LESSONS TO GROW BY

Lessons to Grow By – Plant Needs

The bright green seedlings on the left received enough nutrients. The pale seedlings on the right did not.

In this series of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life.

Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions.

Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

Week 3: Nutrients

Learning Objectives:

This week focuses on the plant need of nutrients. Kids will:

- Learn what nutrients are and how plants obtain the nutrients they need to grow.
- Investigate how nutrient availability influences plant health and growth.
- Explore decomposition and the nutrient cycle.

Materials Needed for the Week

Activity 1: What are Nutrients?

- The Plant Nutrient Cycle Reading Page
- Nutrient Matching Game

Activity 2: Nutrient Experiments

- Tomato seeds
- Potting soil (without added nutrients), peat moss, or coir (coconut fiber)
- Containers
- Nutrient Experiment Worksheet
- A variety of fertilizers (optional)

Activity 3: The Nutrient Cycle

- Food scraps
- Plastic bags (at least 2)
- Soil from an outdoor location
- Decomposition Bag Observation Worksheet

Introduction

Just as vitamins help *people* grow and stay healthy, mineral nutrients help *plants* grow and stay healthy. The nutrients that plants require in relatively large quantities are nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. These are called **macronutrients**. Plants also need a number of other nutrients in much smaller quantities, including iron, copper, zinc, manganese, molybdenum, boron, nickel, and chlorine. These are called **micronutrients**. Though plants need just a tiny bit of these micronutrients (and many are relatively common in soils), a deficiency of any one of them can cause serious problems in plants.

It takes lots of energy and nutrients for a plant to produce such a huge melon!

Below are details about individual nutrients and how gardeners can supply some of these nutrients with fertilizers. But first, here's a closer look at the nutrient cycle in nature.

The Nutrient Cycle

In nature, plants obtain most of their needed nutrients from the soil. Nutrients occur naturally in the soil as a byproduct of the decomposition of organic matter, or in some cases they are released through the weathering process of parent rock. After being taken up by the roots, nutrients are then transported to the rest of the plant where they are needed. However, plants need help to access the nutrients.

Just like the living organisms above the ground, life underground also comprises a very intricate food web that includes both "producers" and "consumers" and results in the recycling of nutrients that plants need. In a simplified overview:

1. Plant roots give off substances called exudates that consist of carbohydrates produced by the plant through the process of photosynthesis.
2. These exudates become food for microscopic bacteria and fungi in the soil.
3. These tiny organisms are consumed by slightly larger life forms (although in most cases still too small to see with the naked eye), such as nematodes, protozoa, and some arthropods.
4. These organisms are eaten in turn by larger creatures that can be seen without a microscope, such as larger arthropods (like millipedes and sow bugs) and earthworms.
5. Finally, near the top of the web, small soil creatures become a buffet for even larger animals, such as moles.

Snails (above) and earthworms (below) break down organic matter, helping to recycle the nutrients it contains.

In addition to eating each other, many of these underground dwellers also consume dead and decaying organic matter (both plant and animal) that has made its way down to the soil. As they digest the decaying organic matter and then deposit it back into soil through their waste, these organisms return nutrients to the soil, "recycling" them so they can then be absorbed by living plants.

Additionally, there are many bacteria and fungi that also facilitate the availability of the nutrients to plants. Nutrients as they naturally exist in the soil are not always in a form that plants can use. Plants depend on soil-dwelling microorganisms to convert certain nutrients into accessible forms that are available for uptake. Some microorganisms even play an active role in helping roots with the process of absorption.

Fertilizers 101

Sometimes gardeners step in to help plants they're growing meet their nutrient needs — especially if the existing soil is lacking any of them. Scientists spent many years conducting experiments to identify the specific nutrients needed for healthy plant growth. They used that information to create substances we call fertilizers. It is important to note that fertilizer is not the same thing as plant food. Plants make their own food (carbohydrates) through the process of photosynthesis. To put it into "people terms," fertilizer is more accurately compared to a multivitamin.

Nutrients: The Big Three

Although plants need all of the macronutrients and micronutrients listed above for optimum growth, scientists have identified three that are needed in larger quantities. These three are often limiting factors for plant growth and are more likely to be missing from soil, especially in a garden setting. The big three plant nutrients are nitrogen, potassium, and phosphorus. Here is a brief overview of why plants need these nutrients, as well as signs that might show plants aren't getting enough of them:

Nitrogen is needed for the plant to make a number of essential compounds, including chlorophyll. A plant that does not have enough nitrogen will look weak and have light green to yellow older leaves.

Phosphorus plays an important role in helping plants make flowers, fruits, and seeds. If a plant does not have enough phosphorus, it may have small, purple-tinged leaves, and will develop few fruits.

Potassium impacts how well water can move around a plant and the opening and closing of the stomata. Common signs of potassium deficiency include stunted growth and yellowing or browning of leaf margins and weakened stems.

To help promote optimum plant growth, gardeners apply fertilizers containing missing nutrients to the soil around plants. Fertilizers are grouped into two major classifications: organic and synthetic.

Organic Fertilizers

These are derived from once-living ingredients. They include things like animal manure, composted plant matter, peat moss, and wood ash. Organic fertilizers more closely mimic the decomposition process that provides nutrients in nature.

- In addition to supplying nutrients to the plants, many organic fertilizers like compost improve the structure of the soil, thus improving the overall health of your plants.
- They are generally less concentrated and less likely to harm your plants if over-applied.
- They support the soil food web, which in turn supports plant life. There's an old saying, "Feed the soil, and the soil will feed the plants."
- They usually contain a multitude of other macronutrients and micronutrients, in addition to the N-P-K listed on the label, due to the variety of natural materials from which they're made.
- Note that some "certified organic" fertilizers, such as greensand and rock phosphate, are finely ground, naturally occurring rock.

Synthetic Fertilizers

Synthetic fertilizers are made up of chemicals that are usually derived from petroleum or rock. They are generally highly concentrated, offer quick results, and may be less expensive than organic fertilizers. Concerns about synthetic fertilizers include:

- They may have a negative impact on the naturally occurring organisms in the soil.
- They may wash away in heavy rains into the water system, leading to a form of water pollution.
- Because some types are in a concentrated form designed to be readily absorbed by plants, if too much synthetic fertilizer is applied it can harm and even kill plants.
- They contain only what's listed on the label — if a nutrient isn't listed, it's not in the fertilizer. Exclusive use of synthetic fertilizers can lead to deficiencies of other nutrients.

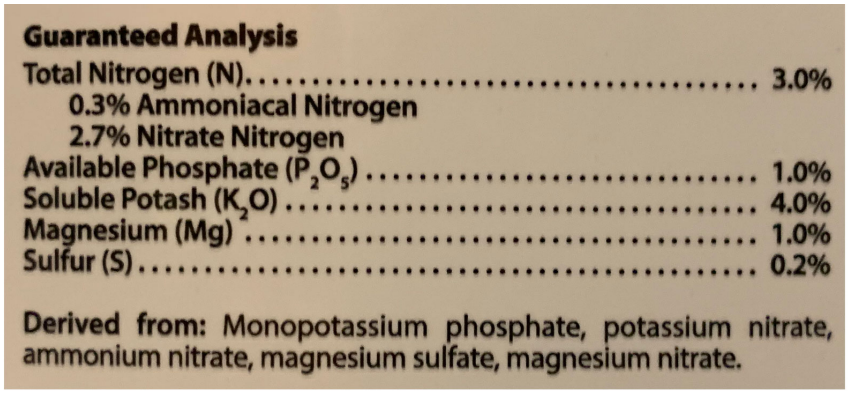
Note: To maintain plant health and reduce environmental impacts, always follow fertilizer label instructions and apply correctly.

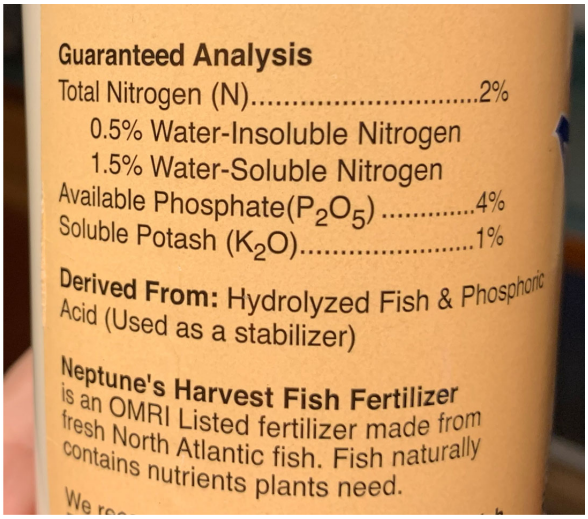
Deciphering Fertilizer Labels

No matter what kind of fertilizer you choose, most times you will notice three numbers listed on the packaging. These numbers represent the ratio of nitrogen, phosphorus, and potassium that is contained in the fertilizer.* An all-purpose fertilizer may list something like 5-5-5 which would mean that nitrogen, phosphorus, and potassium each represent 5% of the weight of the fertilizer. In a 5-5-5 synthetic fertilizer, the remaining 85% is made of some kind of filler, such as sand.

Note that organic fertilizers may have lower N-P-K numbers compared to synthetic fertilizers; at first glance it may seem that they offer less value. However, many organic fertilizers also contain a variety of important other nutrients, and the "filler" may be organic matter, humus, and other materials beneficial to soil life — as opposed to the inert material, such as sand, in synthetic options.

*Technically speaking, the three numbers represent the percentages of nitrogen (N), phosphate (P_2O_5, a source of phosphorus) and potash (K_2O, a source of potassium).





Labels from a synthetic fertilizer, above, and organic fish-based fertilizer, right.

Different Plants, Different Types and Amounts of Nutrients

Different N-P-K ratios are desirable for different types of plants. For example, flowering plants, bulbs, fruits, root crops, and vegetables require more phosphorus than potassium and nitrogen. For these crops, gardeners may choose an 8-12-4 formula.

In addition to needing different types of nutrients, different plants also need different quantities of nutrients. Some plants need a lot of nutrients for proper growth. Others are adapted to needing fewer nutrients. Tomatoes, for example require large amounts of nitrogen. From year to year, gardeners will rotate where tomato plants are grown in the garden to allow the soil to replenish its nitrogen supply. This rotation of crops is also beneficial in preventing diseases from ravaging the same food crop year after year. Flowers such as nasturtiums, on the other hand, prefer a “leaner” (less nutrient-rich) soil. Given too much nitrogen, they’ll produce loads of foliage but few blooms.

Looking Back to Nature

Although adding fertilizer is a handy trick for gardeners, imitating the nutrient cycle found in nature is much more beneficial over the long haul.

Unfortunately, a lack of understanding about the complexities and importance of the soil food web to the health of plants results in problems for many gardeners. The application of insecticides, herbicides, and synthetic fertilizers, along with horticultural practices such as repeated soil tilling, can impact underground organisms and destroy the balance of life within the soil system. For example, a fungicide applied to a lawn will not only kill the fungus that is attacking the lawn, it may also kill off the fungus that is working beneficially with the grass’s roots to make nutrients and water more available to them.

Supplementing soil with organic matter such as humus and compost is the best way to not only provide nutrients but also contribute to soil health. Other organic fertilizers that are friendly to soil microorganisms include liquid seaweed, fish emulsion, composted manures, and alfalfa meal.

Soil pH (acidity/alkalinity) also affects nutrient availability. A professional soil test can help you determine your soil’s pH and nutrient levels. Your state Cooperative Extension may offer soil test kits.

Activity 1: What is Air?

1. Together or independently, read The Plant Nutrient Cycle Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. After getting the background information for the reading page, have kids use the Nutrient Matching Game Worksheet to further explore the Big 3 nutrients that plants need: nitrogen, phosphorus, and potassium.

3. Depending on the time of year, you can extend this lesson by going on a nature walk to look for signs of possible nutrient deficiencies in plants. Vegetable gardens are a good place to look. A lot of our common vegetable plants, especially those that bear fruit that we harvest (it takes the plant more energy to make flowers, fruit and seeds) require more nutrients than other landscape plants.

Also, because we disrupt the nutrient cycle when we harvest vegetables and remove spent plants (nutrients that in nature would be returned to the earth), the soil may become depleted in some of the essential nutrients.

If an outdoor garden is not available to explore due to season or availability, indoor plants can also be explored.

Activity 2: Nutrient Experiments

1. Tomato plants need a lot of nitrogen for healthy growth and so they make a great test subject for nutrient experiments. You can purchase tomato seeds from a seed company, or you can also collect seeds from the tomatoes you eat at the grocery store.

   If you collect seeds from tomatoes you purchased from grocery store, the plants you get may not end up looking exactly like the parent plant because a lot of tomato plants are hybrids. But for this experiment you only need to grow the plants for about a month, not necessarily to maturity.

   To collect seeds from a tomato:
   - Cut open and scoop out the seeds and pulp and placing them in a plastic or glass container. Add enough water to cover.
   - Cover the top of the container with plastic wrap and let sit at room temperature for four days, stirring once daily. The viable seeds will sink to the bottom of the container, while the pulp and non-viable seeds will float to the top. Don't worry if you see mold forming on the floating material.
   - After four days, pour off the water while retaining the viable seeds. Rinse the seeds in fresh water, and drain. You can plant these damp seeds immediately. However, if you plan to store the seeds, spread them out on a sheet of newspaper or a paper plate to dry for 7-10 days.

2. To see the impact of nutrient deficiency on plant growth most quickly, use potting soil with minimal or no nutrients already added. Another option is to sow seeds in pure peat moss or coir (coconut fiber), both of which are low in nutrients. Alternatively, depending on your budget, you can use different types of potting soil mixes and compare the growth of your plants.

3. Fill small pots or seed planting trays with moistened planting mix. Instead of purchasing pots, you can also use recycled plastic or carton food containers; be sure to clean thoroughly and put holes in the bottom for drainage. Plant your tomato seeds ¼" deep and place the containers in a warm, bright location.

4. Watch your tomato plants grow and water as needed. Track observations in your garden journal or use the Nutrient Experiment Worksheet.

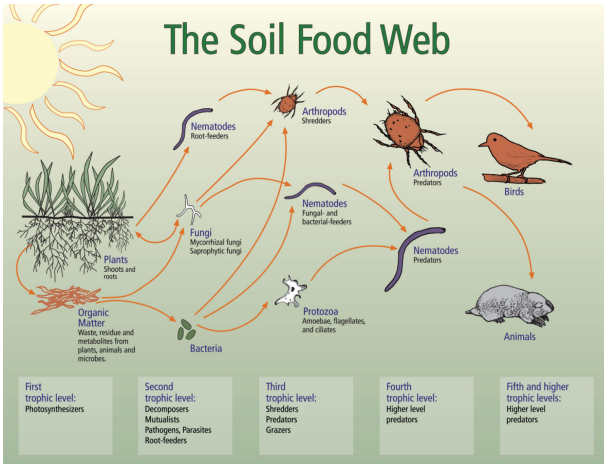
Keep in mind that seeds are like a lunchbox for the new baby plant. They not only include plant food (carbohydrates), but also some nutrients to help the plant begin its new life. So, when the seeds first sprout they will have some food and nutrients available to them which will sustain them for a bit. However, tomato plants quickly use the nutrients provided in this initial store, which is why they make good subjects for a nutrient experiment.

Tomato seeds contain enough stored food and nutrients to allow the seed to begin growing. When those run out, it will need a source of nutrients.

5. About 3 to 4 weeks after sprouting (depending on the nutrients in your potting soil mix), most tomato plants will start to show signs of nitrogen deficiency, such as the yellowing of lower leaves. At this time, you can choose to end your experiment, or you can extend the learning by providing your plants with a selection of fertilizers and then watching to see what happens to the plant when additional nutrients are added.

If you decide to keep growing, there are a number of organic and synthetic fertilizers available from garden centers. All fertilizers should be applied under close supervision of an adult. Read the label and follow the directions carefully when using.

Activity 3: The Nutrient Cycle



1. Use the Background Information above and the Plant Nutrient Reading Page to help you explain the process of decomposition to your kids.

   The Natural Resources Conservation Service of the USDA has a soil food web poster that you may want to use in order to introduce some of the soil decomposers who help make this process possible available at: https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg

2. Next, make simple decomposition observation bags to help kids visualize the decomposition process. Place pieces of plant debris, old fruit, vegetables, and moist bread in clear gallon plastic bags (make at least 2 bags). If you are only making 2 bags, place approximately the same things in about the same percentages in each bag. If you are making more than 2, you can experiment with different combinations for further exploration.

3. In half of your bags, also add a scoop of soil (do not add any soil to the other half of the bags). Close the bags and place them in a warm location where you can make daily observations. You can use your garden journal or the Decomposition Bag Observation Worksheet.

4. What to expect: You will likely see some mold and other fungal growth within a week; however, timing is dependent on the materials chosen, moisture level, and temperature. Continue the observations until the contents of some of the bags begin to resemble soil. Compile the results and discuss. Did some of the bags decompose faster than others? What factors seemed to influence the timing? What do you think was different in the bags that also contained actual soil? What does this information tell us about the formation of soil and recycling of nutrients?

5. Depending on the age and interest of your students, you can look at other variables with your test, such as sunlight availability (offering a variety of light exposures), temperature (perhaps put some in a refrigerator), and moisture levels. You can also experiment with keeping the bags/containers tightly closed versus introducing air regularly, but make sure to warn kids not to inhale or ingest contents while examining. Some types of mold can be harmful.

Extension

You can extend this activity by starting a worm bin composter to make your own fertilizer from worm compost and worm compost tea. Worms provide a free and hassle-free source of rich, organic fertilizer. What's more, they engage kids' hands and minds and teach basic environmental concepts — and they're just plain fun! To start your own worm "farm," you'll need an aerated container, bedding (such as shredded newspaper), a moist and temperate environment, a small amount of soil, and red wigglers. You can find detailed instructions for starting your own worm bin at: https://kidsgardening.wpengine.com/gardening-basics-worm-composting/

Digging Deeper

You can use the following resources to dig deeper into this week's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Diary of a Worm by Doreen Cronin

Compost Stew by Mary McKenna Siddals

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

Videos:

Soil Nutrients from the Ground Up from University of Wyoming Extension:
https://www.youtube.com/watch?v=gBrhZKuG-HY

Green Our Planet's Virtual Academy – What Makes Good Garden Soil?
https://www.youtube.com/watch?v=jVXQ207D9gQ

Green Our Planet's Virtual Academy – How to Make Compost Using Worms:
https://www.youtube.com/watch?v=ZsXt1xbVwmI

Nutrient Cycling Soil Food Web School:
https://www.youtube.com/watch?v=NVhY4ssMtbI

Big Green SEK Soil Investigation Video:
https://biggreen.org/edresources/video-library/

Additional Related KidsGardening Lessons and Activities to Try:

Garden Maintenance: Weeding, Mulching and Fertilizing:
https://kidsgardening.org/gardening-basics-garden-maintenance-weeding-mulching-and-fertilizing/

All the Dirt on Soil:
https://kidsgardening.org/gardening-basics-all-the-dirt-on-soil/

Soil is Alive:
https://kidsgardening.org/lesson-plan-soil-is-alive/

Digging into Soil:
https://www.diggingintosoil.org/

Worm Composting:
https://kidsgardening.wpengine.com/gardening-basics-worm-composting/

Make a Worm Composting Bin:
https://kidsgardening.org/worm-compost/

Gardening Basics- Composting:
https://kidsgardening.org/gardening-basics-composting/

Trouble Shooting Compost Problems:
https://kidsgardening.org/garden-how-to-troubleshooting-compost-problems/

Borage and Other Compost Plants:
https://kidsgardening.org/growing-guide-borage-compost-plants/