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SOIL-PLANT- WATER RELATIONSHIPS

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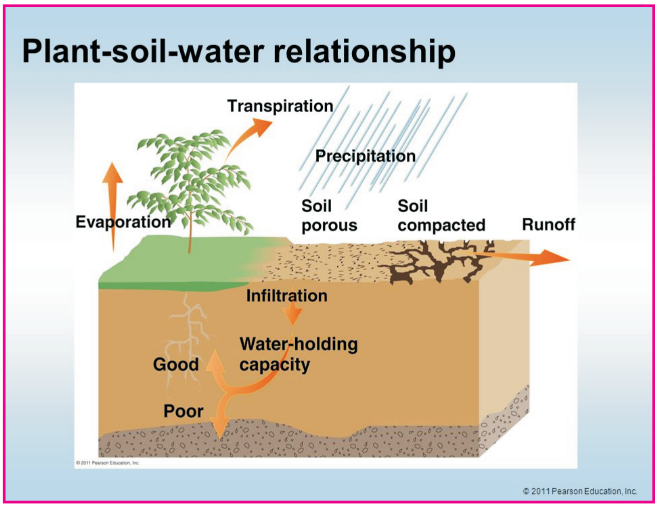
ABSTRACT :

Irrigation is the controlled application of water to arable lands in order to supply crops with the water requirements not satisfied by natural precipitation. In arid climates (fig. 1-l), adequate food and fibers cannot be produced without irrigation. Because of the potential for low crop yields and risk of crop failure due to variations in rainfall, irrigation in semiarid regions is needed most of the time. Furthermore, imgation in humid and subhumid regions is desirable as insurance against crop losses. Even though summer rainfall ordinarily is sufficient for crop growth, sometime during the year a drought may occur. Production of a



profitable crop is generally the objective of agriculture. Irrigation provides the insurance for a profitable agriculture in semiarid, subhumid, and humid areas; it is a necessity in arid regions. Water is introduced to the soil by an imgation system, by a regulated water table, or by precipitation. It is stored in the soil matrix and then extracted by plant roots to meet the plant evapotranspirational (ET) needs. This chapter on soilplant-water relationships treats the physical properties of soils and plants that affect the movement, retention, and use of water and that must be considered in designing and operating systems for conservation imgation. In planning and designing an imgation system, the technician is concerned primarily with the water-holding capacity of a soil, particularly in the root zone of the plant; with the water-intake rate of the soil; with the root system of the crop to be grown; and with the amount of water that the crop uses. In addition, a working knowledge of all soil-plantwater relationships is necessary in order to plan and manage efficiently the imgation for particular crops grown on particular soils and in order to adjust the design to various conditions.

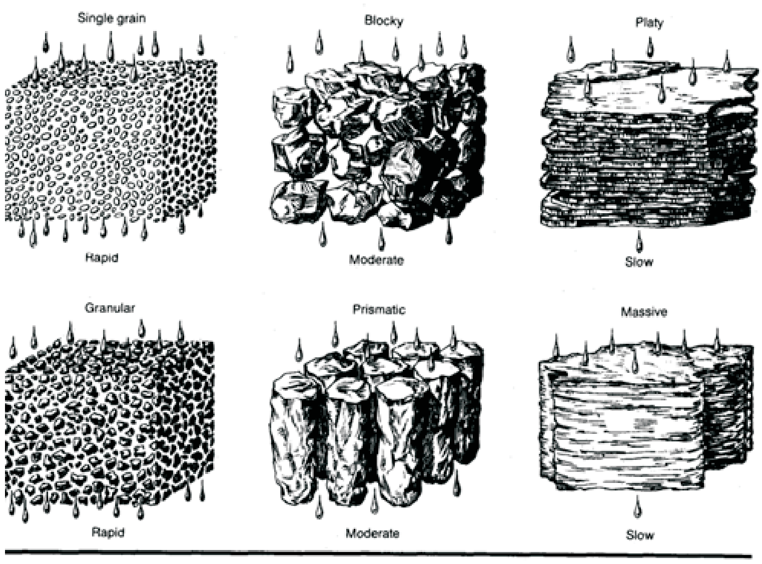
INTRODUCTION

Soil Physical Properties Mineral soils are porous mixtures of inorganic particles, decaying organic matter, air, and water. They also contain a variety of living organisms. The parent material of mineral soils consists of loose, unconsolidated fragments of weathered rocks or unconsolidated sediments. Physical and chemical weathering, with the translocation and the accumulation of various substances, give rise to a horizontal layering of the soil mass that is frequently visible in trenches and road cuts. Collectively, these horizons or layers are called the soil profile. The characteristics of the layers of the profile affect root growth and the retention and transmission of water in the soil. Two important physical properties of soils are texture and structure. Soil texture refers to the relative proportion of variously sized groups of mineral particles in a specific soil or horizon. Soil structure refers to the manner in which soil particles are arranged in groups or aggregates. Together, soil texture and soil structure help to determine the supply of water and air in a soil. The inherent characteristics of a soil may be adversely affected by soil compaction. Compaction can extensively modify soil aeration, water retention, transmission properties, root penetration, temperature relations, and the nutritional properties of a soil system.

Soil Structure Soil structure is the arrangement and organization of soil particles into natural units of aggregation that soil scientists call peds. Peds are separated from one another by planes of weakness that persist through cycles of wetting and drying in place. Most peds are large enough to be seen without magnification. Structure influences the rate at which water and air enter and move through the soil; it also affects root penetration and the nutrient supply of the soil. Structure type (fig. 1-3) refers to the particular kind of particle grouping that predominates in a soil horizon. Singlegrained and monstrous soils are structureless. In single-grained soils, for example, free sand, water permeates quickly. Water moves gradually through monstrous soils, for example, some muds. The more ideal water relations are more often than not in soils that have kaleidoscopic, blocky, and granular structure; platy structure hinders the descending development of water. Unlike texture, structure of the soil can be changed to the depth of tillage. Excellent structure develops in the surface layer of soils high in organic matter and on which perennial grass is growing. Cycles of wetting and drying or of freezing and thawing improve structure in the plow layer. On the other hand, cultivation of medium- or fine-textured soils when their moisture content is high tends to destroy structure. Imgation water that contains large amounts of sodium causes very undesirable structure by dispersing the soil aggregates. Tilth The physical condition of the soil in relation to plant growth and ease of tillage is commonly referred to as tilth. It depends on both the degree and stability of soil aggregates. Good, fair, and poor are the common descriptive terms for tilth. They refer to the ease with which a soil can be tilled Soil and Water Quality.

Figure 1-3.

Types of Soil Structure and Their Effect on Downward Movement of Water



Another factor on the amount of soil water available to the plant is the soil and water quality. For good plant growth, a soil must have adequate room for water and air movement, and for root growth. A soil's structure can be altered by certain soil management practices. For example, excessive tillage can break apart aggregated soil and excessive traffic can cause compaction. Both of these practices reduce the amount of pore space in the soil, reducing the availability of water and air, and reducing the room for root development. The quality of the water is also important to plant development. Irrigation water with a high content of soluble salt is not as available to the plant, so greater soil water content must be maintained in order to have water available to the plant. Increasing salt content of the water reduces the potential to move water from the soil into the roots. Some additional water would also be needed to leach the salt below the crop root zone to prevent salt build-up in the soil. Poor quality water can affect soil structure. Most Kansas crops are considered intermediate in terms of their salt tolerance. Summary Basic knowledge of soil-plantwater relationships makes it possible to better manage and conserve irrigation water. Some of the important factors to remember include: 1. Soil water-holding capacity varies with soil texture. It is high for medium- and fine-textured soils but low for sandy soils. 2. Plant roots can use only available soil water, the stored water between field capacity and permanent wilting point. However, as a general rule, plant growth and yields can be reduced if soil water in the root zone remains below 50 percent of the water holding capacity for a long period of time, especially during critical stages of growth. 3. Although plant roots may grow to deep depths, most of the water and nutrients are taken from the upper half of the root zone. Plant stress and yield loss can occur even with adequate water in the lower half of the root zone. 4. Poor irrigation water quality can reduce the plant's ability to take up water and can affect soil structure.

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