measuring, recording data, performing any calculations needed to draw conclusions later.
10. Write everything down – it will be a long time before this whole process is finished!

Procedure (Session 2) Fall

1. **Hands-on experience.** Select two garden areas for planting the pumpkin, one where nitrogen is added through planting of a leguminous cover crop, the other to be left fallow until spring.
2. If desired, test the soil for nitrogen prior to the experiment.
3. Have students plant the legume cover crop seeds in the designated area.
4. Water as needed.

Teacher note:
Check your area's growing season to make sure you choose a legume that can overwinter. In the Midwest; plant the cover crop **no later** than September 15th!

Procedure (Session 3) Mid Spring

1. **Hands-on experience.** In the late following spring when the legumes are actively growing, and have formed mature leaves, pull some out of the ground to see the samples of nitrogen-containing nodules on the roots.
2. Examine nodules under a magnifier.
3. Have students sketch the roots with nodules in their science journals. They can cut open the nodules and observe the material inside if microscopes are available.

Procedure (Session 4) Late Spring

Hands-on experience. Follow the Greenhouse Planting, Planning the Garden and Planting the Garden Activities establish the two pumpkin gardens, one on the fallow plot and one where the legumes grew. Be sure to till both plots before planting, especially the plot with the legumes. This will aid the nodules in rapid decomposition to create readily available nitrogen for pumpkin plnat growth.When the pumpkins are harvested, have students weigh, measure and count them according to the experimental design generated in session 1.

Teacher note:
Session 4 needs to be completed 7-8 months after session 1-2! In the interim, pumpkins must be planted and harvested. Activities required to complete Session 4 include – Plan the Garden, Greenhouse Planting, Planting the Garden, Summer Day Care, and Harvest the Garden walk through the steps of this process. Session 5 can be done along with the Harvest the Garden Activity!

Procedure (Session 5) Fall

1. **Hands-on experience. Relate activity and principle.** Have students fill in the data sheets (Appendix B) and answer the questions.
2. **Conclusion/Wrap-up.** Use data recorded during the growing season and at harvest time to look at trends that will help draw conclusions enabling them to confirm or deny the original hypothesis. Discuss the following. If the original hypothesis is not correct, what could be the answer to the question? How might the experiment have been affected by unforeseen variables? What would you do differently next time?

Extensions

1. Create a Pumpkin Seed Viewer See directions at http://www.sadako.com/pumpkin/#
2. Research the various kinds of legumes that will grow in northern Illinois.
3. Design an experiment to determine which of several leguminous plants results in the greatest amount of nitrogen in the soil.
4. Measure and tally diameters of pumpkins. Use data to determine maximum, minimum sizes, mean, median, mode.
5. Design an experiment with a different variable, i. e., both fields with legumes, one directly seeded, one with pumpkin starts.

References

"The Matchmaker," "Soil Prescription," "Companion Planting Guide." Jaffe, R. and Appel, G. 1990

The Growing Classroom: Garden Based Science. Addison-Wesley Publishing Company, Menlo Park, CA

http://helios.bto.ed.ac.uk/bto/microbes/nitrogen.htm

http://www.pumpkinnook.com/howto/fertile.htm

http://www.bartleby.com/65/ni/nitrocyc.htmlhttp://zzyx.ucsc.edu/casfs/training/manual/contents.html (instructional manual)

http://www.yankeegardener.com/seeds/hartseed8b.html planting directions

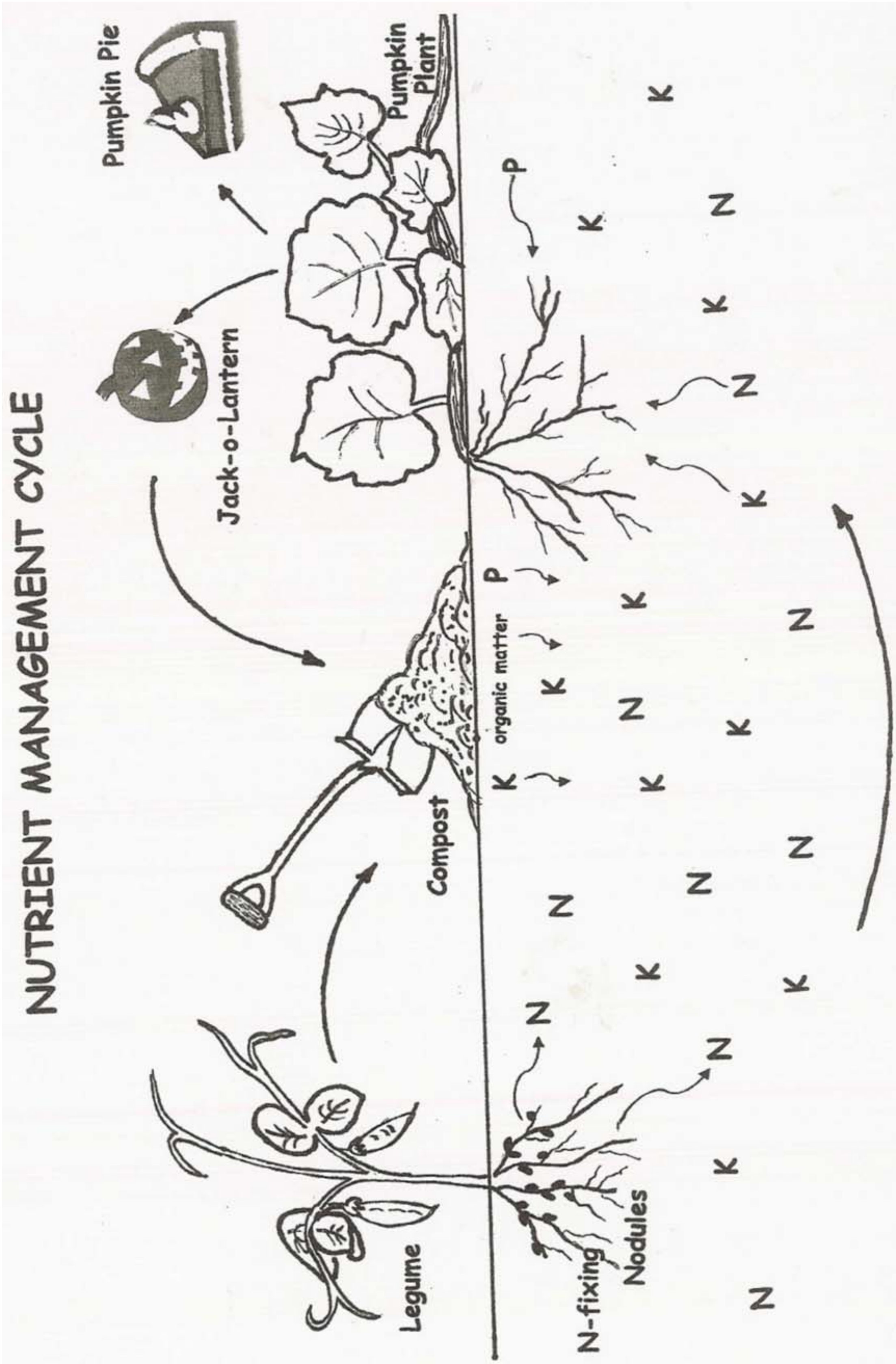
http://www.sadako.com/pumpkin/activities.html Watch a pumpkin seed grow in a home made sprouting chamber

http://www.farm-garden.com/growing-vegetables/growing-pumpkins.php

Diagram of the Nitrogen Cycle by Kenneth J. Edwards Jr. - VP Alken-Murray Corporation http://www.alken-murray.com/Nitrogen.html

http://zzyx.ucsc.edu/casfs/training/manual/contents.html

Appendix A: Nitrogen Cycle.



Appendix B: Pumpkin Harvest Data Sheet.

PUMPKIN HARVEST DATA SHEET

	Total	Legume field	Fallow field
Number of Pumpkins			
Average weight* of pumpkins			
Smallest Weight			
Largest Weight			
Average diameter** of pumpkins			
Smallest diameter			
Largest diameter			

*To find the average weight, add the weights of pumpkins together, then divide by the number of pumpkins.
** To find the average diameter, add the diameters of pumpkins together, then divide by the number of pumpkins.

Which field grew more pumpkins?

Which field grew heavier pumpkins?

Which field grew bigger pumpkins (diameter)?

What conclusions can you draw about planting a legume as a cover crop?