AN INTRODUCTION TO SOILS[1]

by Roger Funk

Abstract. Soil is a dynamic and complex substance composed of mineral particles, organic matter, microflora and microfauna, and pore spaces that contain air, water and dissolved nutrients. Although soils vary widely due to differences in climate, parent materials, vegetation, relief and time, certain physical and chemical characteristics are common to all soils. Arborists should have a basic understanding of these characteristics in order to properly maintain trees and shrubs.

Arboriculture is the total care and maintenance of trees, although the soil is one aspect of tree culture that is often taken for granted or ignored. Soil usually does not attract attention until it malfunctions.

When poor soil conditions exist, the vigor of the entire plant is reduced, making it less attractive and more susceptible to insect and disease attack. With the current emphasis on maintenance of plant health to minimize the need for pesticides, it becomes increasingly important for arborists to have a basic understanding of the physical, chemical and biological characteristics of soil.

Soil is defined simply as the surface layer of earth, supporting plant life. Actually soil is a very complex and dymanic substance that varies widely in composition and structure. Like the study of a fine-tuned engine, the study of soils begins with a discussion of the component parts.

The original composition of soil is controlled by the native materials (rocks, vegetable and animal matter, etc.) which produce the parent materials through physical disintegration and chemical decomposition. Parent materials, conditioned by their relief (contour and percent of slope) are acted upon by climate and biosphere over a period of time to produce soil. Great numbers of small creatures including plants (algae, bacteria, fungi and actinomycetes) and animals (protozoa, insects and worms) are continuously changing the chemical and physical properties of the solum or true soil.

The solum is the upper and most weathered part of the soil profile which includes the A and B horizons or topsoil and subsoil respectively. Underlying the solum is the relatively unweathered parent material or C horizon (Figure 1).

The establishment of definite layer boundaries is often so gradual that it is difficult to determine where one horizon starts and the other ends. Root development occurs throughout the solum although the principal absorbing area of a tree normally is near the surface where conditions supporting root growth are more favorable.

A soil is classified as a mineral soil if it consists predominantly of, and its properties determined predominantly by, mineral matter. It usually contains less than 20% organic matter. Most landscape sites have mineral soils.

Mineral particles are classified by size ranges into groups known as soil separates. These separates — sand, silt and clay — are differentiated only by size with no consideration given to the actual mineral composition. Soil particles between 2mm and 0.05mm in diameter are various classifications of sand, particles between 0.05mm and 0.002mm are silt, and particles less than 0.002mm in diameter are clay.

The textural name of a soil is obtained from the relative percentages of the soil separates. From the soil textural triangle, shown in Figure 2, it can be determined that a soil composed of 40% silt, 50% sand and 20% clay has the textural name "loam."

To confirm this, locate the percent of sand at the base of the triangle and, from the point at 40%, draw a line which slopes to the left, parallel to the right side of the triangle. Next, locate 20% clay and draw another line in a similar manner. The two lines intersect in the center of the textural name "loam." Since the total percentages of sand, silt and clay will always add up to 100, the textural name of a soil can be determined from the percentages of any two of the separates.

Soil structure is the combination of the soil par-

[1]Presented at the annual conference of the International Society of Arboriculture in Louisville, Kentucky in August 1982.

ticles into compound particles or aggregates which determine the arrangement of particulate matter and pore spaces in the soil. A well-structured soil contains 50% solid matter and 50% pore space with the solids composed of 45% mineral matter and 5% organic matter, and the pore spaces composed of 25% spaces filled with air and 25% spaces filled with water (Figure 3).

The important part of this air-water relationship is that there must be enough total pore spaces and that the pore spaces be the proper size ranges to hold enough air to permit root cells to obtain oxygen at all times and enough water to permit continuous contact with moisture. Maximum aeration occurs in open-structured or sandy soils with many large pores that drain quickly following irrigation while maximum water content occurs in soils with many small pores that hold water against gravitational forces. For example, *fine clay soils tend to retain water because of the* minute size of the pores and the surface tension which offers great resistance to the passage of soil water. The smaller the pore spaces the greater the surface tension which may vary from zero in coarse sand to several hundred pounds per square inch in fine clay. Capillary or available water is found in pores small enough to hold water against the pull of gravity but not so small that the surface tension prevents water from being absorbed by plant roots.

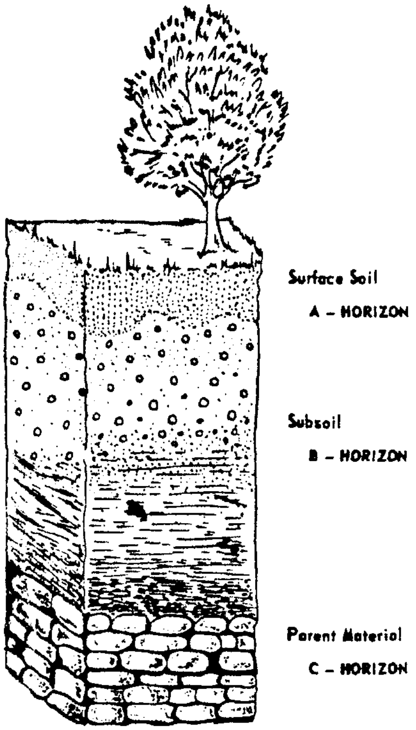

Figure 1. Typical soil profile.

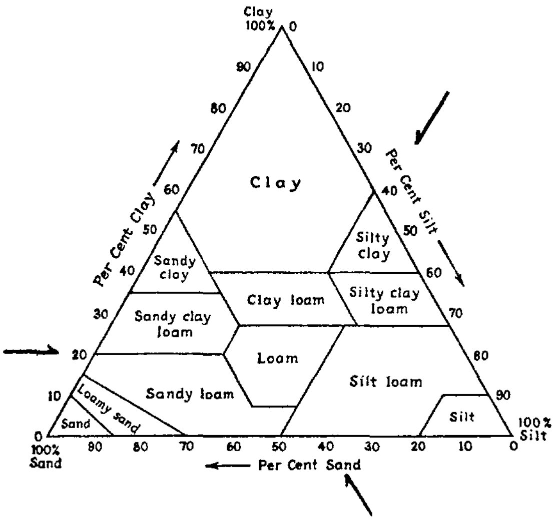

Figure 2. Soil textural triangle.

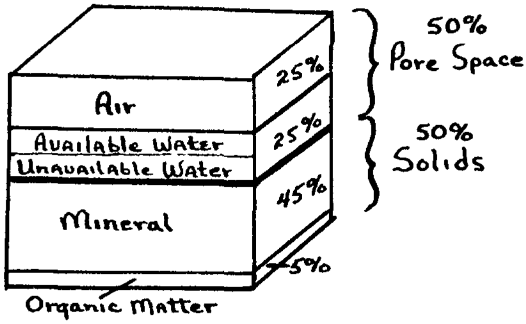

Figure 3. Volume composition of ideal soil.

A well-structured soil contains both large and small particles or granules to allow the proper balance between air spaces and available water spaces.

The capacity of soils to store plant nutrients varies with the textural type and the amount of organic matter. Whereas, sand and silt are composed of fragments of minerals and are relatively nonporous, clay particles are flat crystals with a sandwich-like arrangement. This structure makes clay porous and gives it a large surface area, both internally and externally.

Due to the enormous surface areas of clay particles and th spongy nature of humus, these two materials serve as the principal storehouses for plant nutrients.

Plant roots absorb nutrients by an exchange of cations and anions from the soil solution and the surfaces of clay and humus particles.

When the chemical salts in fertilizers dissolve, their molecules separate into ions which carry either a positive or negative charge known as cations or anions respectively. The clay particles are negatively charged and therefore attract and hold positive cations, of which calcium and potassium are examples. Other cations can exchange places with those already on the clay particles by pushing the original one back into solution, thus effecting what is known as cation exchange. The process of cation exchange enables clay and humus to act

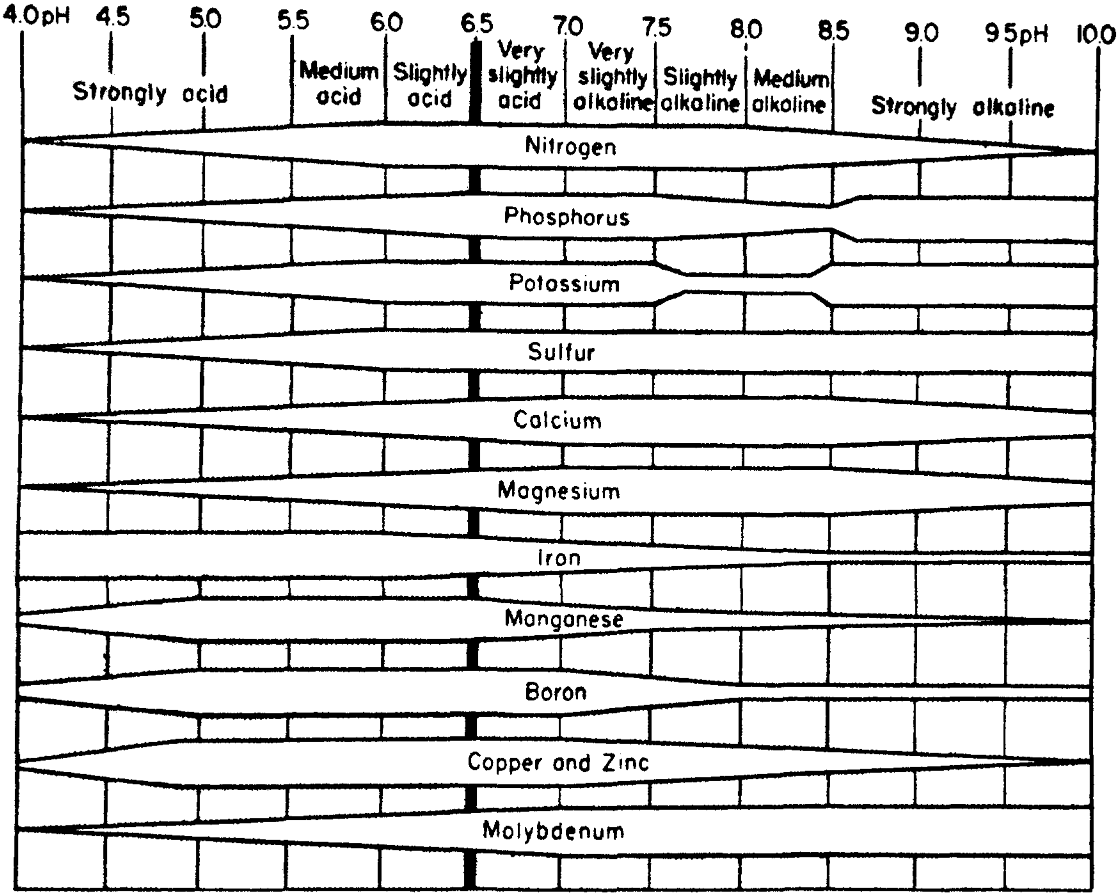

Figure 4. Bar width indicates the relative availability of each element with a change in soil reaction. The pH for greatest availability for almost all nutrients is about 6.5.

as storehouses for plant nutrients while the cations set free are available to plant roots. The capacity of a soil to exchange cations is the best single index of potential soil fertility.

Organic matter in the colloidal state carries both positive and negative charges and is about five times more effective than clay in nutrient exchange. Because soil nitrogen in the nitrate form (NO_3) carries a negative charge, organic matter is the only good storehouse for nitrogen.

The soil pH may influence nutrient absorption and plant growth through the effect of the hydrogen ion and through the indirect influence on nutrient availability. In most soils the latter effect is the most significant.

The term pH expresses the relative concentration of hydrogen and hydroxyl ions in solution. A pH of 7.0 mean the hydrogen and hydroxyl ions are equal and the solution is said to be neutral. A pH below 7.0 means the solution contains more hydrogen ions than hydroxyl ions, and is said to be acid. Similarly, a pH above 7.0 means the solution contains more hydroxyl ions and is alkaline.

The presence of an element in the soil is no guarantee that it is in a soluble form available for absorption. The concentration of hydrogen and associated ions affects soil reaction and the formation of soluble and insoluble compounds. Each nutrient has a pH range of maximum availability simply because within this range it forms a large proportion of soluble compounds. The relationship between soil reaction and nutrient availability for eleven of the essential elements is shown in Figure 4.

Arborists should not neglect the soil when maintaining trees and shrubs. The landscape site often possesses totally different soil conditions, both physically and chemically, from those found in the plant's natural environment. As a result, trees often do not grow vigorously and are more susceptible to insect and disease pests. Because of the importance of soil in root distribution and maintenance of plant health, arborists should have a basic understanding of soil in order to identify and correct and problems that exist.

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CONTRIBUTED ABSTRACT

EFFECT OF DROUGHT AND FREEZING STRESSES ON SUSCEPTIBILITY OF BLUE SPRUCE TO *CYTOSPORA (VALSA)* CANKER[1]

by Donald F. Schoeneweiss[2]

Stems of 5-year-old Colorado blue spruce wound-inoculated with a conidial isolate of *Cytospora (Valsa) kunzei* became predisposed when subjected to controlled drought stress. Typical bark cankers appeared on stems with plant water potentials below −20 bars, while no cankers formed on nonstressed stems or on stems subjected to freezing stress of −20 and −30 °C. Although the pathogen was recovered from wood in both stressed and nonstressed stems, necrotic bark cankers formed only on drought-stressed plants. These results support the hypothesis that drought stress is the controlling factor predisposing spruce to Cytospora canker.

It has been suggested that ascospores serve as inoculum and that conidia are not infective. In this study, cankers did form from conidial infection provided the plants were under significant drought stress for predisposition. Freezing stress had no apparent effect on susceptibility. A selective culture medium was developed (30 g Difco PDA, 0.1 g chloramphenicol, 0.1 g streptomycin sulfate, and 0.3 g ethazol (Truban) in 1 liter H_2O acidified to pH 5.5 with dilute HCl) which should aid in isolating *Cytospora* from spruce stems.

[1] Research supported by a grant from the ISA Memorial Trust Fund.

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