Soil Moisture and Aeration

The Basic Concept of Soil

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The soil is something every floriculturist uses, yet there is a wide spread lack of understanding about soil. The reason for the confusion is the complexity of the soil-plant system plus the great variety of types of soils and plants used. Knowledge about the soil is an absolute necessity if satisfactory crops are to be grown. This knowledge is gained both by practical experience and scientific investigation. It will be the purpose of this series of articles to summarize and simplify this knowledge and to provide a basis for the understanding of the principles of good soil management.

THE SOIL

What is the soil? To a Floriculturist, "soil" is any medium in which plants can be grown and which provides support, oxygen, water and nutrients. This definition of the soil, however, still does not clearly describe 'a soil'. To do this we must first consider the soil as a *physical* system.

Physically, all "soils" consist of three distinct parts or *phases*: (1) a *solid* phase, (2) a *liquid* phase, and (3) a *gas* phase (figure 1). This is true regardless of the kind of "stuff" being used. In every soil the same basic physical interrelationship exists between these three phases. The physical character of a soil is primarily dominated or determined by the nature of the solid phase. In a particular soil the status of the liquid phase determines the character and suitability of that soil for plant growth.

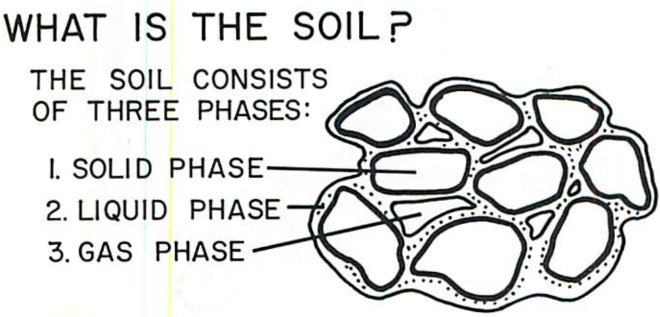

FIGURE 1. The soil consists of 3 phases: solid, liquid and gas.

In the following sections, each of these three phases will be discussed and a picture of their interrelationship presented.

The Solid Phase

The solid phase of the soil, the *soil matrix,* is the framework or backbone of the soil and it initially determines the soil's overall character. The soil matrix is made up of tiny mineral and organic particles. The most important physical feature of these particles is their size. A description of the soil on this basis is called *soil texture.* Generally all soils contain fractions of each texture and are therefore classified into textural groups according to the proportions they contain. This kind of soil description is not entirely accurate, though, because soil particles (especially the finer ones) tend to group together or *aggregate.*

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	DIAMETER
GRAVEL ..... more than	2.0mm
SAND .... more than	0.05mm
SILT .... more than	0.002mm
CLAY .... less than	0.002mm
COLLOIDS .... less than	0.0002mm

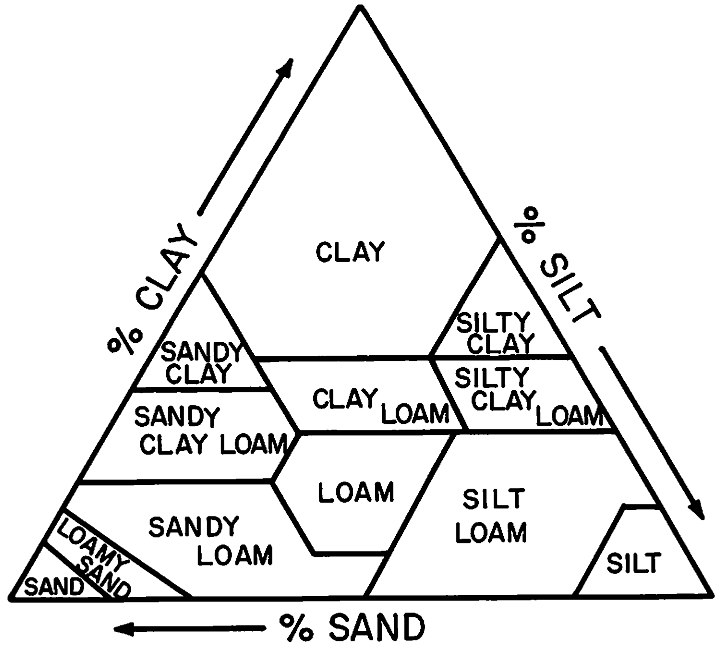

FIGURE 2. Textural classification of soils for individual particles (left) and classification of mixtures (right).

(figure 2). The extent and type of aggregation depends mainly on the amount of clay and organic colloids present and is called *soil structure.* Soil structure is another means which is used in describing the solid phase and often determines the agricultural value of a soil.

The solid phase can also be described or classified according to the organic or mineral matter content. The property of a predominately organic soil will be much different than a predominately mineral soil. Most organic particles and some "synthetic" mineral particles *absorb* water (internally) and tend to break down much more rapidly. It is therefore important to distinguish between organic and mineral fractions when describing the soil matrix.

The Liquid Phase

The liquid phase of the soil, the *soil solution* or *soil moisture,* is the second most important factor in determining the overall character of the soil. For a given soil, the moisture status determines the suitability of the soil for plant root growth. The soil solution consists of water, dissolved salts and dissolved gases. It is retained in the soil as films of moisture which wet the surface of the soil particles. The degree of soil moisture retention is used to classify soil moisture into the following types: (1) *gravitational* water, (2) *capillary* water, and (3) *hygroscopic* water (figure 3). Gravitational water is that water which is not retained on the soil particles or in the soil

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CLASSIFICATION OF SOIL MOISTURE RETENTION

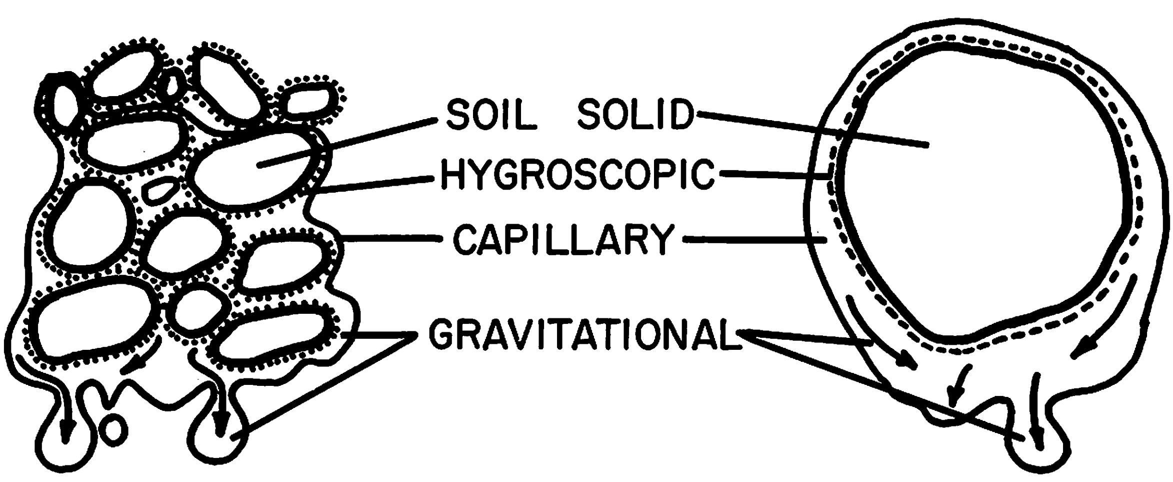

FIGURE 3. The 3 types of water found in the soil—based on the degree of retention on the soil particle surfaces.

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pores and, therefore, moves down or drains out of the soil. Capillary and hygroscopic water does remain in the soil. Capillary water is "free" to move from particle to particle, but hygroscopic water is too strongly adhered to the particle surfaces to move "freely."

The amount of water which can be retained by a soil depends on the amount of particle surface area and the amount and nature of the porosity of the matrix. Both of these factors depend in turn on the soil texture and structure.

The *amount* of water in the soil is usually measured as per cent volume or per cent soil dry weight. This measure is valuable in determining the total amount of water which is potentially available for plant use.

When water is absorbed on soil particles or held in soil pores, it 'loses' a certain amount of energy. The more strongly it is absorbed, the more energy it loses. In order to remove the water from the soil, work must be done on the water by the plant. The more strongly it is held, the more work must be done to remove it. A measure of the strength with which the water is held in the soil is called *soil suction, soil moisture tension,* or *matrix potential.* This is the easiest and probably the most useful measure of soil moisture status for practical purposes since water movement through the soil and into the plant is primarily determined by the energy status of the water, or the tightness with which the water is held to the soil particles.

The Gas Phase

The gas phase or *soil air* is dominated or controlled almost entirely by the other two phases yet its status is still important in determining the overall nature of a soil. The soil air consists of essentially the same composition as the above ground or atmospheric air only in slightly different concentrations (figure 4). In soil air, the oxygen content is usually lower and the carbon dioxide and water vapor contents are usually higher. The soil air acts as the pathway for the "intake" of oxygen used in plant root and microorganism respiration and at the same time it serves as the pathway for the "escape" of carbon dioxide produced by the same respiration. This process of oxygen and carbon dioxide exchange is called *soil aeration.* When this gas interchange is greatly limited or restricted, a condition of *"poor aeration"* prevails and when gas interchange is not greatly limited, *"good aeration"* prevails. The terms "poor" and "good aeration" are somewhat arbitrary, however, and are very much related to the plant being grown (figure 5).

Aeration in the soil can be described in three ways: (1) gas *composition* (qualitative), (2) *amount* or volume per unit soil volume (quantitative), and (3) *rate of movement* or diffusion (supply). [To be expanded in later articles.]

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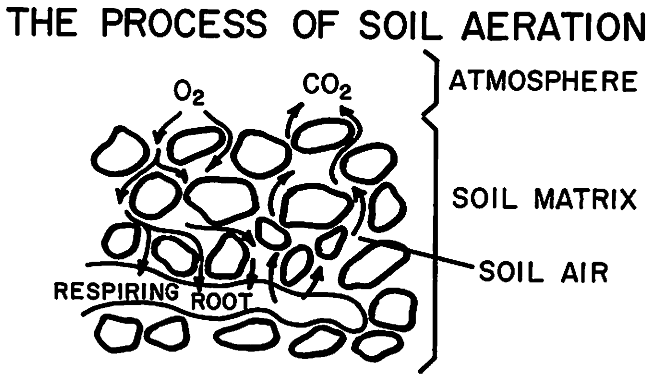

FIGURE 5. Soil aeration is the process of oxygen and carbon dioxide interchange between the soil and atmospheric air.

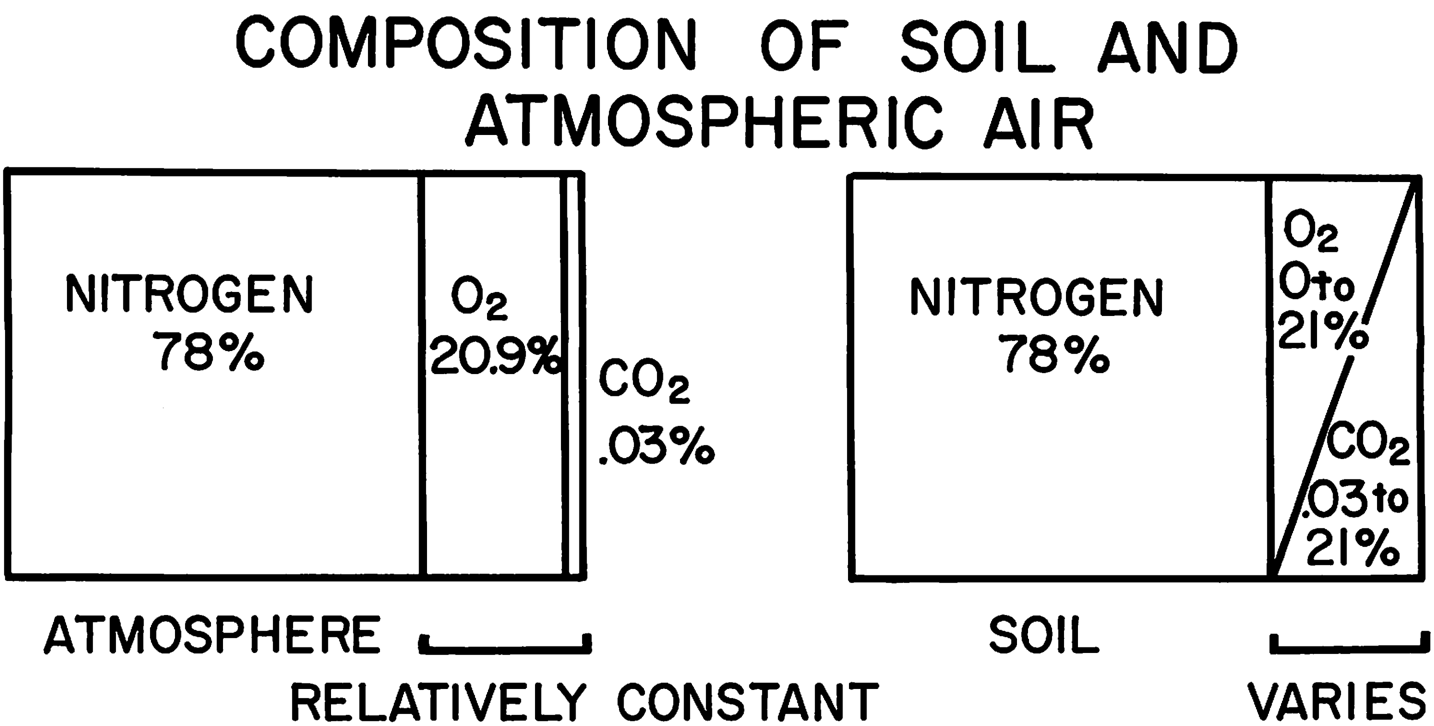

FIGURE 4. Comparison of the composition of soil and atmospheric air (approximate).

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RELATIONSHIP BETWEEN SOIL PHASES

Now that the three different phases of the soil have been briefly defined, the question is raised: "What is their basic physical interrelationship?" The basic relationship between the three soil phases can be thought of as a simple addition-subtraction of volumes of the different phases. This can be illustrated by beginning with a single soil phase and adding the other two in sequence For example, in an empty container only one of the three phases is present, the 'air' If the container is filled with dry solid particles forming a *soil matrix*, part of the volume previously occupied by the 'soil' air is now occupied by the solid matrix. The air-filled spaces left between the particles are called *soil pores* and it can be seen that the total *soil porosity* depends on the sizes and degree of aggregation and packing of the solid matrix. If water is added to this soil, it occupies or replaces still more of the initial volume of soil air. This illustrates that the volume of soil air not only depends on the soil matrix but also on the soil water content. The potential water content of a given soil depends in turn on the total amount of solid surface area, the size of the pores, and the total soil porosity which are determined by particle size and soil structure.

This very simple model of the soil is basic to an understanding of soil moisture and aeration relations and with this picture in mind, it should be easier to understand the more detailed descriptions of the soil in future articles in this series.

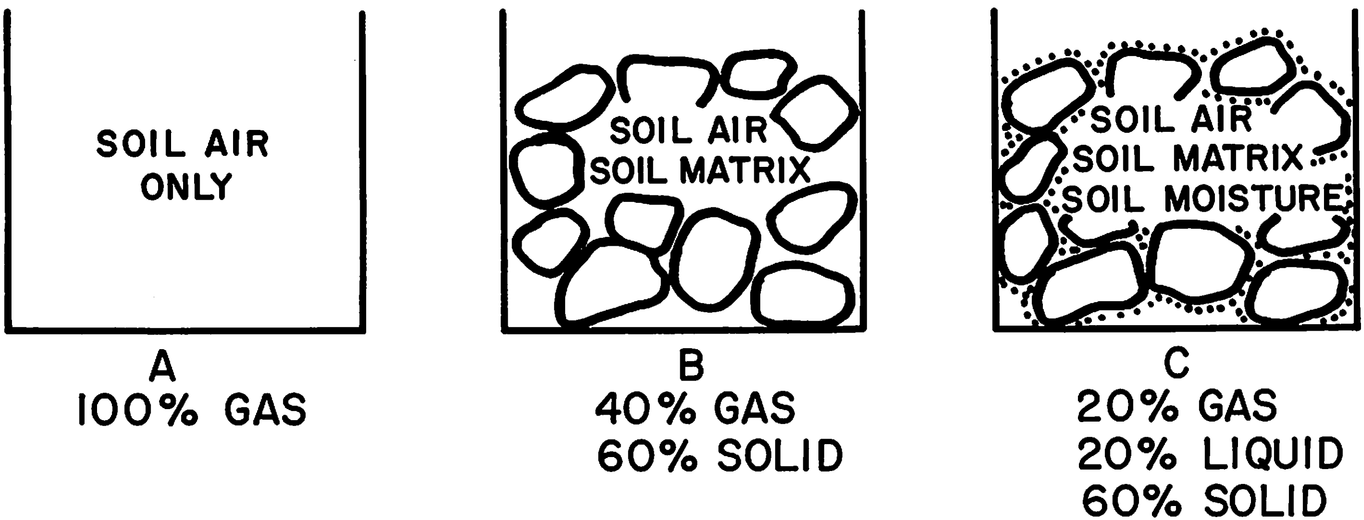

FIGURE 6. The addition-subtraction relationship between the three soil phases as the basic physical concept of soil.