SOIL AND HOW TO TREAT IT

John Cooper
Denton County Extension Horticulturist
jn-cooper@tamu.edu

The Soil Teems With Life

The general health of any plant depends in great measure on the soil environment. After all, half the plant is underground. Besides serving as an anchoring medium in which the plant can stand up, the soil serves as a vast reservoir of water, oxygen and minerals. The soil is teeming with roots, microbes, insects and earthworms in dynamic interaction with considerable effects on soil fertility and plant growth.

A single grass plant may produce 375 miles of roots consisting of almost 14 million individual roots with a combined exposed root surface area of 2,500 square feet. Plant roots continually grow and mine the soil for available water and nutrients.

As roots explore the soil, they perforate the soil extensively and most eventually die, leaving a fine network of organic matter throughout the soil profile which tiny microbes use for food. The microbes, in turn, die and release the digested minerals back to the soil for use by plants.

Better managed lawns and sports turf soils typically contain more than 900 billion microbes for each pound of soil within the root zone. This equals 70 pounds of microbes in each 1000 square feet of soil six inches deep. As these microbes die, they return about 7 pounds of nitrogen, 3.5 pounds of phosphorus, 1.4 pounds of potassium and lesser amounts of other essential elements.

Ants, nematodes, mites, spiders and other macro-organisms inhabiting the soil are less populous than soil microbes but are just as important. Their milling breaks the soil and improves the tilth. There are on the order of one to two million (15-30 pounds) of these critters per 1000 sq. ft. of soil in your yard right now.

Of the soil macro-organisms, earthworms are the most venerated. Although they account for only about eight percent of the total soil macro-organisms, they are highly beneficial to soil tilth. As they mill the soil, they secrete cementing agents which bind soil particles, improving soil structure and increasing pore space.

Plant Health Begins with Good Soil

The foundation of terrestrial plant life is soil. Gardeners understand soil fertility and periodically test their soil to determine the availability of the 13 soil-derived minerals required by plants for normal growth and development, but soil texture and depth which determine the air and water conditions in the rooting profile are just as vital to good plant health.

The mineral fertility of a soil is derived from the minerals locked inside individual sand, silt and clay particles. No matter whether your soil was deposited by wind, water, arose from underlying bedrock, or imported by truck, it is composed of ground up rocks. The individual particles of sand, silt, and clay are the most enduring and unalterable aspects of soil.

Every soil has a certain inherent mineral fertility based on the mineral composition of the parent rock material from which it was derived. A common misconception is that soil fertility can be permanently improved with organic matter. All the organic matter you add to the soil eventually turns into carbon dioxide, water, and heat. No doubt, organic matter helps get new plants off to a good start and is highly useful in "open beds" where frequent and continuous infusions can be made such as for flowers and vegetables but the permanent, lasting, and inherent fertility of a soil will always be based on its mineral content.

Individual soil particles occur in an infinite range of sizes from very coarse to very fine and classified as sand, silt or clay. These soil particle classifications determine soil texture. Texture is so important that soils are named according to their textural classification.

Loam is a term used to describe a soil with a good amount of all three soil particle sizes. Loamy soils are considered good because each particle size, sand to clay, contributes favorable soil characteristics. Sand provides good aeration, drainage, and capture of rainfall and irrigation water. Clay provides water-holding capacity and fertility. Silt bridges the sand and clay particles, making them compatible.

According to standard soil texture classifications, a loamy soil has 7-27 percent clay, 28-50 percent silt and less than 52 percent sand. Loamy soil names, from coarse to fine, include sandy loam, fine sandy loam, very fine sandy loam, loam, silty loam, sandy clay loam, silty clay loam, and clay loam.

Besides the texture of the soil, the quantity of the soil, measured by its depth is equally important. It doesn't matter how good your soil is though if there isn't much of it. Every landscape can use 6 inches of a good, medium-textured soil for turf, 12 inches for ground covers, 18 inches for shrubs, and 24 inches for trees. This gives ample soil for rooting but does not guarantee drainage. There could be an impermeable soil layer below the prescribed soil depth which backs water up into the root zone.

To check drainage, dig a hole one foot deeper than the prescribed rooting depth and fill it with water. The hole should drain completely within 48 hours. If not, dig through the impermeable soil layer and replace the soil with an imported loamy topsoil or plant on a raised berm.

When importing topsoil, use a medium-textured soil. Loamy soils improve the drainage and aeration of clayey soils and improve the fertility and water-holding capacity of sandy soils. Importing loamy soil will improve the depth of loamy soils.

The fertility of a soil is derived from the minerals in the individual particles of sand, silt and clay. No matter whether your soil was deposited by wind or water or arose from underlying bedrock, the particles of soil originated from rocks composed of minerals. Every soil has a certain degree of inherent mineral fertility based on the mineral composition of the parent material from which it was derived. However the more you remove minerals through intensive cropping and/or add minerals through fertilizers and soil amendments, the more dynamic your soil fertility becomes and the greater is the need to test your soil.

Soil Fertility and Mineral Analysis

Much of popular gardening literature today focuses on soil fertility. Through scientific investigation we have learned plants require 16 essential elements for normal growth and function. Of these, carbon is supplied by the air, hydrogen comes from water, oxygen comes from air and water, and the remaining 13 are derived from soil.

Two German plant physiologists, Julius Sachs and W. Knop, around the year 1860 proved plants can grow without soil. By supplying essential elements dissolved in distilled water they not only discovered which elements are required by plants but also their basic concentrations. Their experimentation was our first glimpse at hydroponics. Today, beautiful vegetables are grown hydroponically in greenhouses year around.

Elements in the soil are loosely bound to soil particles. They are constantly exchanged between the soil particles and the surrounding soil water. Elements dissolve in the water around the soil particles and move into the plants as the water is taken up by the roots.

Each plant root cell is surrounded by a thin membrane which allows only certain molecules or ions to pass into the plant. The 13 soil-derived elements enter the plant through the root in only a total of 17 ionic forms. Four elements, copper, iron, phosphorus and nitrogen are taken up in two different forms. Nitrogen enters as either nitrate ion or ammonium ions. The remaining nine elements are taken up in only one ionic form. Sulfur, for instance, can only enter as a sulfate ion.

To understand the ionization of a molecule, take common table salt, sodium chloride. Two of the 13 elements, although required in small quantities, are sodium and chlorine. Sodium chloride, when dissolved in water, separates into sodium ions and chloride ions. As the water evaporates, sodium and chloride bond once again to form a white powder residue, sodium chloride. Plant roots cannot take up the molecule, sodium chloride but they can take up individual sodium ions and individual chloride ions.

Let's say our soil is deficient in potassium and nitrogen so we add potassium nitrate. The potassium nitrate cannot enter the plant. It must first disassociate into potassium and nitrate and each is taken up by the roots as separate and individual ions. Ammonium nitrate (33-0-0) must disassociate to nitrate and ammonium ions before uptake is possible.

All the elements required by plants can be found in organic matter. Plant roots cannot digest organic matter however. This action is taken by soil organisms that decompose organic tissues into simple molecules which may then ionize in solution.

Organic matter provides an excellent source of slow release fertilizer as well as improving a soil's porosity and internal drainage. Organic matter should be incorporated into the soil at every available opportunity but this does not negate the benefits derived from the application of inorganic fertilizers.

Soils and soil environments form complex systems which will reveal secrets far into the future but the question about whether plants are more nourished by organic versus inorganic materials was answered a century ago. Our plants can't tell the difference.

When soil nutrients are deficient, plant performance declines and plant health deteriorates. Weakened plants are more subject to stress from insects, diseases, drought and temperature extremes.

Spring Flush Demands Soil Minerals

Every spring, plants get a new lease on life as they put on a new crop of foliage. Large healthy leaves capture the sun’s energy and transform it into sugars that fuel the plant system for every kind of work from resisting insects and diseases to laying on new wood, ripening fruit, and setting flower buds for next year’s bloom.

Over the spring season trees, shrubs, vines and ground covers produce as much foliage as they can manage before the heat stifles all further development. As they grow and develop, plants need a steady supply of minerals to build strong healthy tissues.

Most soils in our area contain adequate amounts of all the soil-derived minerals except nitrogen (N), phosphorus (P), and potassium (K). These three minerals are used by plants in large quantities so most lawn and garden fertilizers contain the “big three”.

State laws require that materials advertized as fertilizers have a minimum guaranteed analysis stated on the label on the basis of percent by weight. The percent by weight of each of the “big three” minerals are always listed in the order, N-P-K. A fertilizer labeled 15-5-10 has 15 percent nitrogen, 5 percent phosphorus, and 10 percent potassium. If a fourth number is listed in the series, it is sulfur, unless otherwise stated. Numerous other minerals including micro-nutrients may or may not be expressed elsewhere on the label.

The most abundant soil-derived mineral in plants is nitrogen. Nitrogen is the primary ingredient in proteins used to create a vast array of compounds including nucleic acids, the basic building blocks of DNA. DNA directs all plant functions and must be replicated each time a cell divides.

The second-most abundant soil-derived mineral in plants is potassium. Potassium is responsible for regulating proper water pressure in all plant cells. Adequate water pressure maximizes cell size and quickens the pace of growth. Adequate potassium nutrition is essential in maintaining optimum cold, heat and drought tolerance in all plants.

The third-most abundant soil-derived mineral in plants is phosphorus and is important for bloom production and root development. Phosphorus is the principal element in the adenosine triphosphate (ATP) molecule which converts plant sugars into the energy used to drive every metabolic process in the entire plant system. Phosphorus is also required for nucleic acid synthesis including the bonds which link nucleic acids to form DNA.

In the absence of a soil test, fertilize plants every six weeks as long as they are actively growing or blooming. For woody ornamental plants you want to get bigger, apply a 3-1-2 ratio fertilizer at the rate of one pound of actual nitrogen per 1,000 square feet of rooting area. The roots of a tree or shrub extend in all directions as far from the trunk as the plant is tall. For woody plants you want to maintain at their current size, use the same fertilizer but cut the rate in half. Use a 1-1-1- ratio fertilizer at the rate of three-quarters of one pound per 1,000 square feet for plants while in bloom and as a pre-plant fertilizer for any new planting. Select fertilizers with at least half the nitrogen in a slow-release form to provide a more constant availability.

The only sure way to determine precisely what nutrients your soil and plants need in the amounts required for adequate nutrition is to take a soil test. Lawn and garden soils should be tested every three years to determine soil fertility needs. Texas Cooperative Extension operates a state-of-the-art soil testing lab which conducts soil analyses for a minimal fee. You can obtain soil testing forms and instructions from the internet at http://soiltesting.tamu.edu or by contacting your local county office of Texas Cooperative Extension.

Pre-plant Soil Preparation

Improving soil conditions prior to planting is the key to capturing and utilizing natural rainfall. Deep beds with good internal drainage allow rainfall to enter the soil and soak to greater depths at a quicker pace before running off. A deep, porous soil allows plant roots greater depth to explore and tap greater soil water and mineral reserves. This is accomplished by adding organic matter to the soil and planting on soil berms.

Ground bark, peat, and compost are highly lignified, stable and persistent in the soil compared to most other organic soil amendments. Non-lignified, high carbon materials such as wood chips, fallen leaves and grass clippings are more easily degraded in the soil, contribute to temporary nitrogen shortages, and should be composted before they are added to the soil.

Organic soil amendments should make up not more than one-third of the total soil volume. As the organic soil amendment degrades, the soil subsides. For this reason, the finished soil grade after planting should be higher than the original soil grade. For instance if you work three inches of compost into the top nine inches of soil, plant the crown of the plant three inches above the original soil grade. This way, as the organic matter composts and the amended soil subsides, the crown of the plant will not sink below the original soil grade.

Using this method, you are effectively planting on a raised soil berm. Plants are most subject to drowning during the early establishment years. Planting on berms and raised beds also makes your plants appear larger which gives your new plantings a more immediate impact. Avoid poorly drained sites when possible but if necessary, plant root balls half-in and half-out of the ground or even all above the ground level. Backfill the top of the ball with soil and shape the soil to a 6:1 slope to drain the water away.

In addition to organic matter, clayey soils also benefit from the addition of expanded shale and gypsum. Apply expanded shale at the rate of 2-3 inches per 6-8 inches of soil. This material instantly increases soil porosity but unlike organic matter remains a permanent part of your soil and does not need to be re-applied. Apply 6-8 pounds of gypsum per 100 square feet of soil. This increases soil porosity for only a couple of months but helps plants to get rooted in and can be repeated in each time you change flower or vegetable crops.

Composting and Yard Waste Recycling

Yard waste comes in the form of grass clippings, fallen leaves and pruned wood. Grass clippings can be mulched down into the turf using a mulching lawn mower or bagged for use as a compost additive. Fallen leaves can be also be mulched into the turf or bagged through a mower which also shreds and make them ready to use as a ground mulch or compost additive. Pruned wood can be chipped and used as ground mulch or as a compost additive. Wood that is too large to chip into mulch can be used as firewood once it has been seasoned.

Finished compost can be used to top-dress beds of shrubbery, ground covers and flowers as well as vegetable and herb gardens. Unlike inorganic fertilizers, finished compost won't burn plants so it's virtually impossible to apply too much. In fact, you can use compost full-strength directly from the bin as a potting soil for flowers, tropical foliage and containerized vegetables.

Closing the loop with yard wastes is easy because you use them on the very plants that produce them. It is impossible for any property to produce more yard waste than can be utilized on that same property as an organic, slow-release fertilizer.

Gardening, Soil Conservation, and Water Protection

Soil means many things to gardeners for there are many qualities and attributes that separate one soil from another. The bottom line though is that if you have good soil, you can grow plants well. If you have poor soil, you cannot. Soil conservation in the urban environment will always be important if people want to grow anything green. If we haul it off, bury it under subsoil fill, or allow it to wash away, the urban landscape will never do well.

Maintaining a seamless vegetative soil cover is the responsibility of each and every landowner. Each year the water-holding capacity of Lake Lewisville is reduced by one-half percent due to soil sediment washed into the basin in storm water run-off. Keeping the soil knitted with the roots of healthy trees, shrubs, vines, ground covers and turf is the only thing that will reduce this soil loss and the loss of our primary water supply. It is the responsibility of every citizen to garden responsibly and protect our soils and waters.