Soil Characteristics

BWCDD Zanjero Training

Session #2

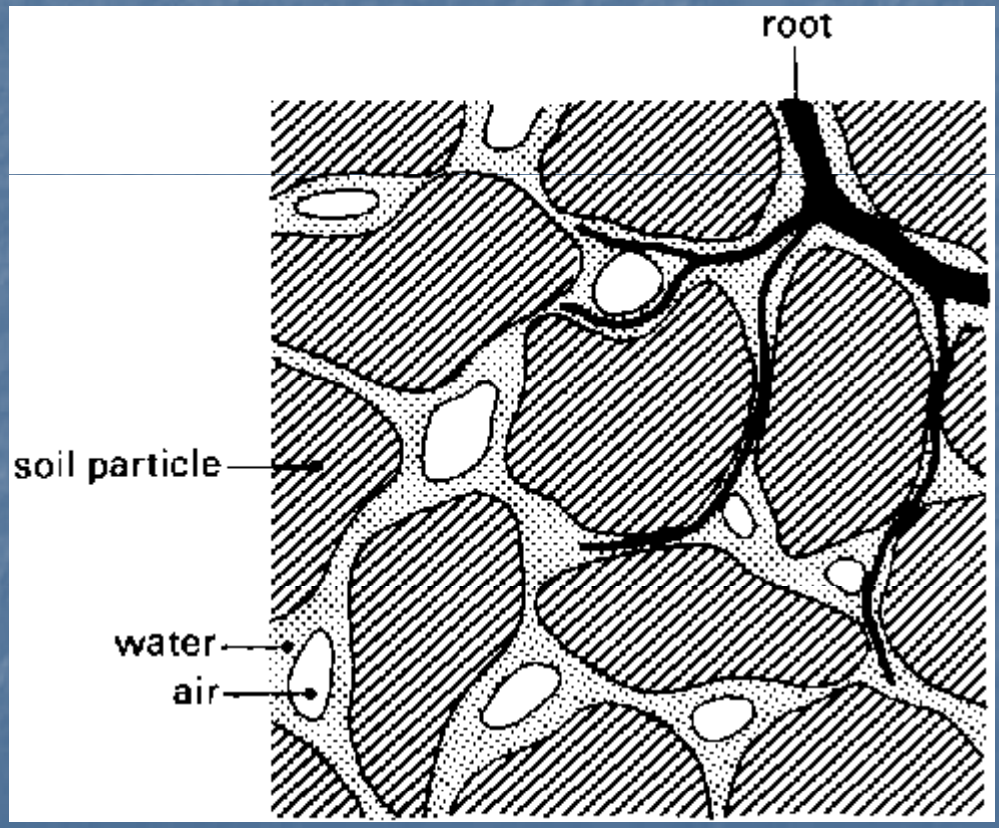
1/9/2008

Soil Composition

- When dry soil is crushed in the hand, it can be seen that it is composed of all kinds of particles of different sizes.
- Most of these particles originate from the degradation of rocks; they are called mineral particles.
- Some originate from residues of plants or animals (rotting leaves, pieces of bone, etc.), these are called organic particles (or organic matter).
- The soil particles seem to touch each other, but in reality have spaces in between. These spaces are called pores.
- When the soil is "dry", the pores are mainly filled with air. After irrigation or rainfall, the pores are mainly filled with water.

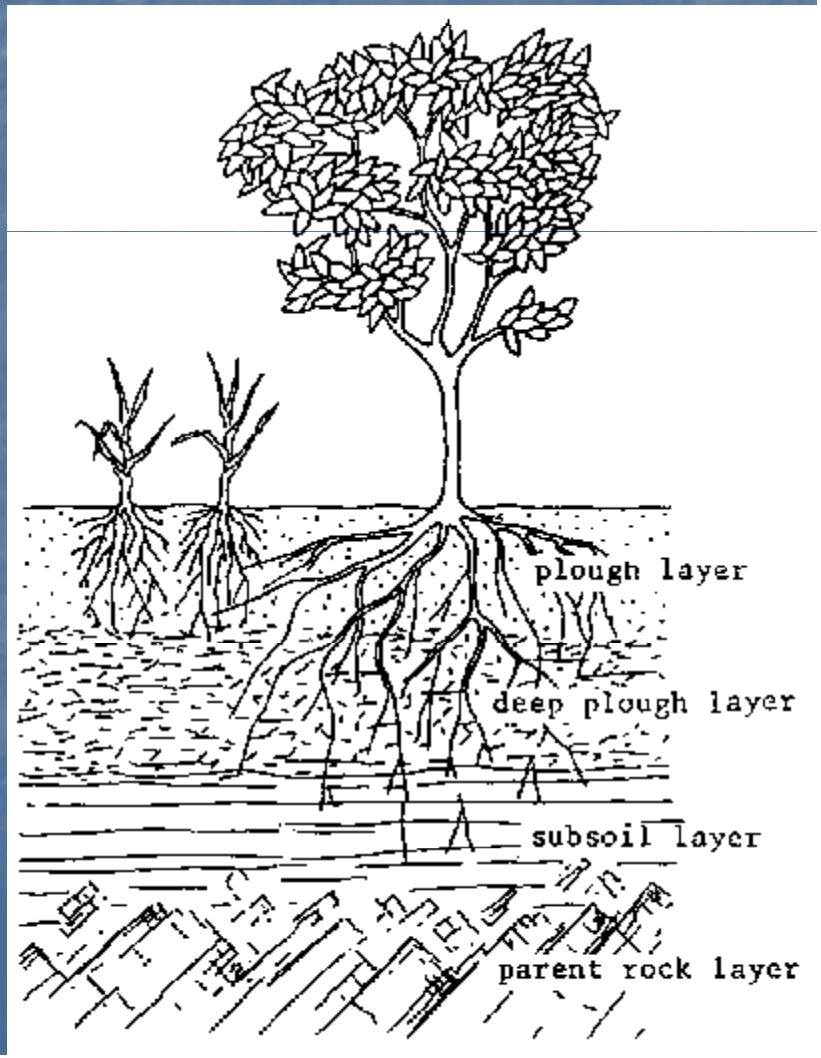
Soil Composition

- Living material is found in the soil. It can be live roots as well as beetles, worms, larvae etc. They help to aerate the soil and thus create favorable growing conditions for the plant roots



Soil Profile

- If a pit is dug in the soil, at least 1 m deep, various layers, different in color and composition can be seen. These layers are called horizons. This succession of horizons is called the profile of the soil



Soil Texture

- The mineral particles of the soil differ widely in size and can be classified as follows:

Name of the particles	Size limits in mm	Distinguishable with naked eye
Gravel	Larger than 1	Obviously
Sand	1 to 0.5	Easily
Silt	0.5 to 0.002	Barely
Clay	Less than 0.002	Impossible

- In coarse textured soils: sand is predominant (sandy soils). In medium textured soils: silt is predominant (loamy soils). In fine textured soils: clay is predominant (clayey soils). In the field, soil texture can be determined by rubbing the soil between the fingers

Farmer Lingo

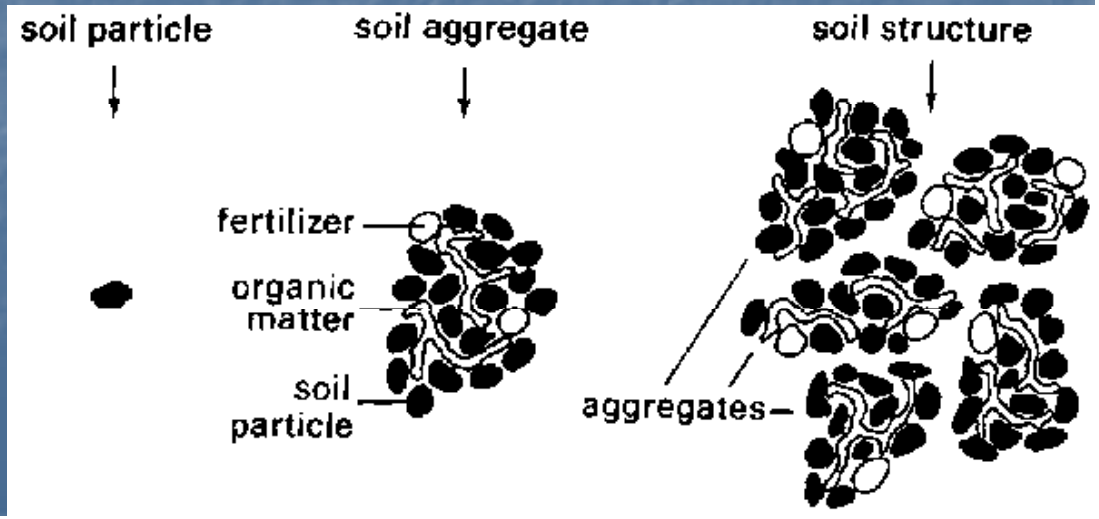
- Farmers often talk of light soil and heavy soil. A coarse-textured soil is light because it is easy to work, while a fine-textured soil is heavy because it is hard to work.

Expressions Used by Farmers	Expression Used in Literature	
Light	Sandy	Course
Medium	Loamy	Medium
Heavy	Clayey	Fine

- **Coarse textured soil is gritty. Individual particles are loose and fall apart in the hand, even when moist.**
- **Medium textured soil feels very soft (like flour) when dry. It can be easily be pressed when wet and then feels silky.**
- **Fine textured soil sticks to the fingers when wet and can form a ball when pressed.**

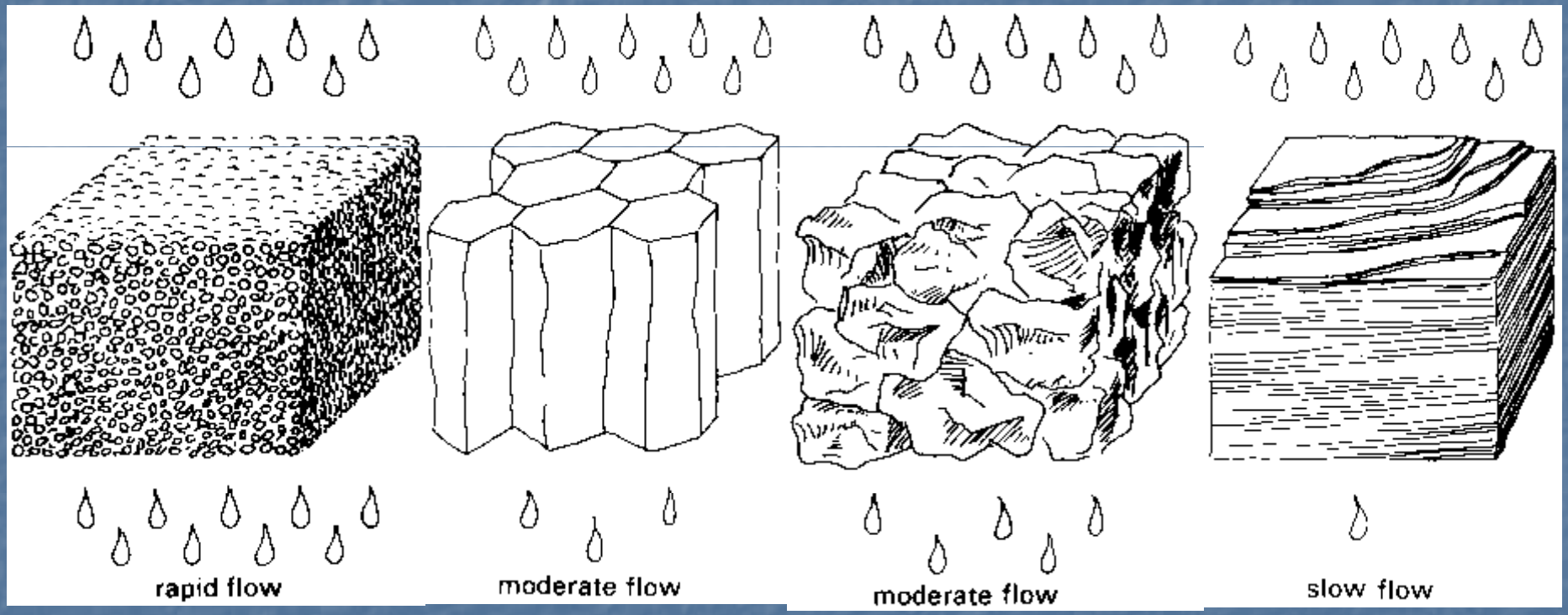
Soil Structure

- Soil structure refers to the grouping of soil particles (sand, silt, clay, organic matter and fertilizers) into porous compounds. These are called aggregates.
- Soil structure also refers to the arrangement of these aggregates separated by pores and cracks



Examples of Soil Structure

Granular Prismatic Blocky Massive



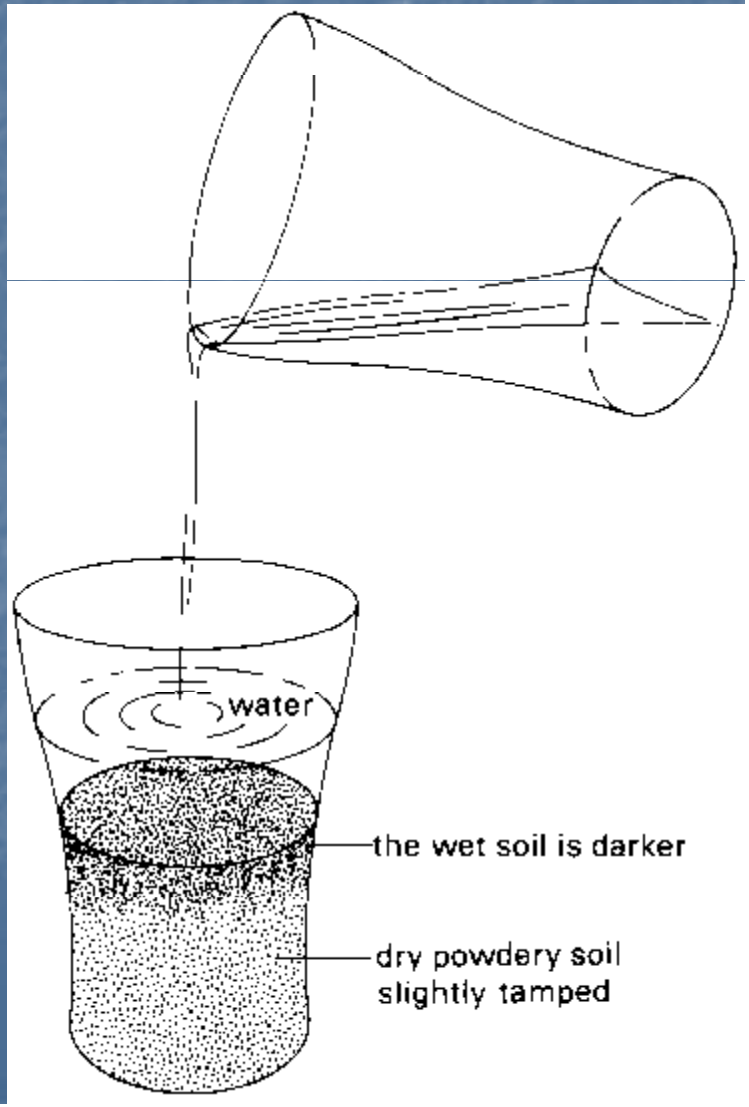
The basic types of aggregate arrangements are shown above

Soil Structure

- When present in the topsoil, a massive structure blocks the entrance of water; seed germination is difficult due to poor aeration. On the other hand, if the topsoil is granular, the water enters easily and the seed germination is better.
- In a prismatic structure, movement of the water in the soil is predominantly vertical and therefore the supply of water to the plant roots is usually poor.
- Unlike texture, soil structure is not permanent. By means of cultivation practices (ploughing, ridging, etc.), the farmer tries to obtain a granular topsoil structure for his fields.

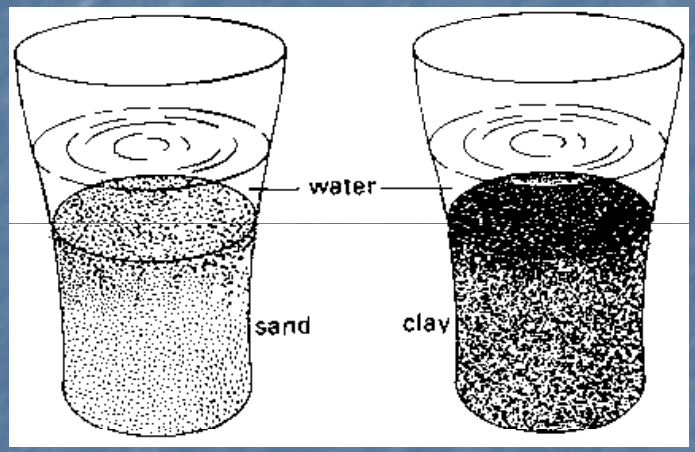
Water Infiltration

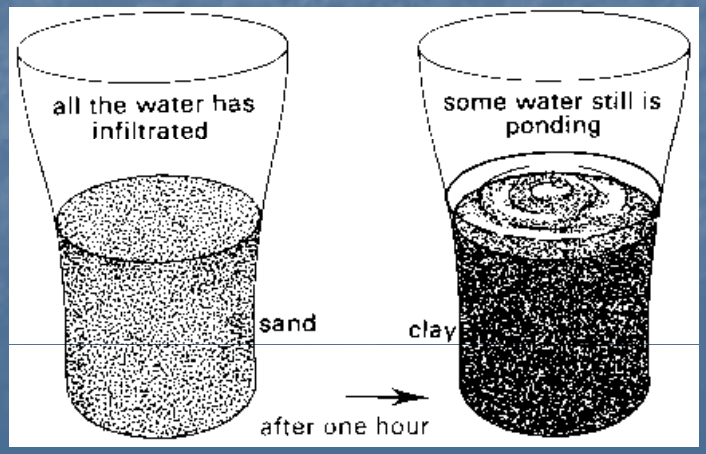
- When rain or irrigation water is supplied to a field, it seeps into the soil. This process is called infiltration.
- Infiltration can be visualized by pouring water into a glass filled with dry powdered soil, slightly tamped. The water seeps into the soil; the color of the soil becomes darker as it is wetted.



Infiltration Rate

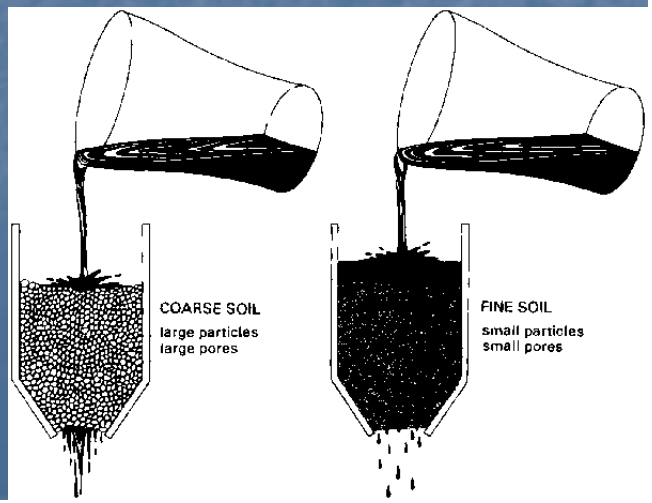
- The infiltration rate of a soil is the velocity at which water can seep into it. It is commonly measured by the depth (in mm) of the water layer that the soil can absorb in an hour.
- An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the surface of the soil, will take one hour to infiltrate.





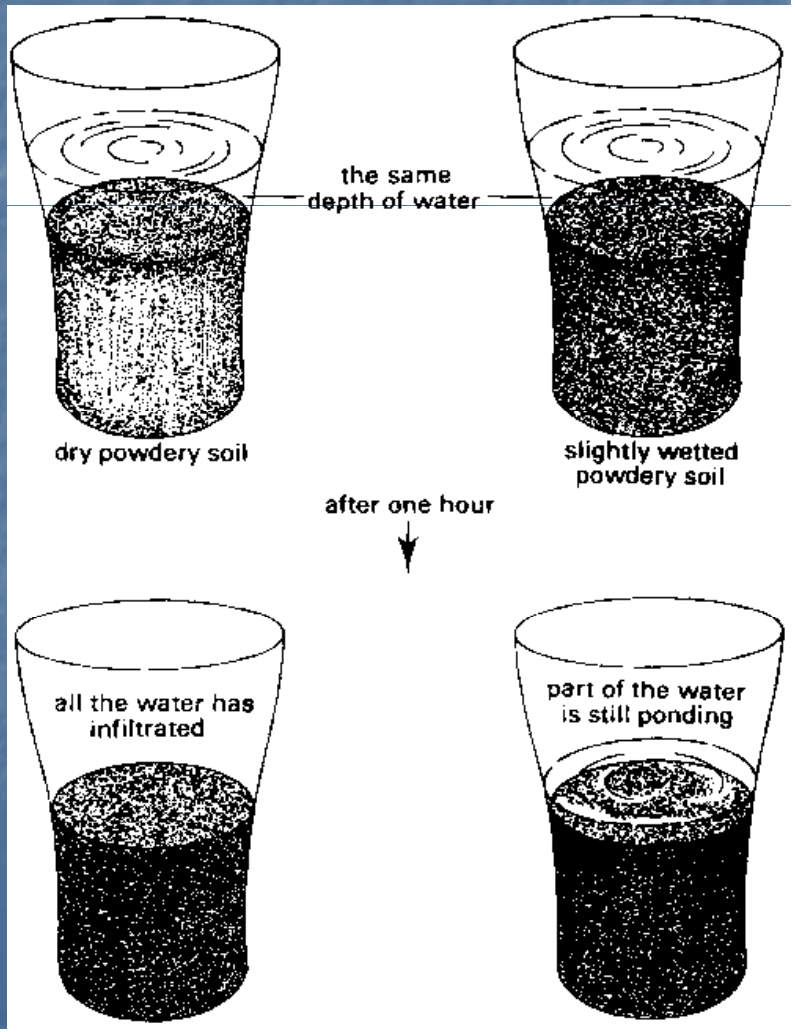
Factors Affecting Infiltration

- The infiltration rate of a soil depends on factors that are constant, such as the soil texture. It also depends on factors that vary, such as the soil moisture content.
- Coarse textured soils have mainly large particles in between which there are large pores.
- On the other hand, fine textured soils have mainly small particles in between which there are small pores



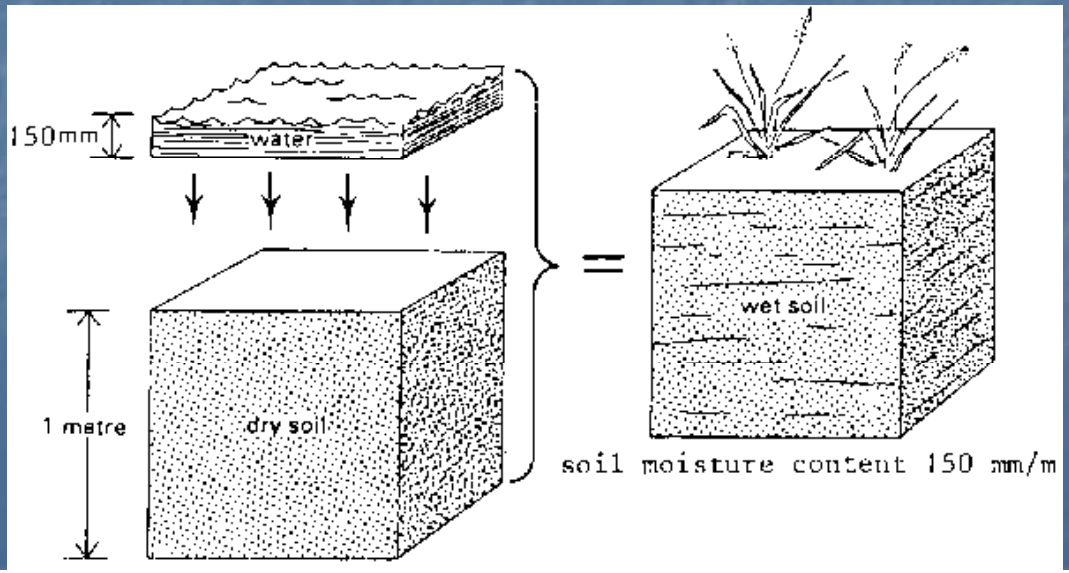
Factors Affecting Infiltration

- In coarse soils, the rain or irrigation water enters and moves more easily into larger pores; it takes less time for the water to infiltrate into the soil.
- The water infiltrates faster (higher infiltration rate) when the soil is dry, than when it is wet.
- As a consequence, when irrigation water is applied to a field, the water at first infiltrates easily, but as the soil becomes wet, the infiltration rate decreases.



Soil Moisture Content

- The soil moisture content indicates the amount of water present in the soil.
- It is commonly expressed as the amount of water present in a depth of soil.



Soil Moisture Content

- The soil moisture content can also be expressed in percent of volume.
- Thus, a moisture content of 100 mm/m corresponds to a moisture content of 10 volume percent.
- Note: The amount of water stored in the soil is not constant with time, but may vary.

Saturation

- During a rain shower or irrigation application, the soil pores will fill with water.
- If all soil pores are filled with water the soil is said to be saturated.
- It is easy to determine in the field if a soil is saturated. If a handful of saturated soil is squeezed, some (muddy) water will run between the fingers.
- Plants need air and water in the soil. At saturation, no air is present and the plant will suffer. Many crops cannot withstand saturated soil conditions for a period of more than 2-5 days. The period of saturation of the topsoil usually does not last long. After the rain or the irrigation has stopped, part of the water present in the larger pores will move downward. This process is called drainage or percolation.

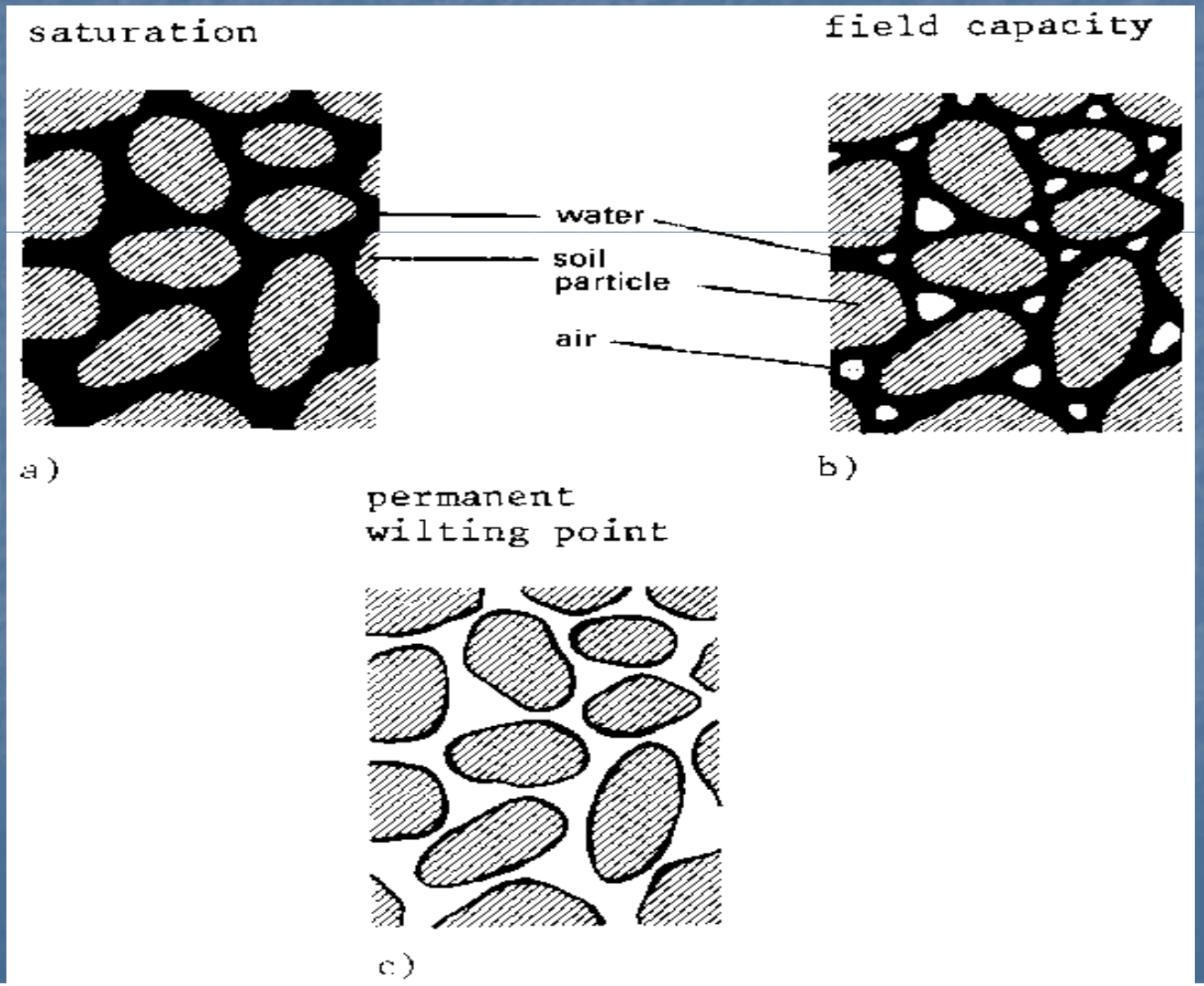
Field Capacity

- After the drainage has stopped, the large soil pores are filled with both air and water while the smaller pores are still full of water. At this stage, the soil is said to be at field capacity. At field capacity, the water and air contents of the soil are considered to be ideal for crop growth

Permanent Wilting Point

- Little by little, the water stored in the soil is taken up by the plant roots or evaporated from the topsoil into the atmosphere. If no additional water is supplied to the soil, it gradually dries out.
- The dryer the soil becomes, the more tightly the remaining water is retained and the more difficult it is for the plant roots to extract it. At a certain stage, the uptake of water is not sufficient to meet the plant's needs. The plant looses freshness and wilts; the leaves change color from green to yellow. Finally the plant dies.
- The soil water content at the stage where the plant dies, is called permanent wilting point. The soil still contains some water, but it is too difficult for the roots to suck it from the soil

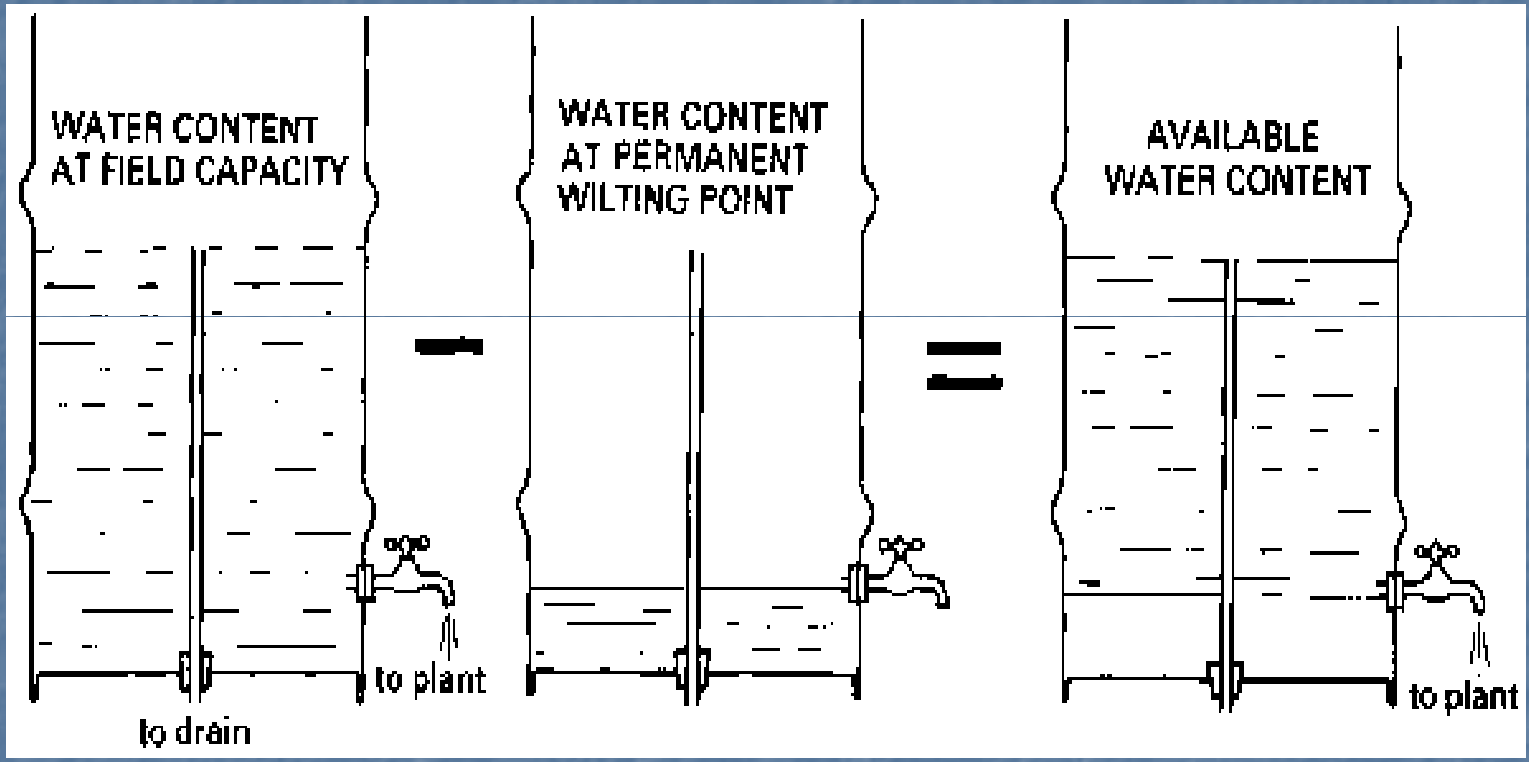
Examples of Moisture Content



Available Water Content

- The soil can be compared to a water reservoir for the plants. When the soil is saturated, the reservoir is full. However, some water drains rapidly below the root zone before the plant can use it
- When this water has drained away, the soil is at field capacity. The plant roots draw water from what remains in the reservoir
- When the soil reaches permanent wilting point, the remaining water is no longer available to the plant

Water Content

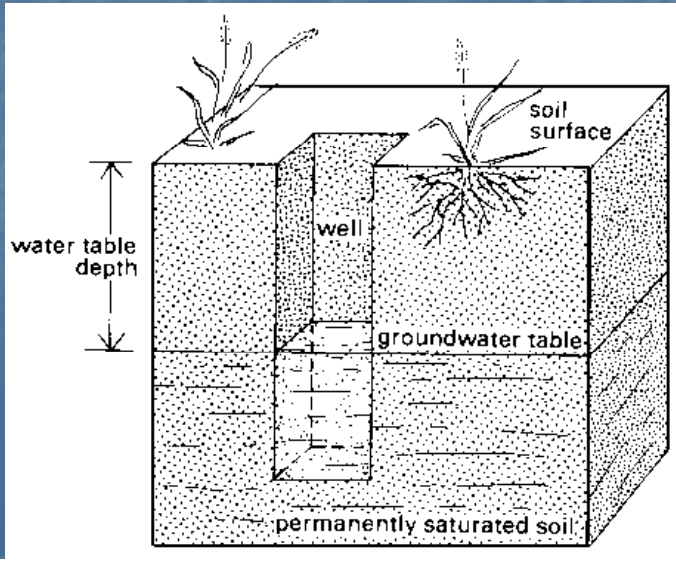


Available water content = water content at field capacity - water content at permanent wilting point

The available water content depends greatly on the soil texture and structure.

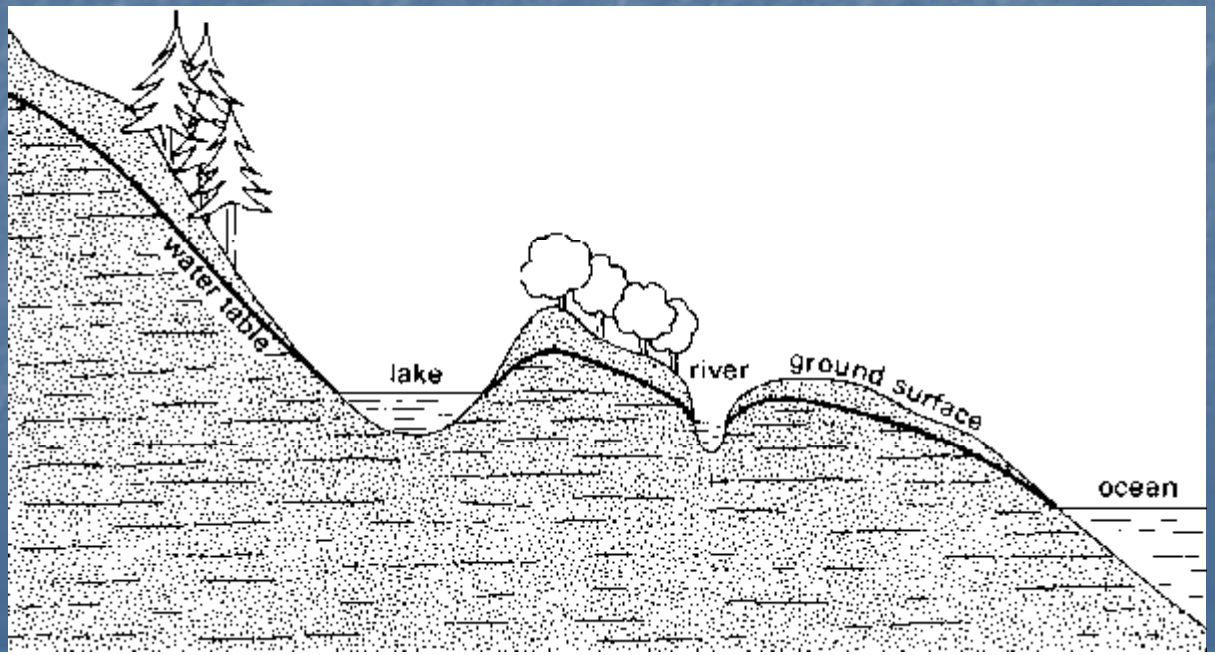
Groundwater Table

- Part of the water applied to the soil surface drains below the root zone and feeds deeper soil layers which are permanently saturated; the top of the saturated layer is called groundwater table or sometimes just water table



Depth of Groundwater Table

- The depth of the groundwater table varies greatly from place to place, mainly due to changes in topography of the area

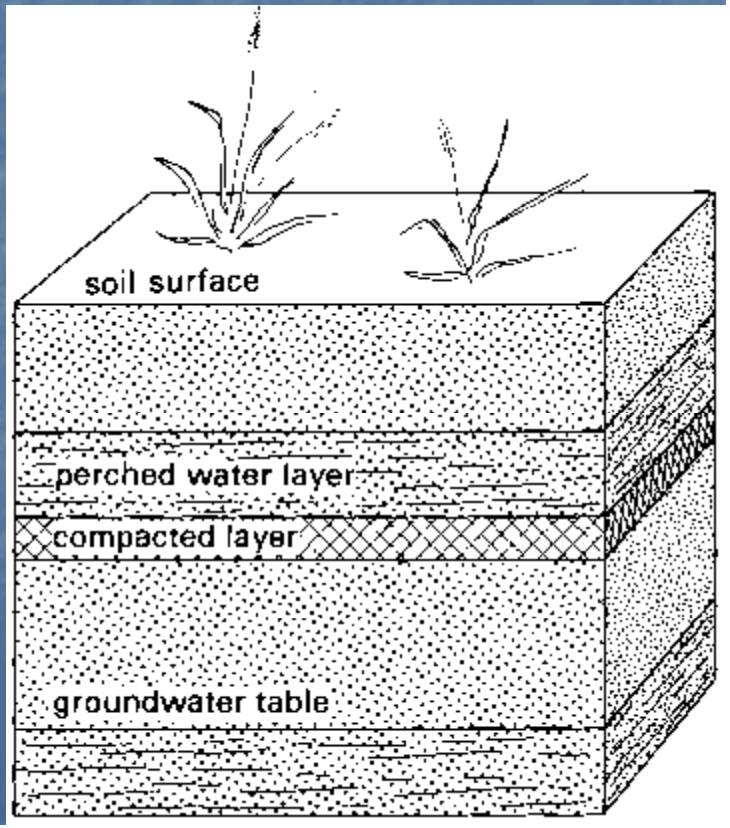


Depth of Groundwater Table

- Following heavy rainfall or irrigation, the groundwater table rises. It may even reach and saturate the root zone.
- If prolonged, this situation can be disastrous for crops which cannot resist "wet feet" for a long period.
- The groundwater table can also be very deep and distant from the root zone, for example following a prolonged dry period. To keep the root zone moist, irrigation is then necessary.

Perched Groundwater Table

- A perched groundwater layer can be found on top of an impermeable layer rather close to the surface (20 to 100 cm). It covers usually a limited area. The top of the perched water layer is called the perched groundwater table.



Capillary Rise

- The same process happens with a groundwater table and the soil above it. The groundwater can be sucked upward by the soil through very small pores that are called capillaries. This process is called capillary rise.
- In fine textured soil (clay), the upward movement of water is slow but covers a long distance. On the other hand, in coarse textured soil (sand), the upward movement of the water is quick but covers only a short distance.

Soil Erosion

- Erosion is the transport of soil from one place to another. Climatic factors such as wind and rain can cause erosion, but also under irrigation it may occur.
- Soil erosion by water depends on:
  - the slope: steep, sloping fields are more exposed to erosion;
  - the soil structure: light soils are more sensitive to erosion;
  - the volume or rate of flow of surface runoff water: larger or rapid flows induce more erosion.

Erosion Characteristics

- Erosion is usually heaviest during the early part of irrigation, especially when irrigating on slopes. The dry surface soil, sometimes loosened by cultivation, is easily removed by flowing water.
- After the first irrigation, the soil is moist and settles down, so erosion is reduced. Newly irrigated areas are more sensitive to erosion, especially in their early stages.
- There are two main types of erosion caused by water: sheet erosion and gully erosion. They are often combined.

Sheet erosion

- Sheet erosion is the even removal of a very thin layer or "sheet" of topsoil from sloping land. It occurs over large areas of land and causes most of the soil losses
- The signs of sheet erosion are:
  - only a thin layer of topsoil; or the subsoil is partly exposed; sometimes even parent rock is exposed; - quite large amounts of coarse sand, gravel and pebbles in the arable layer, the finer material has been removed;
    - exposure of the roots;
    - deposit of eroded material at the foot of the slope.

Gully Erosion

- Gully erosion is defined as the removal of soil by a concentrated water flow, large enough to form channels or gullies.
- These gullies carry water during heavy rain or irrigation and gradually become wider and deeper (see Fig. 45).
- The signs of gully erosion on an irrigated field are:
  - irregular changes in the shape and length of the furrows;
  - accumulation of eroded material at the bottom of the furrows;
  - exposure of plant roots.

Specific Gravity

- The ratio of the unit weight of a given material to the unit weight of water.
- Most values for soils fall in the 2.6 to 2.9 range

Sieve Analysis

- The sorting of soil samples using screens and a shaker
- Screens have progressively smaller openings and capture particles that wont pass through
- Screens are rated on the number of opening per inch
- Analysis gives a percentage per screen
- A Distribution Curve is generated from the test