Soil

"Soil" is a really big topic (about 7 million square miles of the Earth's surface if you're considering the stuff we can grow crops in), but this page will try to break it down into just what people want to know in order to grow vegetables in the DuPont Community Garden.

If you're on this page to answer a specific question, you may use one of the following hyperlinks to take you to the appropriate topic:

At its most basic, soil is a mixture of minerals — clay, silt and sand — and of organic matter from the decaying remains of once-living things. It has been formed over the millennia by processes of weathering, glaciation, digestion by lichens and microorganisms, and the decay of organic life.

The texture of a specific sample of soil comes from the percentages of those ingredients.

- Clay — the very smallest of soil components — is good for retention of moisture and minerals, but too much of it and the soil is too heavy and too wet to grow crops in.
- Silt is mostly broken grains of quartz, ranging in size from just larger than particles of clay to just smaller than grains of sand. Like clay, it can promote water retention but at the same time provides enough coarse structure to allow air to circulate among plant roots.
- Sand, when seen under a microscope, looks like a bunch of marbles — large, rounded particles with lots of space in between. Those spaces allow moisture and nutrients to wash right on through, which is why garden soil needs other components including organic materials. On the other hand, sand does help prevent soil compaction and promotes good drainage. You'll note that most vegetables are described as preferring well-drained soil. It also helps prevent root rot, crown rot and other diseases.
- Organic material serves many purposes. Most importantly, it provides many of the nutrients that plants need to grow and thrive. It also "softens" soil and makes it so that the roots can more easily grow and spread. Organic material also acts like small sponges and allows the soil to retain water.

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The best soil is a balanced mixture of those ingredients plus good amounts of oxygen, water and living things.

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To be more specific about “organic material”: Basically, it exists in three general forms — dead plant material, **compost** and **humus**.

Dead plant material can be such things as leaves; non-woody stems and branches from plants; food scraps; and various grasses, grains and legumes that have been through the digestive system of cows, chickens, etc.

Organic material that is no longer supported by a living organism will decompose. Composting is simply speeding up the process by providing an ideal environment for the bacteria, fungi and creatures to perform the decomposition — providing a balance of aeration and moisture in a confined area. Under proper conditions, the process of decomposition will produce enough heat (130 to 140 degrees Fahrenheit) to destroy most weeds, plant diseases and the larvae or eggs of any pests.

Compost that has been sufficiently “aged” will have nutrients available for growing plants. It will also continue to decompose and release more nutrients as the beneficial microorganisms do their work. Eventually, all of the molecules of organic material that the microorganisms can break down will have been used up. What remains will be very large, complex carbon based molecules that provide structure for the soil for many years. This is humus.

What is good gardening soil?

Each vegetable seems to have a different soil preference, which makes it difficult to generalize any one type of soil as “the best.” Nevertheless, there are certain soil properties that make it “arable.”

- Good soil should contain organic matter and a combination of the essential nutrients nitrogen, phosphorous, and potassium plus micronutrients such as boron, copper, iron, chloride, manganese, calcium, molybdenum, and zinc.
- All vegetables need a good amount of organic material in the soil. The soil color provides a rough indicator of the amount of organic matter; very pale or ashen soils generally have an absence of it while higher levels show up as darker colors.

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IMPORTANT NOTE: The soil that we use in the DuPont Community Garden has all been purchased from a local company and trucked into the garden. It is referred to as “3-way mix”: equal parts sand, loam and compost. This mix is designed to provide optimal levels of both nutrient retention as well as drainage.

How acid should soil be?

No matter what else you do, the acidity of your soil can make or break your garden’s success. That’s because soil acidity plays a huge role in how well your plants can get at the nutrients they need.

The more acidic the soil is, the more easily minerals and plant nutrients dissolve in water. Since plant roots can only slurp up nutrients that are dissolved, this has a big impact on your plants. More dissolved nutrients can help plants out in moderation, but it can easily go too far.

When soil is too acidic, a whole lot of minerals end up dissolved in the water. In very acidic conditions, these minerals can get so concentrated that they become toxic. They can also be toxic to the soil microbes that break down organic matter and help your plants thrive. High concentrations of dissolved minerals make other nutrients harder for your plants to access too.

It’s much less common in the Pacific Northwest, but soils can also be not acidic enough. The opposite of acidic is alkaline. In soils that are too alkaline, it’s hard for plants to access the minerals they need, no matter how much fertilizer a gardener might add.
The take-home message is: it’s all about balance. Plants thrive best within their optimum pH range, which is usually just a bit acidic — in the range of 6 to 7.

Here in the Pacific Northwest, our soils naturally run a bit on the acidic side. Due to the rocks our soils come from and the amount of rain we get, soils in our region usually have a pH of about 5-6. This is great for northwest native plants like Pacific rhododendrons and red flowering currants. It’s also good for a few other plants like azaleas and blueberries.
But vegetables and many popular non-native ornamental plants will struggle in our naturally acidic soils. We need to help them out so that they can thrive here.

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For an accurate measure of soil acidity, you can either submit a sample to a place that has a soil testing service, or purchase a soil tester for yourself. The other option is to perform a DIY soil test that gives less precise but generally useful results.
Two suggested DIY methods:

Number One: Test for alkaline soil.

1. Scoop some soil from the planting area into a clean plastic container.
2. Add 1/2 cup of distilled water to the soil sample and mix. (Use only distilled water since tap water won't have a neutral pH.)
3. Then, add 1/2 cup of vinegar.

If the soil shows a visible bubbling or fizzing action, then it has an alkaline pH. This chemical reaction occurs when an acid (vinegar) comes into contact with something alkaline (soil). The more pronounced the fizzing action, the higher the pH.
Because most of our soil is naturally slightly acidic, any reaction at all with this test indicates that you probably have alkaline soil that may require an amendment to bring it to the pH range suitable for most plants.

Still on test number one: Test for acid soil

1. Scoop another soil sample into a fresh container, add 1/2 cup of distilled water, and mix.
2. Then, add 1/2 cup of baking soda.

If the soil bubbles or fizzes, the soil is acidic. The reaction you're seeing is the result of acidic soil coming into contact with an alkaline substance (baking soda). Again, the vigorousness of the action will give you some indication of how acidic your soil is.
A very small amount of fizzing is natural since most of our soil is slightly acidic to begin with. But a forceful reaction may indicate that you have very acidic soil. You will need to amend the soil to raise the pH. This is generally done by adding lime. Garden lime, also known as calcium carbonate, can be found at most garden supply stores.

Test Number Two:
An alternative method of testing soil pH involves red cabbage.

1. Chop the cabbage into small pieces before boiling it in a pot of distilled water.

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2. After about 10 minutes, the boiling water should turn violet. Remove the pot from the stove and strain out the cabbage.
3. Pour some of the water remaining in the pot into a clear container.
4. Add a spoonful of soil to the violet water and monitor how its color changes.

If the water turns pink, that means the soil acidic; if blue-green, the soil is alkaline. The stronger the color change, the more acidic or alkaline the sample. If the liquid does not change color at all, then the soil is neutral.

Why do we use raised beds?

In general, raised beds have advantages over in-ground gardens:

- They provide great drainage, especially needed with our heavy, clay soils, which tend to hold water very strongly.
- The soil in a raised bed warms earlier in the spring and stays warmer later in the fall.
- The higher beds are easy to access.
- Weeds and pests can be easier to control.
- A raised bed can be covered in winter, providing an opportunity to grow some cool weather crops for all-winter use.
- Irrigation and fertilization needs are limited to the raised beds and not the surrounding pathways.

Specific to our situation in DuPont is the fact that the existing soil is heavily contaminated with lead, arsenic and heavy metals from two industries that operated in the area for decades.

- For almost 100 years, the Asarco Company operated a copper smelter in Tacoma. Air pollution from the smelter settled on the surface soil of more than 1,000 square miles of the Puget Sound basin. Data from the Tacoma Smelter Plume project places our garden in the area of having 40 to 100 ppm of arsenic in the soil. Read more here: https://ecology.wa.gov/Spills-Cleanup/Contamination-cleanup/Cleanup-sites/Tacoma-smelter

- Additionally, the garden is located on land that was part of the DuPont Powder Works, which operated from around 1906 until the mid 1970s. That operation also added significant levels of lead and arsenic in the soil.

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Because of the high level of toxic chemicals in the local soil, every bit of the soil we use in the DuPont Community Garden has been purchased from an outside source. [see earlier "Important Note"]

This is also why we maintain a supply of 3-way soil for replacing any that is lost from beds in the garden.

How should soil be prepared for planting in the spring?

So how do you know your soil is ready to be worked? The tried-and-true method is the squeeze test. Grab a fistful of garden dirt and squeeze. If it easily forms a ball that doesn't crumble, it's not ready. But if it breaks down into granules as you squeeze (because there isn't enough moisture to allow it to clump) then it's ready

Start with a spring cleaning of the area, removing anything in the way until you are back to the bare soil. Dead organic matter can go on the compost pile to break down. Well-composted mulch or organic matter can stay right where it is to be incorporated into the soil, but "fresh" mulch needs to be raked away to expose the soil.

Your main concern will be any weeds that might still be alive. Make sure to get as much of the weed's root system as you can. This is especially important with the very deep-rooted grass that creeps up into the planting beds. You'll find it much easier to effectively remove these grasses before you've planted any crops in the soil.

Since the soil tends to become compacted during the winter, you want to loosen it back up by turning it. Using a garden fork or a sharp spade, work the soil to a depth of 12 to 14 inches. Any mulch or leaf litter that is well-composted should be mixed right in.

> A small tiller can also be used to loosen soil, but experts caution that over-tilling reduces or even destroys some of the soil's structure; the pore structure that allows for easy movement of air and water.

Next add compost and amendments. You can use a soil test to see where you pH and nutrient levels are, which will tell you what type of materials you might want to add.

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One recommendation is once the soil has been turned, leave it in the condition of coarse chunks for a few days to allow birds to pick through it and harvest overwintering soil grubs and insect eggs. Then rake the surface smooth and water thoroughly. Allow the bed to rest several days before you plant so the soil amendments can do their work.

Wait two to three weeks after tilling before planting seeds or seedlings. This gives helpful microorganisms disrupted by the tilling time to reestablish and begin developing nutrients in the soil.

What can be added to the soil to make it better?

There are a number of soil amendments which can be added —

- Compost is a natural organic material that is produced when leaves, plant residue, grass clippings and other yard waste break down over time.
  - Leaves and other plant material that hasn't been well-composted will use up [nutrients] and do more harm than good.

- Tagro (short for "Tacoma Grow" is a blend of pasteurized wastewater byproducts called biosolids and other weed-free gardening components. It's nitrogen-rich (approximately 16-8-1) and is described as having a pH of 8.2 (somewhat alkaline). The Garden contracts with the City of Tacoma to have a certain quantity of it delivered every year.
- Bagged manure is an animal product that has been aged and processed to where it's no longer smelly nor is it high in ammonium like fresh manure. Nutrient content varies according to whether it's from dairy cows, steers or poultry, but all of it is tied up in organic forms so that it is only released gradually by action of soil microorganisms — thereby avoiding problems with over fertilizing.
  - Cow manure is generally better for gardens than steer manure since dairy cows eat more grassy foods such as hay and alfalfa while steers eat in feedlots where their foods are rich in grains such as corn. Steer manure tends to be higher in salt which can affect crops in high concentrations.

To prepare your soil for planting, spread any needed amendments like compost and work them into the soil with a tiller or spade.

- "Microbes" or microorganisms is a generic term for a wide range of microscopic life. They benefit garden soil by digesting organic matter which then provides nutrients to plants and helps improve the structure of the soil. There are a number of products available which claim to add beneficial microbes to soil however, since each gram of soil — approximately the weight of a paperclip — will already contain anywhere from 100,000 to 1 million living microbes, it will be more productive to promote the health of your existing population of them rather than introduce a bunch of new ones that may or may not thrive in our local conditions.

- Boosting the health of existing microbes is best done by adding more organic matter to the soil, giving them more food to live and grow.

- **Beneficial nematodes** are microscopic, non-segmented roundworms that occur naturally in soil throughout the world. Inside the nematode's gut is the real weapon — beneficial bacteria that when released inside an insect kill it within 24 to 48 hours. The hyperlink will take you to the page on beneficial nematodes in the section on pest controls.

Fertilizer

Growing crops takes up the nutrients from the soil, and those nutrients should be replaced in the spring before more plants are grown there. Fertilizers replace those lost nutrients, and ensures that soil nutrient levels are at an acceptable level for healthy growth.

In general nutrients are classified as either basic nutrients or micronutrients.

- The essential nutrients are Nitrogen, Phosphorus and Potassium – the familiar N-P-K listed on any container of fertilizer.

- **Nitrogen** helps with plant growth above ground. Nitrogen does a great job of promoting the green, leafy growth of foliage; and it provides the necessary ingredients to produce lush green lawns, but an overabundance of nitrogen in a vegetable garden is generally counterproductive.
- **Phosphorus** is very effective at establishing growth below ground, in the form of healthy root systems. It is also the component most responsible for flower blooms and fruit production.
- **Potassium** is important for overall plant health. It helps to build strong cells within the plant tissue and allows the plant to withstand various stresses; such as heat, cold, pests, and diseases.

Fertilizer marked as 10-10-10 is a balanced blend of equal portions of Nitrogen, Phosphorus and Potassium. This is what’s termed the “well-balanced fertilizer” most often recommended for growing vegetables.

In addition to N-P-K, there are 7 essential plant nutrient elements defined as micronutrients — also known as “trace” elements: boron (B), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), molybdenum (Mo), chlorine (Cl). (Some sources list Nickel (Ni) as an 8th element.) They constitute in total less than 1% of the dry weight of most plants.

The ideal first step would be to get a basic soil test to see what kind and amount of fertilizer to apply to get to a healthy level of nutrients. Not everyone has the time or inclination to get a soil test. Instead we apply a moderate dose of 10-10-10 fertilizer in the spring when plants need the most help getting started.

Apply fertilizer with caution, though: The only thing worse than starving a plant of nutrients is to overfertilize it. Among other effects, okverfertilizing can result in abnormal growth or reduced fruit production.

In addition to a spring application, plants may also need help when they have been growing and absorbing nutrients for a while, but still need to continue growing.

- For long-season crops many gardeners apply a small amount of fertilizer as a starter at the time of seeding, and then also add a larger amount in early summer, just before the period of rapid foliar growth.
    - **Tomatoes** for example will need extra fertilizer mid-season as the plants take up and use existing nutrients. When tomatoes start producing flowers, switch to a low-nitrogen fertilizer in order to encourage more flowers and fruit rather than foliage.

Depending on what they're made of and/or how they're produced, fertilizers may be classified — and labeled — as either "processed" or as "organic."

Processed fertilizers (also called "synthetic" or "chemical" fertilizers) are manufactured from natural ingredients such as phosphate rock (P) and sodium chloride (NaCl) and potassium chloride (KCl) salts, but these are refined to be made more concentrated. Most (but not all) processed fertilizers are quick-release in a water-soluble form to deliver nutrients quickly to the plant, which can be useful in some situations. (There are some processed fertilizers that are coated to slow down the release.)

Organic fertilizers are materials derived from plants that slowly release nutrients as the micro-organisms in the soil break down. Often applied in granular form (spread over the soil), most organic nutrients are slow-release, adding organic material to the soil so that you don't need to apply it nearly as often. (Plus, they don't leach into and pollute waterways, as do many of the synthetic, water-soluble fertilizers, which plants can't fully absorb.) While most organic fertilizers are slow-release products, some release a portion of their nutrients quickly (examples are animal manure, biosolids, and fish emulsion).

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Chemically, the nutrients for processed and organic fertilizers are the same. Ideally, slow is the way to go. Slow-release granular fertilizers meter out nutrients in a controlled, “digestible,” and safe manner, as opposed to fast-acting, synthetic, water-soluble fertilizers, which are, in essence, an overdose.