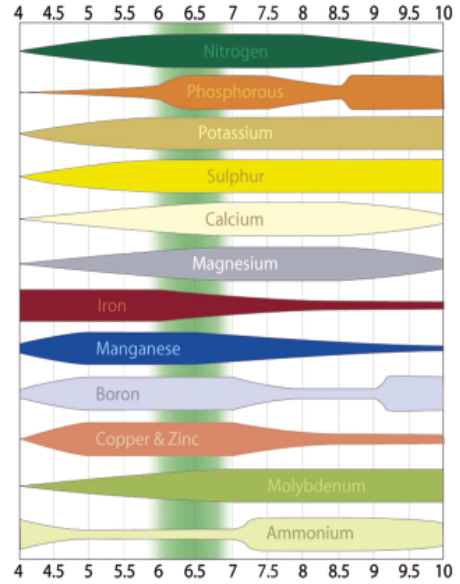
Rich healthy soil is the key to succes, whether gardening outdoors, or in containers.

This cutaway drawing shows how the roots penetrate the soil. Note: There must be enough air trapped in the soil to allow biological activity and absorption of nutrients.



This pH Chart shows the Safe Zone is between 5.8 and 6.8.

Introduction

Soil is made up of many mineral particles mixed together with living and dead organic matter that incorporates air and water. Three basic factors contribute to the plant root's ability to grow in a soil: texture, pH, and nutrient content.

Soil texture is governed by the size and physical makeup of the mineral particles. Proper soil texture is required for adequate root penetration, water and oxygen retention and drainage as well as many other complex chemical processes.

Clay or adobe soil is made up of very small, flat mineral particles; when it gets wet, these minute particles pack tightly together, slowing or stopping root penetration and water drainage. Roots are unable to breathe because very little or no space is left for oxygen. Water has a very difficult time penetrating these tightly packed soils, and once it does penetrate, drainage is slow.

Sandy soils have much larger particles. They permit good aeration (supply of air or oxygen) and drainage. Frequent watering is necessary because water retention is very low. The soil's water- and air-holding ability and root penetration are a function of texture.

Loam soil is ideal for gardens. It contains a mix of clay, silt, and sand. The different sized particles allow a large combination of pore spaces, so it drains well and still retains nutrients and moisture.

To check soil texture, pick up a handful of moist (not soggy) soil and gently squeeze it. The soil should barely stay together and have a kind of sponge effect when you slowly open your hand to release the pressure. Indoor soils that do not fulfill these requirements should be thrown out or amended. See "Soil Amendments."

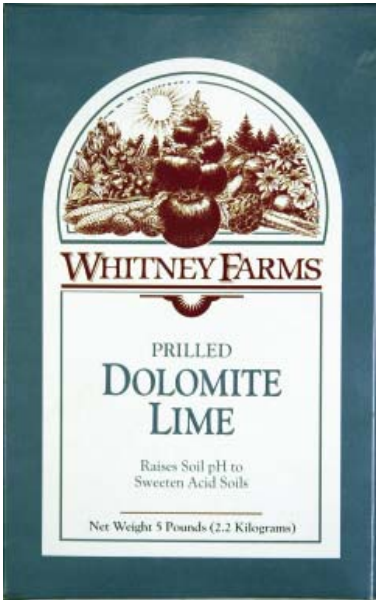
pH

The pH scale, from 1 to 14, measures acid-to-alkaline balance. The number 1 is the most acidic, 7 is neutral, and 14 most alkaline. Every full-point change in pH signifies a ten-fold increase or decrease in acidity or alkalinity. For example, soil or water with a pH of 5 is ten times more acidic than water or soil with a pH of 6. Water with a pH of 5 is one hundred times more acidic than water with a pH of 7. With a ten-fold difference between each point on the scale, accurate measurement and control is essential to a strong, healthy garden.

An inexpensive electronic pH tester is easy to use.

Most plants grow best in soil with a pH from 6.5 to 7. Within this range plants can properly absorb and process available nutrients most efficiently. If the pH is too low (acidic), acid salts chemically bind nutrients, and the roots are unable to absorb them. An alkaline soil with a high pH causes nutrients to become unavailable. Toxic salt buildup that limits water intake by roots also becomes a problem. Hydroponic solutions perform best in a pH range a little lower than for soil. The ideal pH range for hydroponics is from 5.8 to 6.8. Some gardeners run the pH at lower levels and report no problems with nutrient uptake. The pH of organic soil mixes is very important because it dictates the ability of specific pH-sensitive bacteria.

Measure the pH with a soil test kit, litmus paper, or electronic pH tester, all of which are available at most nurseries. When testing pH, take two or three samples and follow instructions supplied by the manufacturer "to the letter." Soil test kits measure soil pH and primary nutrient content by mixing soil with a chemical solution and comparing the color of the solution to a chart. Every one of these kits I have seen or used is difficult for novice gardeners to achieve accurate measurements. Comparing the color of the soil/chemical mix to the color of the chart is often confusing. If you use one of these kits, make sure to buy one with good, easy-to-understand directions, and ask the sales clerk for exact recommendations on using it.



When planting, add one cup of fine dolomite lime to each cubic foot (one ounce per gallon) of planting medium to stabilize the pH and provide calcium and magnesium.

For an accurate pH test with an electronic pH meter:
- Clean the probes of the meter after each test and wipe away any corrosion.
- Pack the soil around the probes.
- Water soil with distilled or neutral pH water before testing.

If using litmus paper, collect samples that demonstrate an average for the soil. Place the samples in a clean jar, and moisten the soil samples with distilled water. Place two pieces of litmus paper in the muddy water. After ten seconds, remove one strip of litmus paper. Wait a minute before removing the other one. Both pieces of litmus paper should register the same color. The litmus paper container should have a pH-color chart on the side. Match the color of the litmus paper with the colors on the chart to get a pH reading. Litmus paper will accurately measure the acidity of the substance to within one point. The pH readings will not be accurate if altered by water with a high or low pH, and the litmus paper could give a false reading if the fertilizer contains a colored tracing agent.

Electronic pH testers are economical and convenient. Less-expensive pH meters are accurate enough for casual use. More-expensive models are quite accurate. Pay special attention to the soil moisture when taking a pH test with an electronic meter. The meters measure the electrical current between two probes and are designed to work in moist soil. If the soil is dry, the probes do not give an accurate reading. I prefer electronic pH meters over the reagent test kits and litmus paper because they are convenient, economical, and accurate. Once purchased, you can measure pH thousands of times with an electronic meter, while the chemical test kits are good for about a dozen tests. Perpetual pH-metering devices are also available and most often used to monitor hydroponic nutrient solutions.

Check the pH of irrigation water. In dry climates, such as the desert Southwest United States, Spain, and Australia, irrigation water is often alkaline with a pH above 6.0. The water in rainy climates, such as the Pacific Northwest of North America, the United Kingdom, Netherlands, and maritime Northern Europe is often acidic with a pH below 6.0. The pH and EC of water supplies in municipalities and cities can also change throughout the year in some countries. After repeated watering, water with a pH that is too high or low will change the pH of the growing medium, especially in organically amended soils. Raw-water pH above 6.0 helps keep fertilizer mixes from becoming too acidic. Climatic conditions can also affect irrigation water pH. For example, the pH can become more acidic in late autumn, when leaves fall and decompose. Large municipalities carefully monitor and correct the pH, and there are few water-quality problems. Check the pH at least once a week.

Plants will grow in almost any soil but will flourish when the pH is between 6.5 and 7. Commercial potting soil almost never has a pH above 7.5. A lower pH is more common, even as low as 5.5. Some potting soils purchased at a nursery are pH balanced and near a neutral 7. However, most potting soils have a tendency to be acidic. The easiest way to stabilize soil pH is to mix in one cup of fine dolomite lime per cubic foot (0.25 liters) of potting soil. Mix dolomite lime thoroughly into dry soil. Remix the soil in the container after it has been watered.

Fine dolomite lime has long been a favorite pH stabilizer for gardeners. It is difficult to apply too much as long as it is thoroughly mixed into soil. Dolomite has a neutral pH of 7, and it can never raise the pH beyond 7.0. It stabilizes the pH safely.

Compensate for acidic soil by mixing dolomite with soil before planting. It will help keep the pH stable and maintain the correct pH when applying mild acidic fertilizers. Dolomite, a compound of magnesium (Mg) and calcium (Ca), is popular among indoor and outdoor gardeners in rainy climates with acidic soil. Dolomite does not prevent toxic-salt accumulation caused by impure water and fertilizer buildup. A proper fertilizer regimen and regular leaching help flush away toxic salts. When purchasing, look for dolomite flour, the finest fast-acting dust-like grade available. Coarse dolomite could take a year or more to become available for uptake by roots. Mix dolomite flour thoroughly with the growing medium before planting. Improperly mixed dolomite will stratify, forming a cake or layer that burns roots and repels water.

Hydrated lime contains only calcium and no magnesium. As the name hydrated implies, it is water-soluble. Fast-acting hydrated lime alters the pH quickly. Mix it thoroughly with warm water and apply with each watering for fast results. Many gardeners use a mix of 0.25-cup (6 cl) hydrated lime and 0.75-cup (18 cl) dolomite lime. Hydrated lime is immediately available, whereas the slower-acting dolomite buffers the pH over the long term. Do not use more than 0.5-cup (12 cl) of hydrated lime per cubic foot of soil. The larger quantity is released so fast that it can toxify soil and stunt or even kill plants. The beauty of hydrated lime is that it washes out of the soil in about two weeks. Leach it more quickly by flushing pots with copious quantities of water. Hydrated lime is also used as an indoor garden fungicide. Sprinkle it on the floor and around the room. It kills fungus on contact.

Do not use quicklime; it is toxic to plants. Calcic lime (quicklime) contains only calcium and is not a good choice. It does not have the buffering qualities of dolomite nor does it contain magnesium.

Raise the pH of a growing medium or irrigation water by adding some form of alkali, such as calcium carbonate, potassium hydroxide, or sodium hydroxide. Both hydroxides are caustic and require special care when handling. These compounds are normally used to raise the pH of hydroponic nutrient solutions but can be used to treat acidic nutrient solutions when applied to soil. The easiest and most convenient way to raise and stabilize soil pH is to add fine dolomite lime and hydrated lime before planting. To raise the pH one point, add three cups (60 cl) of fine dolomite lime to one cubic foot (30 L) of soil. An alternate fast acting mix would be to add two and one half cups (590 cl) of dolomite and one-half cup (12 cl) of hydrated lime to one cubic foot (30 L) of soil.

Pulverized eggshells, clam or oyster shells, and wood ashes have a high pH and help raise soil pH. Eggshells and oyster shells take a long time to decompose enough to affect the pH; wood ashes have a pH from 9.0–11.0 and are easy to overapply. Ashes are often collected from fireplaces or woodstoves that have been burning all kinds of trash and are, therefore, unsafe. Do not use wood ashes on indoor gardens unless you know their origin, pH, and nutrient con-