



“I can  
grow”  
Soil Symbiosis

Soil Nutrition and Plant Development

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Burpee Home Gardens acknowledges the National Gardening Association for their participation in developing the “I Can Grow” guide and educational materials.

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There is nothing like seeing the joy of discovery and self-satisfaction in the eyes of a child! At Burpee Home Gardens, we believe the vegetable garden offers the perfect opportunity to sow the seeds of a healthy mind, body and soul. It can teach children the wonders of nature along with hands-on skills that will stay with them – for a lifetime of good eating habits and environmental stewardship.

As the interest in school garden programs rises, so does the need for useful and fun curriculum guides and activities. In partnership with the National Gardening Association, Burpee has developed the “I Can Grow” guide for educators, and now expands that resource with individual lesson activities. These educational guides cover a range of subjects with activities rooted in the ground and in the world around us.

“I Can Grow” remains Burpee Home Gardens’ initiative to support the new, popular interest in vegetable gardening among younger and novice gardeners. The program reflects a growing interest in fresher, more nutritious food; supporting community needs and environmental responsibility; saving money; and finding personal satisfaction through home gardening.

From seed science and plant classification, to basic genetic and heredity lessons, and on to sustainability and nutrition practices, we hope these “I Can Grow” educational resources complement lessons in the classroom to discover a newfound awareness of the benefits of homegrown vegetables.



# Soil Symbiosis

**Objectives:** Students will understand that soil particle size will affect how a plant grows and develops. They will observe “Liebig’s Barrel” concept and be able to explain why the most limiting nutrient will determine the plant’s overall productivity. Students will examine the bacteria Rhizobium with a microscope and convey its importance in nitrogen fixation.

**Grade Level:** 3-9

**Time:**

**For Everyone:** 30 minutes

**For Older Students:** 1 hour

**Four Younger Students:** 45 minutes, with 15 minute follow-up

## Materials:

### For Everyone:

- An empty, clean gallon milk jug (see Teacher’s Note for preparation)
- Black marker
- Knife\*
- Corks or rubber stoppers in various sizes
- 1 gallon of water in a separate container

### For Older Students:

- Microscopes, preferably one for each pair of students
- Legume root nodules (e.g., clover), available from biological supply stores
- Scalpel or knife\*
- Microscope slides
- Coverslips
- Dropper of water
- Bottle of immersion oil with dropper (one drop for each pair of students)
- Optional: lens tissues

### For Younger Students:

- Large beaker or jar
- An assortment of golf balls, marbles and beads
- One quart jar for each soil sample, clean, with lid
- 1 tsp. salt
- 3-4 soil samples from different locations in the school garden or schoolyard

*\* Young children should be supervised carefully at all times when using scissors, knives, etc.*

## **Background:**

Soil is one of the most essential natural resources. Soil is important because it provides a place for roots to anchor and the nutrients plants need to grow. Plants provide us with food, clothing and shelter and they also add oxygen to the atmosphere, so without plants (and soil) we could not meet our basic needs for survival.

There are three particle sizes that make up the thousands of different soil types within the United States. These particles are known as sand, silt, and clay. Sand describes the largest particle followed by silt which is similar to flour in consistency. Clay is the smallest. Individual clay particles cannot be seen without magnification. The proportion of sand to silt to clay is one factor that determines the quality of the soil.

Soils with lots of sand have big spaces between the particles. They don't hold water or nutrients. Sandy soils don't stick together well and plant roots struggle to hold onto this soil. Silt is finer than sand and feels smooth and slippery. Silt is commonly found in areas that readily flood, which makes for excellent farmland, but it is also extremely susceptible to erosion. This is the soil that is blown away in dust storms or carried away during a flood. Clay particles are very small and they make the soil heavy and dense. The spaces between clay particles are very tiny. When clay soil is too dry it can be as hard as concrete. Plant roots can't push through it. Little air can get in from the soil surface to provide the oxygen that most bacteria and other soil organisms require. But clay is important because it can change the soil chemistry. Clays give off minerals and absorb acids, which are critical for plant growth and development. Plants grow best in a loam, or a mixture of sand and silt, plus a smaller amount of clay. This soil type has enough large and small spaces for air and water to travel through. Roots can easily grow through these spaces and absorb enough water and nutrients. It also has enough clay to hold the soil particles and organic matter together.

The soil provides structure to support the roots, holds and releases water to plants, holds and releases nutrients to plant roots, and recycles nutrients through decomposition of plant and animal residues to form soil organic matter. When plants experience a deficiency of a particular soil nutrient, it can result in stunted growth, an imbalance of other nutrients or even plant death. Excess amounts of a nutrient can also be detrimental. Since a plant can experience either a nutrient deficiency or toxic levels of nutrients, it is important to maintain adequate nutrient levels without giving the plant too little or too much.

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## **Background** *continued*

Nitrogen is often the mineral that has the greatest effect on plant growth. Although nitrogen is readily available in the atmosphere, plants are not able to use atmospheric nitrogen. Rather it must be converted into a different nitrogen compound to be absorbed by the roots. One way this conversion takes place is with the help of microorganisms such as fungi and bacteria. They work symbiotically with the plant to help convert the nitrogen to a form both they and plants can use (a process called nitrogen fixation). Plants in the legume family (peas and beans) are specifically adapted for nitrogen fixation. They grow Rhizobium bacteria nodules directly on their roots. The Rhizobium obtains sugar from the legume plants and returns to the plant a supply of fixed nitrogen. The nodules can easily be seen on the roots with the human eye.

### **Lesson Takeaways:**

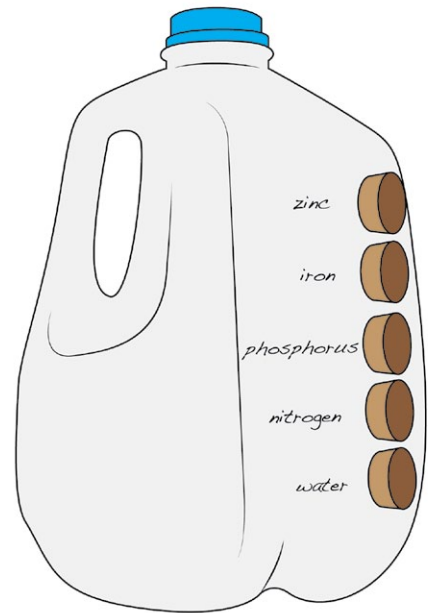
- Soil is an essential natural resource for plant growth.
- There are three particle sizes that make up soil types: sand, silt and clay.
- Plants grow best in loam, or a mixture of sand and silt, plus a small amount of clay.
- The mineral nitrogen is best absorbed by plants through soil.

## Activity for Everyone: Limiting Factors

**Teacher's Note:** Prepare the gallon jug in advance by cutting holes in it with a sharp knife; use the rubber stoppers or corks of different sizes to plug the holes. Write the needs and nutrients next to the corked holes (*see example*).

1. Have a student read the following paragraph:

Justus von Liebig was a German chemist who discovered that plants need nitrogen for their development. He formulated the “*Law of the Minimum*,” stating that a plant’s development is limited by the one essential mineral that is in the relatively shortest supply. He is known as the “*father of the fertilizer industry*” for his discoveries related to the development of nitrogen supplements. As a professor, he devised the modern laboratory and taught many students the importance of working in a laboratory to conduct scientific investigations. He is regarded as one of the greatest chemistry teachers of all time.



2. Relate to the students that Liebig demonstrated the “*Law of the Minimum*” by using wooden barrels. This concept of “*Liebig’s barrel*” is still a qualitative version of the principles used to determine the application of fertilizer today by demonstrating that plants grow proportionally to the most limiting nutrient.

3. Remove the corks/stoppers from the jug. Turn the jug away from the students so that they cannot see the holes and words. Have a catch basin below the jug to catch the leaking water.

4. Ask the students how much water the jug will hold? Begin to pour water into the jug; when the water begins to run out the bottom hole, turn the jug around so that students can discover why it isn’t filling up.

5. Tell the students that the total amount of water that the jug will hold represents plant growth and yield (i.e., productivity). Help them to see that when certain needs are not met, the plant cannot meet its full potential. Discuss the limiting nutrient concept.

6. Plug the holes from the bottom to the top to show that the jug will hold more water (i.e., will be more productive as these nutrient needs are met).

7. When the jug is full, remove the nitrogen stopper. This is a great illustration of the importance of nitrogen. If the nitrogen needs of the plant are not met, growth cannot continue beyond that point.

8. Ask the students to determine ways to provide plants with the proper nutrients. *Compost, commercial fertilizer, planting legumes/crop rotation.*

## Activity for Older Students: Recognizing Rhizobium

1. Tell the students that planting legumes (plants from the pea and bean family) is a great way to get nitrogen into the soil. When these plants are grown every other year it is called crop rotation and it is one of these most sustainable methods for replacing soil nutrients.
2. Divide the students into pairs. Each set of students should have a scalpel or knife, a pipette filled with water, a microscope slide and a coverslip.
3. Give each pair of students a root nodule and demonstrate the “squash technique” for observing the microorganisms.
  - a. Use a knife to cut the nodule in two and observe the color.
  - b. Use the pipette to place a drop of water on the slide.
  - c. Use the end of the knife to *carefully* grind up the nodule in the drop of water.
  - d. Place a coverslip over the material.
4. Have the students observe the material at 10X and 40X magnification. Then have the students place a drop of immersion oil on the coverslip and observe at 100X magnification. Students should be able to identify the rod-shaped bacteria.
5. Review the different types of symbiotic relationships between organisms. *Mutualism, commensalism and parasitism.*
6. What are the benefits that the plant receives from the relationship? *Supply of nitrogen.* What are the benefits that the bacteria receive from the relationship? *Supply of sugar and a home.* What are some other examples of beneficial bacteria?
7. Challenge the students to research other symbiotic relationships that occur within the garden or environment. Have them present their findings in a written report.
8. If you have legumes growing in a school garden, consider carefully digging up a mature plant and searching for the root nodules on the roots. Showing this to the students is a great way to solidify the concept to the students.

### Additional Activity:

1. Have students collect soil samples from the garden and perform simple soils tests for nitrogen, phosphorus and potassium. Simple soils test kits are available from gardening and home stores. Students should use the information collected to determine the best way to increase nutrient levels within the garden.

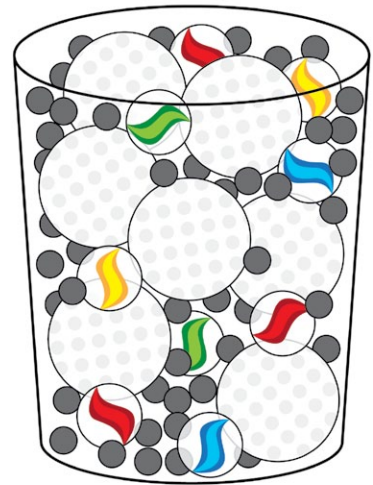
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## Additional Activity *continued*

2. Have the students examine pictures of plants with nutrient deficiencies. Ask the students to examine the plants in the school garden or schoolyard and make some hypotheses about how to better meet the plants' needs.

### Activity for Younger Students: Soil Spaces

1. Fill a large beaker or jar with a random assortment of golf balls, marbles and beads.
2. Tell the students that this jar represents a loam or a mixture of sand, silt and clay.
3. Ask the students to identify what each object represents. The golf balls represent the sand particles, marbles for the silt, and beads for the smallest clay particles.
4. Ask the students what other things are found within the soil. *Air, water, nutrients, organic matter, microorganisms and animals.*
5. To help the students understand how air and water move between the soil particles, divide the students into three groups. Have the first group stand and place their arms straight down to their sides. Have the second group place their arms on their hips with their elbows poking out from the sides. Have the third group hold their arms straight out from their body with fingertips extended. Now ask the students from the first group to stand with their arms touching—they should be standing very tightly to each other. The second group should stand with their elbows touching and the last group with their fingertips touching each other.
6. Now tell the students that you are going to become either air or water and weave your way through the students. They will immediately notice how easy it is for you to bend and weave through the fingertips and still through the elbows, but it is difficult with the arms. Challenge the students to guess which soil particles are represented through this activity. Review the background information with the students to help them understand how particle size affects plant growth and development.
7. Obtain 3-4 soil samples from different places in the school garden or schoolyard.
8. Place those soil samples in clean quart jars (they should measure about one inch deep in the jar). Add water to nearly the top of the jar (leave about 2 inches of head space) and add the salt (the salt will help disperse clay particles). Immediately students should see bubbles rising from the soil samples. Make sure to point this out to students so that they can see the air being released from the soil.



[Example: The golf balls are representative of sand particles; marbles of silt; and small beads of clay.]

## **Soil Spaces** *continued*

**9.** Twist a lid tightly onto the jar. Have students carefully shake the soil and water in the jar. Ask the students, what will happen to the soil in the jar? Predict which soil layers will settle first. *The sand particles are heavy and they will fall very quickly, followed first by silt and then clay. Organic matter will float at the top.*

**10.** Allow the jars to settle for a full day. Ask the students why there are layers of soil. What do the layers represent? What does this tell us about what kind of plants will grow best in the garden? How can soil be amended for optimal plant production?

**11.** Have the students measure the depth of each layer and compare the results between locations. Are there differences within the garden/schoolyard? Which sample had the most organic matter? Why is organic matter an important component of soil?