LESSON 3
Soil and Composting

Healthy soil = healthy plants. The biggest part of a gardener's work is to build good soil, since the soil helps feed your garden plants, and, ultimately, your friends and family. Soil in a natural system, such as a forest or prairie, is rich with nutrients and has a porous texture, because living organisms (insects, worms, microbes) are constantly decomposing dead plant matter on the ground and turning it into humus, the organic component of soil. The organic gardener seeks to mimic and speed up this natural process to build soil with these same positive attributes. Good soil looks dark and crumbly, smells 'earthy', and is full of living organisms and decaying organic matter.

Learning Objectives

1. Understand the primary elements that make up soil.
2. Understand how to test/evaluate your soil before starting a garden.
3. Know the various ways to improve soil quality through amendments and garden preparation.
4. Know how to start and maintain a compost pile and worm bin.

Materials Needed

For shake test:

- **quart glass jar, soil, water**

For compost pile:

- **used pallets for sides, wire/rope or cable ties for tying, 'brown' (dry) and 'green' (fresh) plant matter or food waste, water, pitchforks/shovels;**

For vermicompost bin:

- **plastic bin with lid or large bucket with lid, drill for making holes, torn cardboard or newspaper, water, worms, small amount of veggie waste.**

Soil Components and Properties

Healthy garden soil will have many, if not all, of the following properties:

1. *Mineral particles* (sand particles are largest, silt is medium sized, clay is the smallest or finest) are the "bones" of the soil; Good soil, or "loamy" soil, has at least two or all three sizes of these particles. They come originally from rock.

2. *Organic* matter is once-living matter (like plants, animals, insects, animal waste) in various stages of decomposition.

3. *Biota* (bacteria, fungi, protazoa, mites, worms, ants, etc) are living organisms that decompose organic matter. This converts nutrients into forms that are accessible to plants. Larger organisms like worms also create space in the soil.

4. *Porosity* is the presence of pores/spaces made by roots and biota, which allows for water and nutrients to reach roots and for roots to grow.

5. *Structure* describes how the soil particles are arranged relative to each other (do they bind closely?) and partially determines porosity of the soil.

6. *Drainage* is how readily water seeps down through the soil; it is determined by the soil's mineral makeup, structure, and management. It is closely related to porosity.

Soil Tests to Determine Componets and Properties

(For additional tests see "10 easy soil tests" in the references section at the end of the lesson):

1. *Touch Test* - Feel the soil, dry and wet. When dry, does it crumble easily? If not, it may be compacted or have a lot of fine clay particles. If it's powdery or feels like sand it is likely lacking organic matter. Take a small handful, wet it and rub a little between your fingers. Now squeeze the soil into a ball. Sandy soils feel gritty. Silty soils feel slippery. Clay soils feels slippery and sticky. A good mixed soil will form a ball, but not easily form a ribbon shape when squeezed between thumb and forefinger. A clay soil will easily form a ribbon about 2 inches long and hold the shape, but a very sandy soil will not form a ball or ribbon.

2. *Shake Test* - Place a cup of your garden soil in a clean quart glass jar and fill up to ¾ full with water. Label the jar to indicate from where in your garden space the soil came. Shake well, then let it sit for several hours or ideally overnight. The particles will separate into layers. Observe the proportions of sand (bottom), silt (middle), and clay (top). While most soils in their natural proportions will need amendment, this test will give you a good sense of what type of soil lies beneath your garden and how well it will drain.

3. *Test Kits:* You can test soil with a soil nutrient test kit, a kit typically under $10 and commonly available at nurseries and home improvement stores. With this you can test the soil's pH and its nitrogen, phosphorus, and potassium (NPK) content. These are the primary macronutrients needed by plants. They are the elements that plants use most for their growth, so knowing the content of those elements in the soil and the soil's pH will help you predict how plants will grow.

4. *Other Soil Tests:* There are places to send soil samples for more rigorous testing to determine its micronutrient levels or to test for soil contaminants. If you are concerned about your garden site's past history, or especially if it was used for a commercial or industrial activity, it is worth testing to determine if your garden soil has contaminants like lead or mercury. Possible companies for our region include:

General Analytical Laboratories	www.galtest.net/index.htm
Wallace Labs	www.bettersoils.com/default.cfm
Clarkson Lab	store.clarksonlab.com
Environmental Engineering	619.298.6131
Fallbrook Ag Lab	760.728.4628
John Deere Landscapes	www.johndeerelandscapes.com
Pacific Analytical Incorporated	760.496.2200
Soil and Plant Lab	714.282.8777

Soil Building and Preparing for Planting

Soil amendments help create healthier soil by improving soil nutrients, soil texture, and/or porosity which, in turn, promotes good plant growth. How you prepare for planting can also impact soil health. The results of soil testing will help you best determine how to amend your soil. You'll learn what nutrients and properties your soil has and what it lacks. For more detail on nutrients needed for plant growth, see "Plant Nutrients" from the North Carolina Department of Agriculture at: www.ncagr.gov/cyber/kidswrld/plant/nutrient.htm.

Soil Amendments

1. *Compost* is an amendment of decomposed organic matter, which, when mixed into your soil adds nutrients, food for biota, good texture, water-holding capacity, and more (see below for compost lesson). Worm castings and/or tea- castings are a specific form of compost created by earthworms, which are rich with balanced nutrients. The liquid created naturally by worm composting can be added as an excellent amendment to your garden.

2. *Organic fertilizers* are amendments that are natural substances with relatively high levels of nutrients. Examples are kelp, fish emulsion, bloodmeal and manure. You can buy these premixed or separately at many garden stores. When using organic fertilizers of any kind, it is very important to not over-apply the fertilizer; apply only as directed by the package or your source. Plants will not use extra fertilizer that is applied. Instead, the excess will be shed into the environment, potentially contaminating air, streams, rivers, stormwater run-off, and the ocean with nutrient pollution.

3. *Cover crops* such as fava beans, vetch, rye grass, and clover are grown specifically to enrich the soil rather than to eat. Cover crops do one or more of the following: increase soil nutrients and organic matter, prevent soil erosion, send down deep roots to break up compacted soil layers or suppress weeds. For some N fixers like legumes it is recommended that before they set seed, you either harvest and compost or cut them down and till into the soil where they will break down over time. They will then eventually provide nutrients to your food crops. Legumes, such as clover and fava beans, "fix" nitrogen in the soil through a symbiotic relationship between the plants' roots and a type of bacteria (Rhizobia), that converts atmospheric nitrogen into a form that is useable to the plant. In return, the bacteria receive sugars from the plant. See appendix "Cover Crops" for more information on this process and how and why to use cover crops.

4. *Mulching* involves adding organic materials on top of the soil that break down over time to increase soil organic matter. Straw, woodchips, sawdust, tree bark, or shredded leaves can be used in mulching. Mulching serves an important role in protecting topsoil from erosion, suppressing weeds, keeping soil cool, and preserving soil moisture by slowing down evaporation. Mulches should stay on top of the soil because many of them are mostly carbon and they can tie up soil nitrogen when they decompose in the soil, thus making the nitrogen less available for plants.

Soil Preparation for Planting

One common preparation for an in-ground bed is double digging, described below. However, you might also decide to use a rototiller, especially for heavy soils, or to use a "no-till" approach. No-till minimizes soil disturbance, preserving existing organisms, and amendments are added on top rather than digging them in. Sheet mulching is a form of no-till, using layers of organic materials to create the bed.

1. Double digging is a technique to build a raised bed, loosen the soil and add amendments. It is used to create new, in-ground beds. To make a double-dug bed, dig a trench 1' deep and 1' wide across the width (no greater than 4 feet) of the bed, setting the dug soil aside but nearby. Plunge a pitchfork 1' deeper in the trench and rock back and forth, loosening the soil. You can also add some compost at this point. Dig a second trench behind the first, and put excavated dirt into the first trench, filling it in. Pitchfork the second trench. Continue in this pattern down the entire bed. For a demonstration video, see the following YouTube videos from Windy Hill Farm:
   www.youtube.com/watch?v=UkU5nwGU_kA or
   www.youtube.com/watch?v=W85QmZgDxFk

2. Sheet Mulching: You can use a technique called "sheet mulching" or "composting in place." It is a "no-till" method to enrich soil in your garden bed by laying down the components of compost to create your garden bed. Also called "lasagna" beds, this technique conserves water, moderates soil temperature and suppresses weeds in addition to amending your soil. For more complete detail and a recipe for "sheet mulching", see the appendix by Elevitch and Wilkinson called, "Sheet Mulching : Greater Plant and Soil Health for Less Work."

Composting and Using Compost: A Closer Look

Composting is a good way to put your kitchen and garden waste to good use. Compost is a wonderful soil amendment. With time and the activity of microbes,insects and worms, kitchen and garden waste turns into dark, crumbly, nutrient-rich matter to add to your garden soil. There are three commonly practiced ways of composting: an active "hot" pile, a passive pile or worm composting.

Making Compost and Vermicompost

See appendices "Building Fertile Soil" for more details on composting techniques, and "Worms and worm bins" for more details on vermicomposting.

Making Compost

You can make compost in an uncontained pile, a large crate, or in a small bin (even indoors). Any form of composting requires combining "browns"(dry carbon sources like straw, newspaper, dead leaves) with an equal amount/volume of "greens" (living nitrogen sources like fresh garden waste, and kitchen scraps). Compost piles also need air and moisture to speed the breakdown process. See the appendix "Building Fertile Soil" for more on composting techniques.

1. *Active composting,* or creating a "hot pile" of these ingredients in a concentrated area like a bin requires more gardener involvement. Active piles are tended by the gardener regularly. They are turned at least once a week to provide air and moisture throughout the pile and to thoroughly mix all ingredients. Active piles break down into compost more quickly and compost can be ready in as little as 7 or 8 weeks. Decomposition is done by a range of microbes, fungi, protozoa etc. and it is their metabolic activity that is the heat source, (not the sun or some other external source). Essentially, you are speeding up the natural breakdown of these materials into nutrient-rich food for your garden. Also, a "hot" pile of between 130 and 140 degrees can kill pathogens and weed seeds.

2. *Passive composting* is simply heaps of browns and greens that break down naturally with little gardener involvement. This is much like what happens in a forest or other plant rich environment. They need to be occasionally moistened if they dry out. Passive piles will break down into compost more slowly; compost can be ready in 4-6 months.

3. While much organic matter can go into a compost pile, there are some items to avoid: meat, bones, cheese and other non-plant-based material. These items tend to attract pests like rodents more than vegetable matter does.

4. It can take some practice to achieve the right moisture and temperature level for ideal composting. Refer to the appendix "Building Fertile Soil" for more details.

ACTIVITY 1

Build a simple compost bin as a class and add initial materials.

Making Vermicompost

Vermicomposting is a process that uses worms, specifically Red Wigglers (*Eisenia foetida*) (as well as naturally-occurring microbes) to turn organic waste into odorless and nutrient-filled worm composts (also known as worm manure or castings). It is a fast way to change organic waste into a valuable natural fertilizer. The production of worm castings usually takes about 4 to 6 weeks. It is a promising sustainable method. You can also collect "worm tea" from your worm bin.

Making and Using "Worm Tea"

Worm tea is the natural by-product of worm castings and moisture. You can collect worm tea by placing a container beneath your worm bin where liquid in the bin can accumulate. This oxygenated liquid causes a bloom of good bacteria, plus the added benefit of nitrogen, phosphate, calcium, magnesium and potash. You can water your plants with it.

This type of organic plant food is said to increase plant appearance and increase productivity 4-10 times. Plants really perk up with this product, almost over-night. It's like having a compost pile in a bottle, much easier to use and it's available year around. This organic plant food is great if you have pets or children, there are no chemicals to be breathed in, digested, or absorbed through the skin.

A basic recipe for worm tea is 1 cup of composted worm castings, 1 tablespoon of molasses, and water. Fill an empty bucket with water and let it sit overnight to kill off any chlorine. Place the worm castings in an old sock or handkerchief. Add the molasses and sock / handkerchief to the water and let set for 24 hours. Stir occasionally. The worm tea is read for use.

Since the tea is alive and full of microbes, it has a shelf life. The quicker you use it, the greater the benefit. If your tea stinks, it has gone bad, and don't use it. The most common way to use the tea is to put it in a hand sprayer and spray your plants with it. Think of worm tea as a natural immune system booster for plants. It provides the good microorganisms and nutrients needed for plants and soil to repel insects and disease.

For more details on vermicomposting, see the appendix by Lori Marsh called "Composting Your Organic Kitchen Wastes with Worms"

ACTIVITY 2

Build a vermicompost bin system in class for each participant. Each participant can provide the plan and materials listed in the Lori Marsh article.

Using Compost

1. Typically, a 2-3 inch layer of fully-decomposed, uniform compost spread over each bed and dug in to a depth of 8 - 10 inches before planting is ideal. Compost can also be spread around a plant that is planted.

2. Double-digging (see earlier in the lesson for how-to) is a good way to thoroughly incorporate compost into the soil. When filling in each trench, add compost.

3. You can also add worm castings in the same way you would use regular compost, or spray worm tea, a solution made from worm castings steeped in water and strained.

References

1. Marsh, Lori.
   Virginia Cooperative Extension.
   "Composting your organic kitchen waste with worms"
   Learn about why and how to use Red Wigglers to compost kitchen scraps.

2. Monahan, Julie.
   "10 Easy Soil Tests"
   Learn how to perform soil tests for various soil characteristics.

3. Windy Hill Farm.
   Double Digging videos.
   Available at: www.youtube.com/watch?v=W85QmZgDxFk
   www.youtube.com/watch?v=UkU5nwGU_kA
   See double-digging in action so you can mimic the process.

4. UC Santa Cruz Center for Agroecology and Sustainable Food Systems.
   "Building Fertile Soil."
   A detailed but accessible resource on the positive qualities of soil and how to create them; how to compost.

5. UC Santa Cruz Center for Agroecology and Sustainable Food Systems.
   "Cover Crops for the Garden"
   What are cover crops and how to use them in the garden.

6. Knol.google.com. Easy steps for Vermicomposting. Version 2.
   Available at: knol.google.com/k/dr-worms/easy-steps-for-vermicomposting/3uwot87iz92z0/2
   A short how-to on starting a worm composting bin.

7. North Carolina Department of Agriculture.
   "Plant Nutrients."
   Available at: www.ncagr.gov/cyber/kidswrld/plant/nutrient.htm
   An overview chemical elements that are known to be important to a plant's growth and survival.

8. Elevitch, C.R. and K.M. Wilkinson. 1998.
   "Sheet Mulching: Greater Plant and Soil Health for Less Work."
   The Overstory.
   Available at: www.agroforestry.net/overstory/overstory96.html
   A guide for protecting and enhancing soil.