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SOIL-PLANT-WATER INTERACTIONS

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Soil is a dynamic interactive environment that includes physical, chemical, and biological interactions. The soil-plant-water relationship is a function of these interactions.

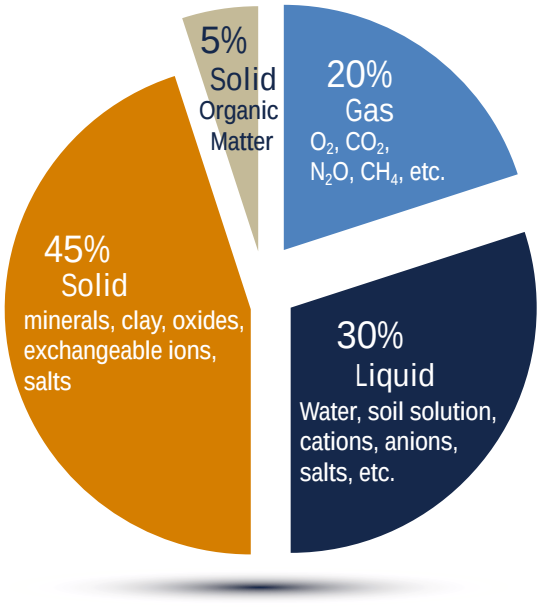
Soil is a physical media that serves as storage for plant nutrients, anchor for plants, habitat for various organisms, and water reservoir to supply moisture for plants.

Chemical interactions involve numerous ion exchanges between minerals, soil particles, soil solution, and chemical compounds.

Biological activity is essential for optimum plant root growth and nutrient uptake. Biological populations range from beetles to bacteria, which fulfill important roles in the plant nutrient uptake process.

The soil environment is composed of a three phase system that contains solids, liquids, and gases. The solid phase consists of minerals and organic matter. The liquid phase is water. The gas phase contains oxygen and carbon dioxide (Figure 1.0). Plant growth is impacted by all three phases and the ratio between each phase can influence crop response. An acceptable composition ratio is approximately 50% solids, 30% liquids, and 20% gases.

Figure 1.0 Three Soil Phases



PLANT NUTRIENT UPTAKE PROCESS

Multiple factors influence nutrient uptake by plants including availability, supply, and nutrient absorption rate. Soil supplies nutrients to the soil-root interface by three processes. First, as roots grow and penetrate the soil, direct contact with soil particles occur. Roots and root hairs contact and absorb nutrient ions. This process is root interception. The quantity of nutrients intercepted by roots depends on concentration of nutrients in the soil and volume of soil displaced by roots.

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Generally, roots occupy approximately 1-2% of soil volume (Table 1.0). Root interception provides a relatively small amount of total nutrient uptake.

Table 1.0 Percentage of the Total Soil Volume Occupied by Plants and Roots of Different Crops

CROP	ROOT VOLUME % (0-8 INCHES)
Kentucky Bluegrass	2.8
Winter Rye	0.9
Oat	0.6
Soybean	0.4 – 0.9
Corn	0.4

Adapted from S. Barber, Soil Nutrient Bioavailability, 1984

The second method of nutrient uptake is mass flow. Mass flow is a process where dissolved nutrients in soil water flow through the root zone and to the plant roots. Nutrients supplied via mass flow are a function of flow rate and concentration of nutrients in soil solution. They include nitrate (NO_3), sulphate (SO_4), boric acid (H_3BO_3), and chlorine (Cl). Some factors that affect mass flow include:

1) amount of soil water
2) temperature [lower temperatures reduce plant transpiration and evaporation]
3) size of the root mass.

The third method is diffusion. Diffusion occurs when ions move from an area of high concentration to an area of low concentration. Those nutrients that move into the plant by diffusion are phosphorus (P) and potassium (K) and, to smaller degree, iron (Fe) and zinc (Zn).

Plant nutrient uptake involves significant activity at the root-soil interface. Plants release carbon dioxide (CO_2) and exudates (organic substances) from the roots. Exudates are a food source for microorganisms. Higher microbial activity in the root-soil interface (rhizosphere) increases the movement of nutrients into plant (Brady, 1974).

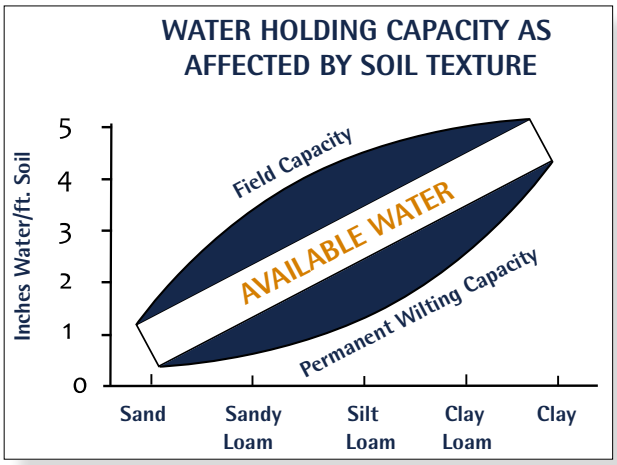
SOIL WATER

All plants require water directly or indirectly as herbaceous plants are 80-90% water and woody plants are over 50% water on fresh weight basis. Water serves four primary functions within plants as a constituent, solvent, reactant, and maintaining turgor (Kramer & Boyer, 1995). Plants' source of water is the soil; therefore, soil characteristics influence the amount of water plants can utilize.

Soil texture determines the volume of water soil is capable of retaining and the percentage that is plant available. Physical properties that determine soil texture is the aggregate of the amount of sand, silt, and clay present in the soil. Soils that have a high percentage of sand are course textured and have low water holding capacity. Soils that have a high clay content are fine textured and have high water holding capacity.

The water holding capacity of a given soil is determined by the difference between field capacity and permanent wilting point expressed in inches of water per foot of soil or percent of total soil volume. Field capacity is the percentage of water remaining after free drainage has ceased or retained by soil against gravity. The permanent wilting point is the lower limit of available soil moisture when plants wilt and cannot recover. Plant available moisture varies with soil texture as illustrated in Figure 2.0.

Figure 2.0



Sulphur (TIGER® 90CR) and several sulphur compounds can be present in the soil as a component in either of the three soil phases. Soil bacteria (*Thiobacillus*) are dependent on oxygen in the gas phase and water in the liquid phase to maximize the oxidation process to convert sulphur to sulphate. When sulphur has been converted to sulphate it is moved through the root zone with soil water and plant uptake occurs via mass flow. Only the sulphate compound is plant available and requires management attention to maximize greatest potential plant availability. Many factors influence sulphate and other plant nutrient uptake beyond those presented. Some of those factors include root surface area, root hairs, mycorrhiza, root structure, soil properties, and ion carriers which deserve discussion time in a future newsletter.

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