Soil Plant Water Relationship

Soil

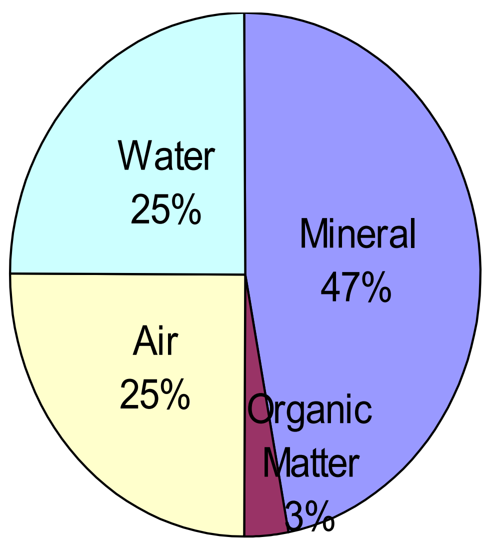
1. Act as water reservoir between rains and/or irrigation.
2. Act as nutrient/O.M. reservoir.
3. Mechanically support and stabilize plants.
4. Home for natural Habitat.
5. Temperate regime for plant growth.

Soil is a cheapest medium that fulfill all above listed requirements

Physical Characteristics

Soil Composition

- ✓ Mineral matter (45-49 % of the soil volume)
  - Sand
  - Silt
  - clay
- ✓ Organic matter (1-5 % of the soil volume only in upper 0.3m of soil)
  - Decayed plants
  - Animal substances
- ✓ Pores (50 % of the soil volume)



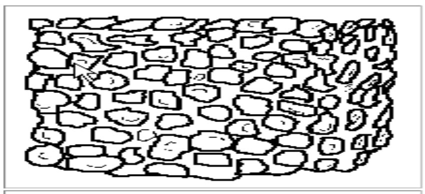
SOIL TEXTURE

- Texture is type and size of soil particles that make up the soil.
- Fine-textured soils generally hold more water than coarse textured soils.
- Medium-textured soils actually have more water available for plant use than some clay soils, since water in clays can be held at a greater tension that reduces its availability to plants.

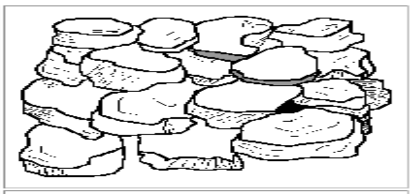
SOIL STRUCTURE

- Soil structure is the arrangement and organization of soil particles into natural units of aggregation.
- These units are separated from one another by weakness planes that persist through cycles of wetting and drying and cycles of freezing and thawing.
- Structure influences air and water movement, root development, and nutrient supply.

Soil Structure – Aggregation of soil particles (silt, sand, clay, OM)



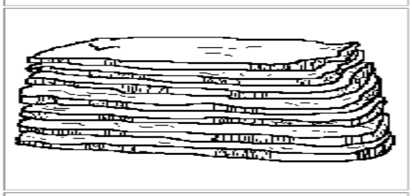
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.



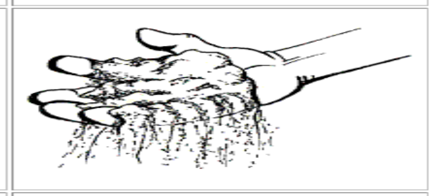
Blocky: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.

Prismatic: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.

Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.



Platy: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.



Single Grained: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Structure can either be improved or destroyed

Soil Structure

Causes of Poor Structure (poor Water Holding Capacity)

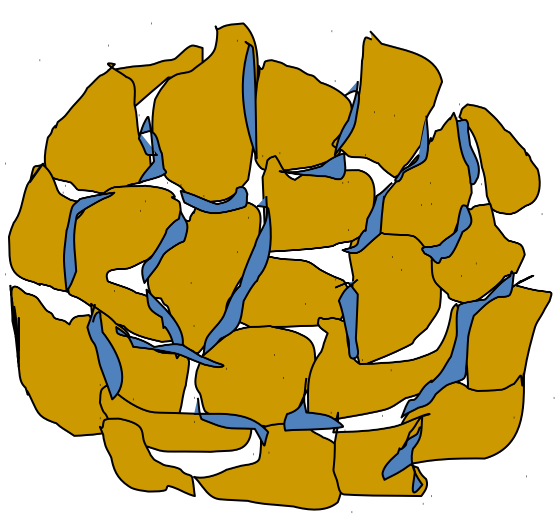
- soil compactness.
- excessive tillage.
- depletion of organic matter or biological activity.
- Irrigation with water having high percent sodium.
- Irrigation with water having high ratio of magnesium to calcium.
- Irrigation with very poor quality water.
- Sprinkler irrigation with low pressure and large droplets.
- Furrow irrigation which compacts the bottom of furrow over time.
- Establishment of hardpan .

Soil Structure Improvements enhance WHC

Porosity And Soil Water Status

Large and Capillary Pores in Soil:

- ST - all porous are full with water
- FC - water only in Capillary Porous
- WP - water within balks



Water tension increases as moisture declines

Water Movement in Soil

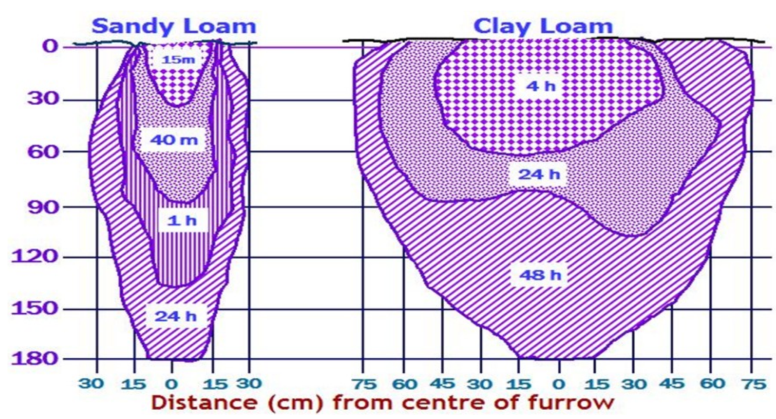
- Soil intake/water infiltration is the process of water entering the soil at the soil/air interface.
- Water enters the soil through pores, cracks, worm and decayed root holes, and through cavities introduced by tillage.
- Infiltrated water may evaporate again from the soil surface, may be transpired by the plants or may percolate downward beyond the plant roots and contribute to groundwater.
- If the rate of application exceeds the infiltration rate, water will be ponding on the surface or moving over the surface through runoff.
- The infiltration rate determines the amount of water entering the soil and amount that will subsequently be stored in the root zone.

Factors Affecting Infiltration

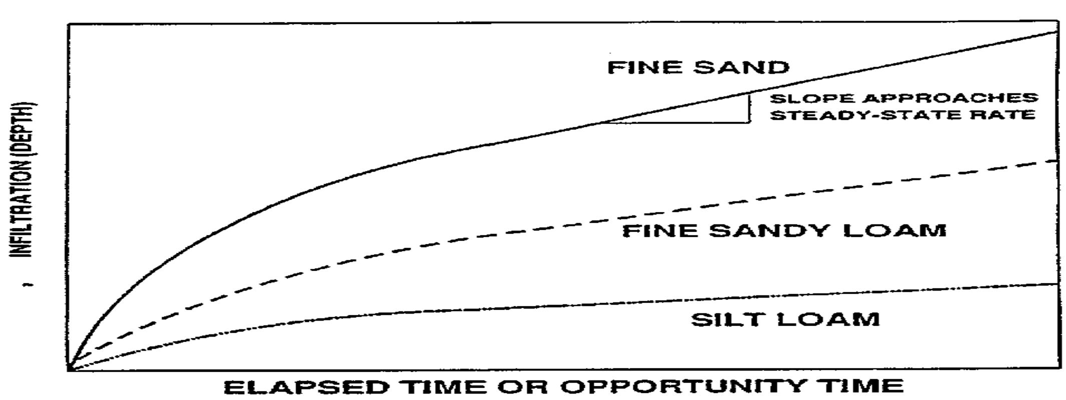
- *Soil water content*:
- *Soil sealing*:
- *Compaction*:
- *Organic matter*:
- *Salinity*:
- *Soil cracking*:
- *Soil depth*:
- *Water table*:
- *Slope*:
- *Soil erodability*:

Cumulative Infiltration Depth vs. Time

Soil texture, Infiltration and wetting pattern



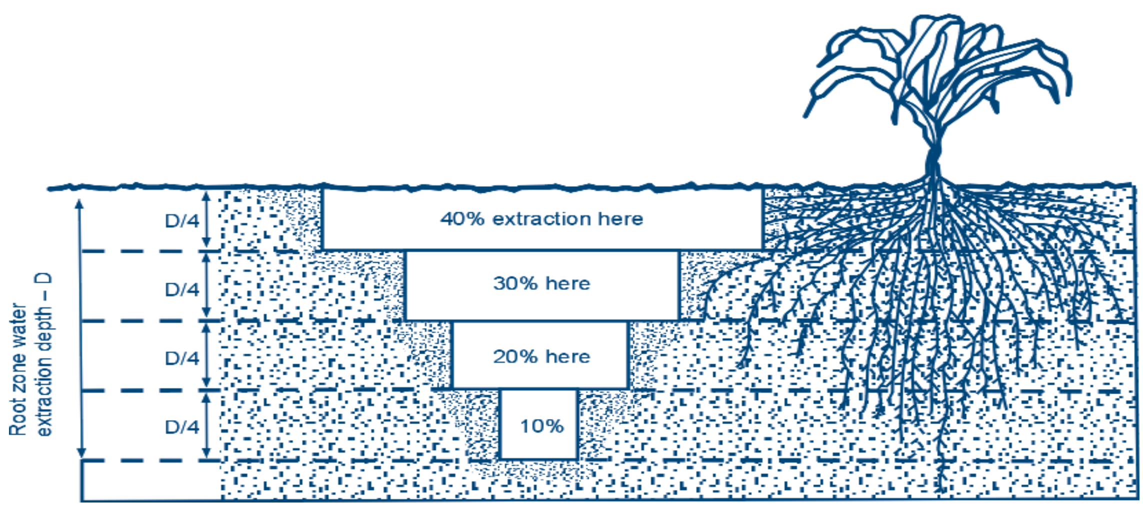
For Different Soil Textures



Effective Root Zone Depth

- Published data on the depth from where the crops extract most of their water differ greatly.
- As a rule, for most field crops 40% of the water uptake takes place from the first quarter of the total rooting depth, 30% from the second quarter, 20% from the third quarter and 10% from the fourth quarter (Figure 28).
- According to FAO (1984), ETc is not affected even when rooting depth is severely restricted, as long as plants are sufficiently anchored and proper growing conditions, including available water, nutrients, soil aeration, soil temperature and soil structure, prevail.
- While for surface irrigation systems there is a tendency to accept deeper root zone depths in selecting root zone depths for pressurized systems, the decision is based on the majority of feeder roots.
- Knowing the crop water requirements, the type of soil and the root zone depth, the readily-available moisture for the crop can be calculated, which is the amount of water that can be extracted by the crop in the root zone without suffering water stress.

Extraction of water by roots



Soil Health/Quality

Indicator		**Relationship to Soil Health**
SOIL ORGANIC MATTER	OM	Soil fertility, structure, stability, nutrient retention: soil erosion.
PHYSICAL	Soil structure, depth of soil, Infiltration and bulk density: water holding capacity	Retention and transport of water and nutrients: habitat for microbes: estimate of crop productivity potential: compaction, plow pan, water movement: porosity: workability.
CHEMICAL	pH: electrical conductivity: extractable N-P-K	Biological and chemical activity thresholds: plant and microbial activity thresholds: plant available nutrients and potential for N and P loss.
BIOLOGICAL	Microbial biomass C and N: potentially mineralizable N: soil respiration.	Microbial catalytic potential and repository for C and N: soil productivity and N supplying potential: microbial activity measure.

Soil Water Holding Capacity

Terminology

- **Saturation Capacity (Maximum Water Holding Capacity)**

Condition at which all soil pores are filled with water, No air spaces

- **Soil Intake rate/Infiltration rate**

Measure of how fast the soil will take-in water (inches/hours)

- **Field Capacity (Water Holding Capacity)**

Amount of water held in soil after excess water had drained out and water contents has be stable. Roots can take water with ease.

- **Permanente Wilting Points**

Soil moisture contents at which plant can no longer obtained water to meet evapotranspiration.

- **Available water (AW)**

Amount of water between field capacity and permanent wilting point . This is also called Water Holding Capacity of Soil.

- **Irrigation Interval (Management Allowable Depletion)**

It is a management decision as to how much of the available water should be deleted before next irrigation (MAD is measured in percentages)

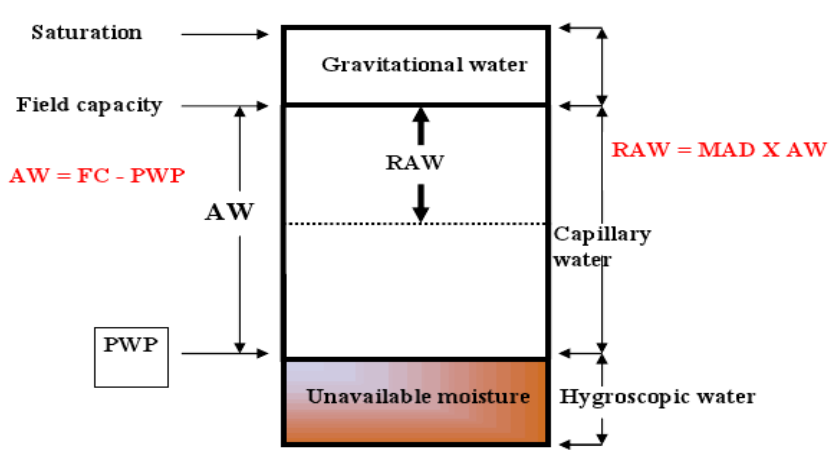
Soil Water Potential

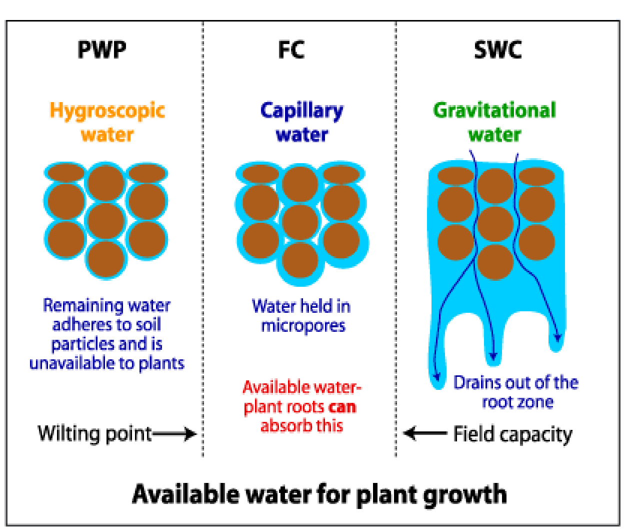
- Description
  - Measure of the energy status of the soil water
  - Important because it reflects how hard plants must work to extract water.
  - Units of measure are normally bars or atmospheres.
  - Soil water potentials are negative pressures (tension or suction).
  - Water flows from a higher (less negative) potential to a lower (more negative) potential.

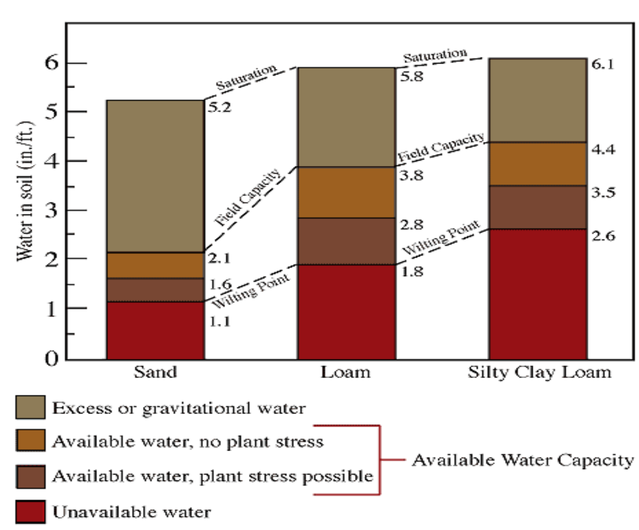
Soil Water Potential

Available Water

- Definition
  - Water held in the soil between field capacity and permanent wilting point.
  - “Available” for plant use.
- Available Water Capacity (AWC)
  - AWC = θ_{fc} - θ_{wp}
  - Units: depth of available water per unit depth of soil, “unitless” (in/in, or mm/mm).
  - Measured using field or laboratory methods (described in text).







Soil Hydraulic Properties and Soil Texture

Table 2.3. Example values of soil water characteristics for various soil textures.*

Soil texture	θ_{fc}	θ_{wp}	AWC
	---------- in/in or m/m ---------		
Coarse sand	0.10	0.05	0.05
Sand	0.15	0.07	0.08
Loamy sand	0.18	0.07	0.11
Sandy loam	0.20	0.08	0.12
Loam	0.25	0.10	0.15
Silt loam	0.30	0.12	0.18
Silty clay loam	0.38	0.22	0.16
Clay loam	0.40	0.25	0.15
Silty clay	0.40	0.27	0.13
Clay	0.40	0.28	0.12

* Example values are given. You can expect considerable variation from these values within each soil texture.

Total Available Water (TAW)

TAW = (AWC) (R_d)

- TAW = total available water capacity within the plant root zone, (inches)
- AWC = available water capacity of the soil, (inches of water/inch of soil)
- R_d = depth of the plant root zone, (inches)
- If different soil layers have different AWC's, need to sum up the layer-by-layer TAW's

TAW = (AWC_1) (L_1) + (AWC_2) (L_2) + . . . (AWC_N) (L_N)

- L = thickness of soil layer, (inches)

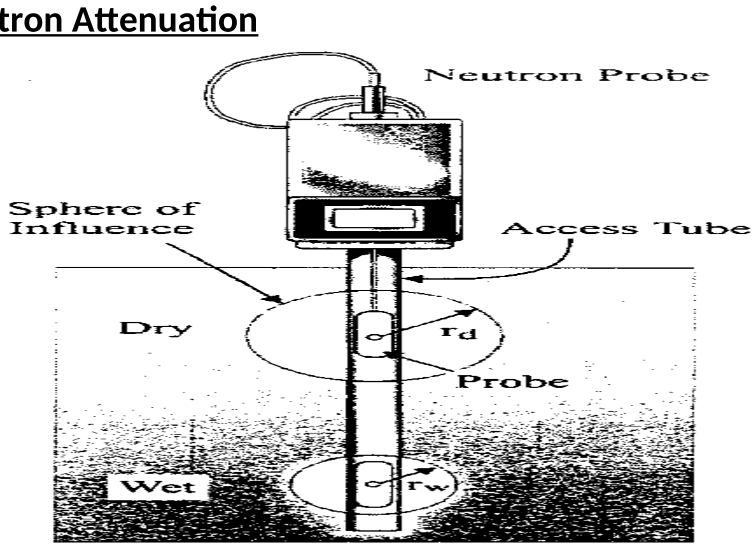
- $_{1, 2, N}$: subscripts represent each successive soil layer

Soil Water Measurement

- **Feel and appearance**
  - Take field samples and feel them by hand
  - Advantages: low cost; Multiple locations
  - Disadvantages: experience required; Not highly accurate
- **Dielectric constant**
  - A soil's dielectric constant is dependent on soil moisture
  - Time domain reflectometry (TDR)
  - Frequency domain reflectometry (FDR)

Primarily used for research purposes at this time

Neutron Attenuation



- **Tensiometers**
  - Measure soil water potential (tension)
  - Practical operating range is about 0 to 0.75 bar of tension (this can be a limitation on medium- and fine-textured soils)
- **Electrical resistance blocks**
  - Measure soil water potential (tension)
  - Tend to work better at higher tensions (lower water contents)

Tensiometer for Measuring Soil Water Potential

Electrical Resistance Blocks & Meters