SOILS FOR NURSERY AND LANDSCAPE MANAGEMENT

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Many decisions a nursery or landscape manager makes are dependent upon knowing characteristics of the soil in which the plants are grown. Soil is a diverse and dynamic system consisting of air, water, mineral particles, organic matter, and living organisms. It supports plants and their roots, and it supplies nutrients and water for plant growth. Healthy soil also supplies oxygen to plant roots. Various parent materials from glacial deposits, wind blown particles, river deposits, volcanos, etc., are the basis from which soils are formed. The ongoing process of soil formation takes hundreds or thousands of years and is influenced by rainfall, temperature, and plant and animal life. The physical and chemical properties of soil are determined by these soil-forming processes. Critical soil characteristics for plant growth include texture, structure, drainage, aeration, water holding capacity, nutrient holding capacity, compaction, pH, and salinity. Thus, the type of soil will dictate the type of crops that can be grown, and the management practices required to grow them successfully.

A good growing soil is composed of approximately 50% solids, 25% moisture, and 25% air as shown in Figure 1. Approximately 95 to 99% of the solid component consists of sand, silt, and clay particles and one to five percent consists of organic matter. The water component or soil solution, includes a soluble salt concentration of 100 to 1000 parts per million, which contains many of the nutrients necessary for plant growth. The air component contains the high concentrations of 0.3 to 0.6% carbon dioxide which is approximately ten to 20 times more than the air people breathe. It also contains oxygen, which is essential for root respiration and growth. If the normal 15 to 20% soil oxygen level is reduced to ten percent by excessive moisture or compaction, root injury can occur. Root growth stops at three percent soil oxygen, and roots are killed if soil oxygen further decreases or remains at this level for a short period of time. For optimum plant growth, all soil must maintain adequate moisture, but at the same time, provide adequate aeration.

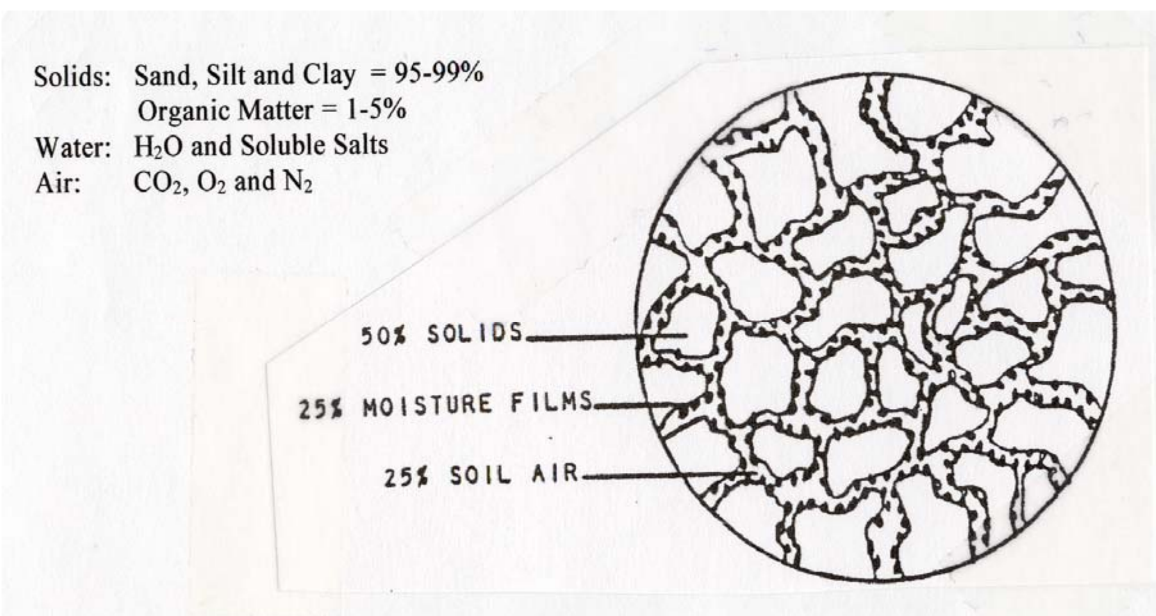

Figure 1. Soil is composed of Solids, Water and Air.

Soil Texture

One of the most important physical properties of a soil is texture. Soil texture is the proportion of sand, silt, and clay particles that make up a soil. By definition, these particles are distinguished solely by size. Clay particles are less than 0.002 millimeters, silt is 0.002 to 0.05 millimeters, and sand is 0.05 to 2.0 millimeters in size. The relative size of these particles is depicted in Figure 2. The 12 different textural classes of soil are based on their different proportions of sand, silt, and clay, and are identified as follows: clay, sandy clay, silty clay, sandy clay loam, clay loam, silty clay loam, sand, loamy sand, sandy loam, loam, silt loam and silt. Soil scientists use a textural triangle to delineate these soil textural classes as shown in Figure 3. The percent of sand, silt, and clay is measured in the laboratory and then the respective percentage lines are followed to their intersections on the triangle. For example, a soil with 20% clay, 60% silt, and 20% sand is classified as a silt loam. Note that a soil classified as a "loam" has roughly equal proportions of silt and sand and less than 25% clay. Soil is often called "loam", when it may, in fact, have quite a different texture.

Even though the exact percentages of sand, silt, and clay for a particular soil may not be known, a good idea of the textural class can be determined by a “feel” test. First, moisten a small handful of soil and knead it until the soil has the consistency of putty. Then squeeze the ball of soil between thumb and forefinger to push out a ribbon. A soil that sticks together for a ribbon one to three inches long indicates a high clay content and is fine textured. A soil that feels gritty with low cohesion indicates a high sand content and is coarse textured. A soil that feels silky and forms a ball, but does not feel sticky, is medium textured and indicates a high silt content.

Soil texture is important because it influences water and nutrient holding capacity, drainage, aeration, susceptibility to compaction, irrigation and planting practices, and erodability. For example, coarse-textured soils such as sand, loamy sand or sandy loam, have a low water holding capacity, drain quickly, and are low in nutrients, especially nitrogen and potassium. These soils usually require irrigation to be productive. Medium-textured soils such as loam and silt loam usually have good drainage and adequate water and nutrient holding capacity. Fine-textured soils such as clay loam and clay, have a high water and nutrient holding capacity, but are usually poorly drained and are difficult to manage when wet. These soils must often be tiled to improve crop productivity. The water holding capacity of a soil as influenced by texture is illustrated in Table 1.

Table 1. Soil texture and soil water-holding capacity.

Texture	Inches of Water/Foot of Soil
Loamy Sand	0.6 to 1.0
Sandy Loam	1.0 to 1.3
Loam	1.7 to 2.3
Silt Loam	2.0 to 2.8
Clay	2.0 to 3.5

When a soil has an organic matter content of greater than 20 to 30%, the soil is referred to as "organic soil". Soils with an organic matter content greater than 60 to 80% are referred to as peat and muck. These soils are usually low in phosphorus and potassium, and may or may not provide significant amounts of nitrogen. They are usually found in low-lying areas, they are slow to warm up in the spring, and unless special measures are taken, they are poorly drained.

Soil texture is extremely difficult, if not impossible, to change. To add enough sand or loam to a field or even to a landscape to provide a meaningful change across the entire area and to a significant depth would require exorbitant quantities and would most likely be cost prohibitive.

Soil Structure

The manner in which sand, silt, and clay particles are held together is referred to as soil structure. Decayed organic matter and humic acids interact with mineral particles to form structural aggregates of various shapes and sizes. Soil structure may affect pore size distribution and therefore, affect the ability of a soil to drain and provide adequate aeration. A soil with 60% stable aggregates, which are aggregates that do not break down easily, is considered to have good structure. A good soil structure, often referred to as good tilth, will allow cultural operations to be performed with minimal problems and enable plants to establish extensive root systems.

SOIL TEXTURE PARTICLE	RELATIVE SIZE	DIAMETER OF PARTICLE (Millimeters)
SAND		0.05 – 2.0
SILT		0.002 – 0.05
CLAY		LESS THAN 0.002

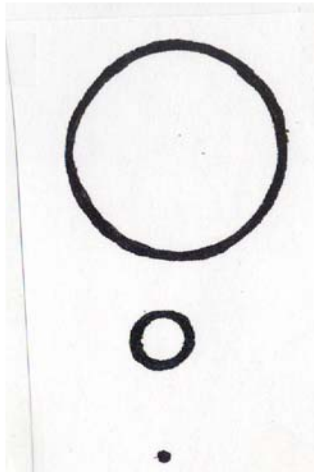

Figure 2. Relative sizes of sand, silt, and clay particles enlarged 500 times.

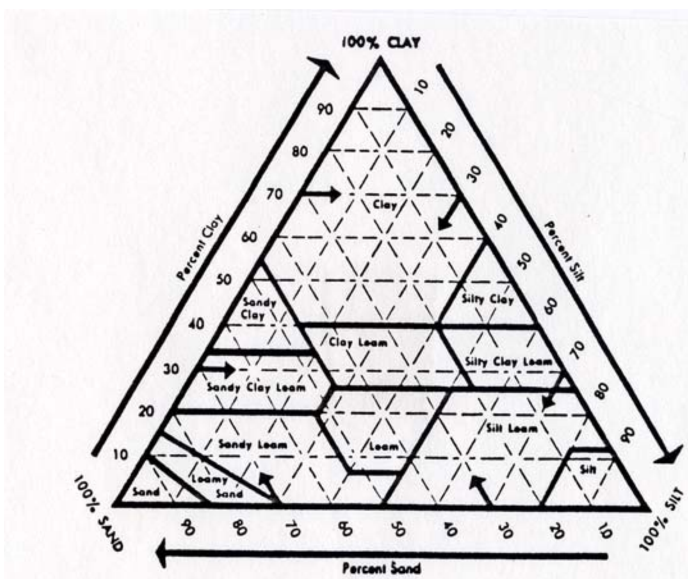

Figure 3. Soil Texture Triangle. After measuring the percent sand, silt, and clay in a soil sample, the texture is determined from the Soil Texture Triangle.

While soil texture is generally considered a fixed property that cannot be changed, soil structure can be modified, for better or worse, in a relatively short period of time. Working or traveling over a wet soil can cause compaction and it will destroy good soil structure. Compaction crunches soil aggregates, therefore, compacted soils have much less pore space and a greater amount of solid particles per unit. This decreases soil oxygen and therefore, restricts root growth. To prevent compaction from occurring, allow soils to drain after a rain or irrigation before working the soil or driving on the soil. The amount of time to wait after a heavy rain will depend upon how the soil texture allows the soil to drain. For example, a sandy soil may require one day to reach a proper moisture content, whereas a clay soil may require up to a week or more. Soils can range from being very poorly drained, where the soil is saturated with water much of the time, to excessively well drained, which is a droughty soil. Poor drainage is a leading cause of transplant failure. Poor drainage is most likely to be a problem on heavy clay soils, and in low areas. The poorest drainage occurs when there is a water table near the surface. Certain plants, like yews and rhododendrons, are particularly sensitive to poor drainage. Deep tillage of two to three feet, berms, tilling, large planting holes, and turf aeration will facilitate drainage and aeration of compacted soils.

Organic Matter and Soil Amendments
Amendments to a soil may include organic matter or the addition of a different soil texture. Whenever any amendment is added to an existing soil, the possibility of developing an "interface" exists. An interface is the connecting surfaces of existing soil and the amendments. If these two meeting surfaces are quite different, aeration and drainage may be negatively influenced. This may have a significant effect on root growth and may prevent roots from growing through or into the interface. To prevent interface formation, insure that the two components are thoroughly mixed. Always mix some of the existing soil with the amendment; thereby creating a transition zone and preventing a complete soil change from one area to the next. Organic matter is essential in building and maintaining soil structure. For clay soils, organic matter may improve drainage and aeration and should make the soil easier to work. For sandy soils, organic matter increases moisture-holding capacity. Some organic matter such as manure **may** serve as a source of slow release nutrients, however most organic matter sources consume more nutrients than they provide. Organic matter does increase the ability of the soil to hold on to certain nutrients such as potassium, calcium, magnesium, by increasing the cation exchange capacity. Soil organic matter enhances the presence of soil microbes and earthworms, which in turn can improve soil structure. Soil crusting is also reduced as organic matter content increases.

The addition of organic matter such as compost, peat, wood chips, or bark can help improve soil water holding capacity, drainage, and pH. The rate of incorporation will depend on the situation and soil. For example, where trees or shrubs are to be planted, a "transition zone" can be developed by using a large planting hole and adding amendments directly to the backfill such as 1/3 amendment, 2/3 existing soil. This will prevent the roots from encountering a severe interface. For larger areas where turf will be planted, amendments can be applied to the entire area and rototilled into the existing soil. Approximately one to three inches of peat, compost, or other amendment should be thoroughly mixed with the soil to a depth of at least six inches. The deeper the mixing of existing soil and the amendments, the better for the plant root zone. Failure to thoroughly mix the amendments with the soil will result in an interface, which may restrict water movement and root growth. If non-composted bark or wood chips are added as amendments, additional nitrogen fertilizer will be needed to prevent depletion of soil nitrogen. Manure and some composts may increase soluble salts and weed seeds to a detrimental level. Caution should be used if fresh sawdust is applied because supplemental nitrogen will definitely be needed. Peat contains very few plant nutrients.

Some homeowners and landscapers use "black dirt" as a soil amendment. There are no specifications in Minnesota that define "black dirt" so its composition can range from a sand to a muck or to a clay. If "black dirt" is to be used in a landscaping situation, it should be relatively free of stones and rocks, have a pH between 5.8 and 7.0, contain no more than 20% clay, and have a soluble salt content less than 1.5 mmhos/cm. Highly degraded organic soil, which is muck, should be avoided. To prevent an interface from occurring, incorporation of the "black dirt" with a rototiller or mixing it with backfill is required, particularly if the texture of the "black dirt" is different than that of the original soil.

Cation Exchange Capacity (CEC)
Clay particles and organic matter in the soil have negative charges that attract and hold on to positively charged ions called cations. The cation exchange capacity of a soil is a measure of the amount of positively charged ions that a soil can hold. Examples of such ions include calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), and hydrogen (H^+). In general, the higher the clay and organic matter content of a soil, the greater the nutrient holding capacity. However, a high nutrient holding capacity does not always imply high nutrient levels.

Soil pH
Another important soil chemical property affecting nutrient availability and plant growth is soil pH, which is a measure of acidity or alkalinity. Very simply, pH is a relative measure of the hydrogen ion (H^+) concentration. The pH scale ranges from 1 to 14, with 7 being neutral. A pH less than 7 is considered acid as it has a high concentration of hydrogen ions. A pH greater than 7 is alkaline or basic as it has a low concentration of hydrogen ions. Nutrient availability as affected by pH is illustrated in Figure 4.

In extremely acidic soils wherein the pH is less than 4.5, aluminum or manganese toxicity may result. In highly basic or alkaline soils such as with a pH greater than 7.0, iron becomes unavailable and iron chlorosis may develop. For most plants, a pH of 5.5 to 7.0 provides the greatest nutrient availability. For some plant species such as azalea, blueberry, and rhododendron, the optimal pH is 4.5 to 5.5.

Various materials can be used to either raise or lower soil pH. Before any pH adjustment is attempted, the soil should be tested to determine the initial pH. Agricultural limestone is the most common material used to raise soil pH from a pH of 4 to a pH of 5. A lime requirement test is available through most soil testing labs and is more accurate for determining lime requirements than a simple pH reading. Agricultural lime takes several months to react with the soil and should, therefore, be applied and incorporated six months to one year before planting. Liming or increasing the pH is seldom required or necessary for nursery crops or container media in most of Minnesota. Test the soil **before** adding lime.

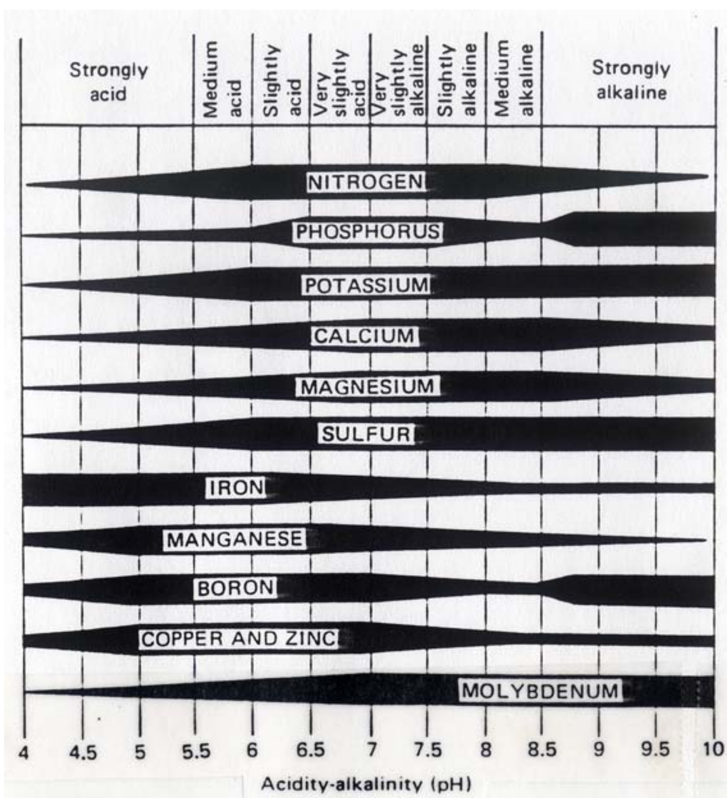

Figure 4. Effect of pH on the availability of plant nutrients.

Table 2. Materials and rates required to decrease the soil pH by 1 pH unit in various soil types.

Materials	Sandy Loam (lb/100 ft^2)	Loam (lb/100 ft^2)	Clay Loam or Peat (lb/100 ft^2)
Iron Sulfate	2.5	5	7.0
Sulfur	0.5	1	1.5

Elemental sulfur or iron sulfate can be used to lower soil pH, for example from a pH of 7 to pH of 6. Table 2 provides the quantities of these materials to lower the pH one unit in various soils. However, it is more difficult to lower the pH than to increase it. Elemental sulfur is slow acting and may take several months before a pH change can be detected. Iron sulfate is faster acting and can lower pH within two to three weeks. Adding large amounts of sphagnum peat to the soil will help lower the pH, but the effect is temporary. Aluminum sulfate is not recommended as an acidifying amendment due to potential toxicity problems created by soluble aluminum. Do not use gypsum, which is calcium sulfate, for soil acidification, as this amendment is a neutral salt and will not alter soil pH.

Irrigation water often has a high pH and, therefore, can raise the pH of the soil or medium over time. Masonry is also alkaline, so soil pH may increase around foundations, sidewalks, and masonry debris. Limestone-based rock mulches can significantly increase pH, and should never be used around acid-loving plants. To avoid an increase in pH, use acidic fertilizers like ammonium sulfate and iron sulfate. Acidification treatments like sulfur may need to be repeated.

High levels of soluble salts in the soil will damage roots and foliage. This is a greater problem in heavy soils than in well-drained soils where the soluble salts can be leached through the soil profile. High soluble salts can also occur from over fertilization, or from deicing salts, which may damage trees and turf near roadways and sidewalks. Soluble salts must be less than 2.5 mmhos/cm to prevent foliar injury. Heavy irrigation to leach the soluble salts out of the soil or growing medium is an effective corrective treatment.

Soil Surveys and Soil Sampling Techniques

Most Minnesota counties offer detailed soil surveys that can be obtained from local Extension or soil Conservation District Offices. These surveys contain a wealth of useful information about soils of the area, including potential problems for landscape uses. However, the soil maps may not be fully accurate in sites heavily modified by home construction or other developments.

The manner in which a soil sample is taken has a profound effect on the final analysis. It is critical to have consistency in sample collection over time, but randomization across the area is necessary each time a sample is taken.

Use a soil sample probe to sample field soil when conditions are suitable for cultivation. Soil should be neither hard and dry, nor too wet. Take samples at least six hours after irrigation and at least one month after an application of fertilizer, except where a constant fertilization program is used. In that case, sample one to two days after the last irrigation. Take 15-20 core samples from an X or zigzag pattern across the field. Discard one inch of surface soil and then remove a core of soil 12 inches deep. If the soil varies greatly within this depth, take two samples: one sample one to 12 inches deep and another sample 12 to 24 inches deep; have them tested separately. If fertilizer was applied in bands within one month of sampling time, avoid taking soil cores on those banded areas. Mix the core samples together and package for shipment to a soil testing laboratory. If the sample is to be sent to the University of Minnesota Soils Testing Lab, fill out the University of Minnesota Soil Sample Information Sheet for the Nursery Field Stock Soil Sample. For field soils, request the **Regular Series plus the Nitrates and Soluble Salts Test.** Indicate on the form that the test is for trees and shrubs. Sample each field in late fall and late spring, or more often if problems exist.

For container medium samples, scrape aside ½ to one inch of the surface of the medium. Take a core of the medium just off-center of the container and through the entire container depth. Sample at least ten containers per species, or groups of species. Mix the core samples together and package for shipment to a soil testing laboratory.

Samples should be taken at least monthly throughout the growing season. In addition, each component of the medium should be sampled separately prior to mixing and the final medium should be sampled prior to adding the slow release fertilizer.

If the sample is to be sent to the University of Minnesota Soils Testing Lab, fill out the front of the Soil Sample Bag for a Nursery Container Stock Media Sample. Request the Florist Test, which is for Greenhouse and Nursery Container media. Indicate on the bag that the test is for trees and shrubs. Consistent use of the same soils lab is recommended for comparative results. Results from one lab to the next may not be relative for meaningful comparison from test to test. Soil test forms to accompany soil samples and examples of Soil Sample Bags for field, landscape and container samples are provided in the Fertilization for Nursery and Landscape Management chapter. Refer to the chapters on Container Production, Field Production, and Fertilization for Nursery and Landscape Management for additional soil management information. Also refer to the chapter on Fertilization for Nursery and Landscape Management for information on Mycorrhizae.