

## It's Not Just Dirt...

**I**t's the basic raw material of the gardener's art! Soil is a complex structure full of living organisms. Therefore, the more you can tell about your soil's characteristics, the more effective you can be in managing and improving your garden's production.

### Soil Texture

Soil texture refers to the relative proportions of sand, silt and clay particles that make up the soil. Sand is the largest particle, silt is the intermediate size and clay is the smallest. Rub some soil with a bit of water between your fingers; sand particles will feel gritty, silt will feel smooth like flour and clay particles will be sticky.

Texture is important because it determines the amount of watering and fertilizing your plants will require. For example, sandy soils drain so fast they don't retain water or nutrients well. Fertilizer leaches, or moves down rapidly, through the soil. Therefore, sand requires more frequent watering and fertilizer applications. However, sand's relatively coarse structure does provide good aeration for root growth.

On the other end, clay retains water and nutrients well. It will require less frequent watering and fewer applications of fertilizer; however, because the tiny clay particles fit so closely together, poor drainage and aeration can cause roots to literally drown.

Silt falls somewhere in between the other two; it retains nutrients better than sand and has better drainage than clay. A mixture of clay, silt and sand with generous quantities of organic matter makes an excellent garden soil.

It comes as a surprise to many beginning gardeners that there



is little that you can do to change the soil's texture; if you have clay, you will always have clay. However, we'll tell you how to improve your soil's structure in the next section.



## Class Activity

### Determine Your Soil's Texture

An easy way to determine soil texture is to shake some soil in a jar of water and watch it settle. Sift some soil to remove chunks, pebbles and debris. Put a cup of sifted soil into a straight-sided quart jar. Add one tablespoon each of table salt and laundry detergent. (These act to disperse the negative charge of the clay particles and help eliminate binding between different soil particles.) Add water until almost full. Secure the lid tightly and shake vigorously for five to ten minutes (or long enough to give everyone a turn). Put the jar where it won't be disturbed. As the particles settle, sand will reach the bottom first, silt will be next and clay will be the slowest to settle. When the water is clear, all the particles have settled, and students can determine the relative percentages of each by the thickness of the layers.



## Soil Structure

Soil structure refers to the arrangement of sand, silt and clay particles in the soil, which determines its permeability and its ability to retain water. For example, soil particles might be clumped together in large chunks that allow water and air to pass through easily, or separated into tiny pieces that fit tightly together like a jigsaw puzzle and prevent water and air from penetrating. As stated earlier, you can't change soil's texture; however, you can improve its structure by adding plentiful amounts of organic matter. Organic matter is the decayed remains of formerly living plants or animals. (See the following list of soil amendments for different types of organic matter.) Adding organic material to clay soils helps improve drainage and aeration; added to sandy soils, organic matter will help retain water and nutrients. Organic matter in all types of soils can improve soil fertility.

Whatever your soil, if you live in the Southwest, you should add organic material on a regular basis, at least two–three times per year. Since our soils contain less than one-half of one percent of organic matter, which is continually decomposing into its basic elements, adding organic material is not a one-shot deal but a regular garden maintenance item. Plan on incorporating a three- to six-inch layer of organic matter into the soil before each planting season. This is one of the most important things you can do to improve your garden.

Soil organisms that consume the organic matter and break it down into nutrients for your plants need nitrogen to do their work. For short periods of time, they can actually “rob” the soil of nitrogen that should be feeding your plants. That is why it is important to do one of two things when adding organic matter to your soil:

1. Add organic matter two to three weeks before planting and irrigate thoroughly, allowing the soil organisms to do their work and then release the nitrogen back into the soil for your plants' use. Or,

2. If you can't wait to plant, add a nitrogen source to your organic matter before incorporating it into the soil. (Sources of nitrogen are listed below under “Fertilizers.”)



## Soil Amendments: Organic



### Compost

- Most valuable amendment for desert soils.
- Make it on-site at little or no cost. It will provide a great learning experience for kids to see how the earth “recycles” plants. (Appendix B lists references for making compost.)
- Provides food for beneficial microorganisms and worms.
- Improves sandy soil’s ability to retain water and nutrients.
- Improves drainage of clay soil.



### Manure

- Use manure only from plant-eating animals, such as cows, sheep, horses, rabbits and chickens. Do not use dog, cat or pet bird manure, which may contain parasites that can spread to humans.
- Should be well-aged (six months) or composted with other materials because its high salt content may burn roots.



### Leaves

- Best if composted first. Whole leaves may take a long time to decay and often create a dense mat.
- If no shredder is available, run a lawn mower back and forth over the leaves until shredded.



### Pine needles

- Best if composted first. Waxy coating on needles means they can take a long time to decay and prevent the soil from absorbing water. Pine needles are acidic and can help lower the high pH (alkalinity) of desert soils.



### Cover crops

- Legume crops (peas, beans, alfalfa) are also a good source of nitrogen.
- See “Cover Crops” in Chapter 13 for further information.

Do not use fireplace ashes, which are highly alkaline and will only contribute to the high alkalinity of desert soils.





## TIP

A constant supply of organic matter in the soil will attract earthworms, those fascinating and hardworking creatures who decompose organic matter and make it available for plants, aerate the soil and leave behind their rich castings, or droppings. And, kids love earthworms!

## Macronutrients

This is a good time to discuss soil fertility and nutrients. The major nutrients that plants need are nitrogen, phosphorus and potassium, which correspond respectively to the three numbers marked on bags of fertilizer. The numbers represent percentage of contents by weight. For example, a bag of ammonium nitrate (33-0-0) contains 33 percent nitrogen, 0 percent phosphorus and 0 percent potassium. A container of fish meal marked 5-3-3 contains 5 percent nitrogen, 3 percent phosphorus and 3 percent potassium, by weight.

Although how plants use these three nutrients for growth and reproduction is intertwined and extremely complex, it might be helpful for beginning gardeners to think of them in the following manner: nitrogen produces green, lush vegetative growth; phosphorus helps promote root growth and the reproductive cycle (flowers and fruit); and potassium strengthens the plant's hardiness, vigor and disease resistance. Unlike nitrogen, phosphorus does not easily move through the soil with watering. Phosphorus is usually mixed thoroughly into the soil before planting or placed at the bottom of planting holes where it is readily available for uptake by the plant's roots.

Annual flowers and vegetables need nitrogen and phosphorus for quick, single-season bursts of productivity. Perennial herbs need far fewer fertilizer dressings as they will become fairly invasive on their own. Southwestern soils already have plenty of potassium, so if you are purchasing fertilizer, a "zero" for the third number is perfectly acceptable. So is a fertilizer with potassium.

Calcium, magnesium and sulfur are other nutrients that plants require. Calcium and sulfur are usually added in the form of soil amendments such as gypsum (calcium sulfate) or soil sulfur. (See the section on “Sodium in the Soil” below for more information on these soil amendments.) Magnesium deficiency is generally not a problem with vegetables, flowers or herbs in our soils.



## Micronutrients

In addition to the above macronutrients, there are also micronutrients that are equally important to the health of plants but are needed in much lower quantities. They are boron, chlorine, copper, iron, molybdenum, and zinc. Compost and other types of organic matter are a good source of the important micronutrients. Fish emulsion and kelp are other sources. Generally, it is not necessary to apply micronutrients to annual flowers and vegetables. Check with your local County Cooperative Extension office for special conditions in your area.

## Fertilizers

Organic fertilizers contain carbon; they may be natural or man-made. Natural organic fertilizers are derived from the decayed remains of formerly living things and have had minimal processing, such as bone meal or fish meal. Man-made organic fertilizers, such as urea, are synthetically manufactured from materials containing carbon. When we talk about organic fertilizers in this book, we are referring to the natural organics.



Soil microorganisms will further decompose organic fertilizers, and this slow-release process feeds both the soil and the plants during the growing season. Organic fertilizers help to foster abundant microbial life in the soil. Over time, less nitrogen needs to be added to the soil.

Inorganic or synthetic chemical fertilizers are man-made and contain no organic (carbon) elements. They are made from mineral salts. They are usually more highly concentrated and less expensive than organic fertilizers. Inorganic products generally contain only nitrogen, phosphorus and potassium so they don't have some of the indirect benefits, such as micronutrients or organic matter, that organic products can have. Because they are highly concentrated, inorganic fertilizers can burn the plant if too much is used or it is placed too close to the roots.

How quickly nutrients are available to plants is largely determined by water solubility. If the fertilizer is not water soluble, then the plants can't absorb it immediately. It must first be consumed by soil microorganisms and then released. Inorganic fertilizers are often in a form that is released and absorbed more quickly by the plants than are organic fertilizers. There are also slow-release inorganic fertilizers. They are in a pellet form with a coating that gradually decomposes and releases the fertilizer to the plant. Slow-release fertilizers tend to be more expensive than other types.



## Choosing a Fertilizer

Which should you use? Plants do not differentiate between organic and inorganic nutrients. The form that the nutrient takes when it is absorbed by the plants' roots is the same whether it was derived from a natural or a synthetic source. But fertilizers are more than just nutrient carriers, and they impact more than just the plants. The misuse of fertilizers can kill microorganisms, alter soil characteristics, pollute water supplies and may even affect pest and disease resistance.

Some people believe that the "ecological profile" of a fertilizer is more important than whether it was dug from the ground or "produced" in some way. Not all "natural products" are healthy (e.g., grass clippings from a lawn that has been heavily treated with herbicides and pesticides); and not all synthetic products are



bad for the environment. For example, elemental sulfur, which can help control plant diseases and neutralize soil alkalinity, may be naturally mined or scrubbed from industrial smoke stacks. Distinguishing between sulfur obtained from these two different sources is difficult. Using the waste-product from the smoke stacks promotes clean-air controls and makes them more economically feasible. This may be a more environmentally sound practice than mining.

As you can see, there are many variables to consider when selecting a fertilizer. Examine the accompanying charts for some of the pros and cons of each type. Involve the children in the decision. As you continue to add organic material to the soil over the years and become more familiar with the nutritional needs of plants, you may discover that you do not need to rely on the quick bursts of elements provided by synthetic fertilizers. Appendix B lists books on organic gardening if you want further information.



### Questions To Ask When Choosing A Fertilizer

It is probably not possible to answer all of these questions for each fertilizer. However, it is a good place to start to involve students in a discussion of choices they can make and the possible long-term consequences.

1. How quickly will the nutrients be absorbed by the plants?
2. What effects will it have on plant growth and health?
3. What is its cost?
4. Is it convenient to use?
5. What will it do to, or for, soil organisms?
6. Can it lead to air or water pollution?
7. Does its mining, manufacture or transport harm the environment?
8. How energy intensive is it to produce?
9. Does it recycle an existing organic waste product?
10. Is there an alternative that may be more environmentally benign?



## Natural Organic Fertilizers

Type	Primary element	N-P-K ratio*
Alfalfa meal	Nitrogen	5-1-2
Blood meal	Nitrogen	14-0-0
Coffee grounds	Nitrogen	7-2-2
Cottonseed meal	Nitrogen	6-2-1
Fish emulsion	Nitrogen	5-2-2
Seabird guano	Nitrogen	1-12-0.5
Bone meal	Phosphorus**	1-11-0
Rock phosphate	Phosphorus**	0-3-0
Greensand	Potassium	0-0-7
Seaweed/kelp	Potassium	1-0.5-2.5
Compost	varies	0.5-0.5-0.5 to 4-4-4

\*N-P-K analysis can vary considerably.

\*\*These decompose and release phosphorus very slowly in our alkaline soils. A little soil sulfur added with it can speed up the process.



### Advantages

- Slower to leach from soil; fewer applications required.
- Encourages beneficial soil organisms and worms.
- Improves soil structure, including aeration and moisture-holding capacity.
- Little or no salt build up.
- Difficult to overfertilize and burn plants.
- Most contain micronutrients.
- Compost recycles yard waste rather than sending it to landfills.



### Disadvantages

- Takes longer to decompose and allow nutrients to be available to plants.
- May need to be combined with other types to create a complete fertilizer.
- Analysis of NPK ratio can vary; ratio is usually low.
- Usually not as concentrated as synthetic fertilizers.
- Cost per pound of nutrients is higher.

## Inorganic Fertilizers

Type	Primary element	N-P-K ratio
Ammonium nitrate	Nitrogen	33-0-0
Ammonium sulfate	Nitrogen	21-0-0
Ammonium phosphate	Phosphorus	16-20-0
Triple super phosphate	Phosphorus	0-45-0

### Advantages

- Nutrients have been broken down into simple molecules; thus are readily available to plants.
- Higher or more concentrated nutrient levels.
- Cost per pound of nutrients is lower.

### Disadvantages

- Nitrogen generally leaches through the soil fairly quickly, so requires more frequent applications.
- Overfertilizing may burn plants.
- No beneficial impact to the soil's structure.
- Do not provide organic matter, which is extremely important for soil fertility and workability.
- Many are easily volatilized (lost to the air) if not immediately watered in.



## Soil pH

Soil pH is a measure of the soil's level of acidity or alkalinity on a scale from 0–14. Readings below a neutral 7 are acidic; those above are alkaline. Southwestern desert soils generally register between 7.5 and 8.5. Unlike much of the rest of the nation, we do *not* add lime to our soils, which would cause increased alkalinity. Nutrients are more available to the plants in the neutral range. The addition of organic matter, which puts acidic compounds in the soil, can improve pH on a temporary and localized basis. This



adjustment to the pH makes minerals like iron more available to, or easily absorbed by, the plants.

## Sodium in the Soil

Clay soils have a tendency to attract and hold sodium (in addition to other nutrients), and our limited rainfall does not usually leach sodium from the soil. Our water contains sodium, and after we irrigate, evaporation will tend to leave it and other salts on the soil surface. Shallow and frequent watering practices, which may moisten only the top few inches of soil, add more salt to the soil surface. (See Chapter 11 for a discussion of correct watering practices.) As sodium accumulates, it disperses the clay particles and impedes water penetration through the soil. To remedy the situation, apply gypsum or soil sulfur and water deeply (12–24"). Calcium in the gypsum will cause sodium in the soil to be leached beyond the root zone. Soil sulfur will accomplish the same result through a different set of chemical reactions in the soil. Gypsum and soil sulfur are considered to be inorganic soil amendments because they contain no carbon.

As with the addition of organic matter, this is not a permanent solution and should be repeated yearly. Incorporating one of these products into the soil during bed preparation is easiest. Follow package directions to determine how much to apply.



## Soil Amendments: Inorganic



### Gypsum (calcium sulfate)

- Improves the structure of clay soils and thus helps improve drainage.



### Soil sulfur

- Improves the structure of clay soils and thus helps improve drainage.
- A naturally occurring mineral that can, on a limited basis, lower soil pH and make some nutrients more available to plants.
- Some organic gardeners believe that soil sulfur is detrimental to earthworms, particularly if it is not well mixed into the soil.
- Sulfur is not recommended for soils that will be growing onions, as it makes them more pungent.

