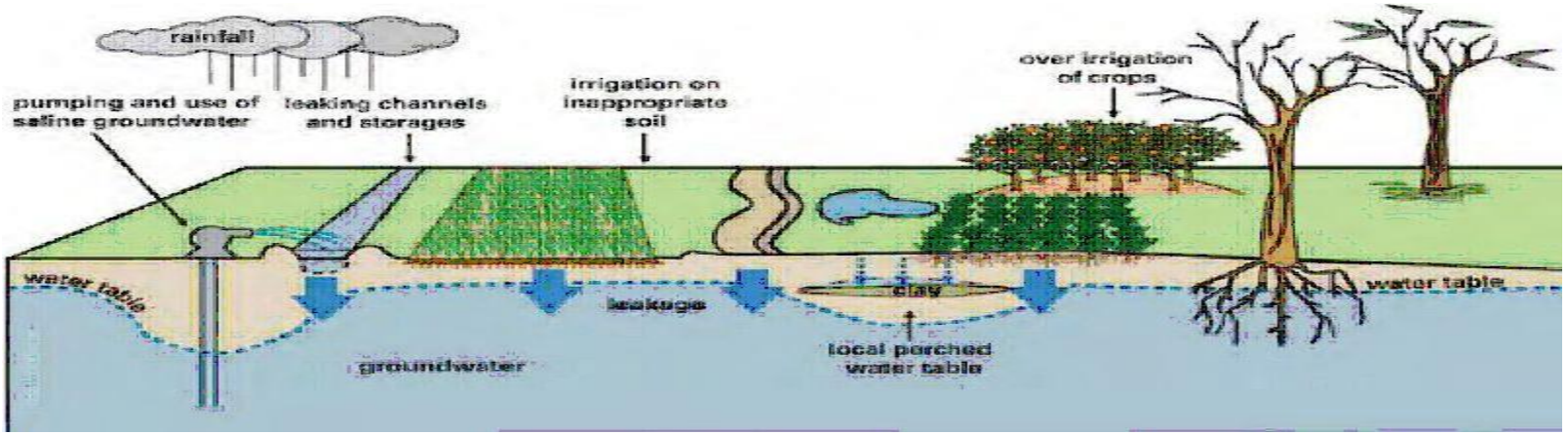
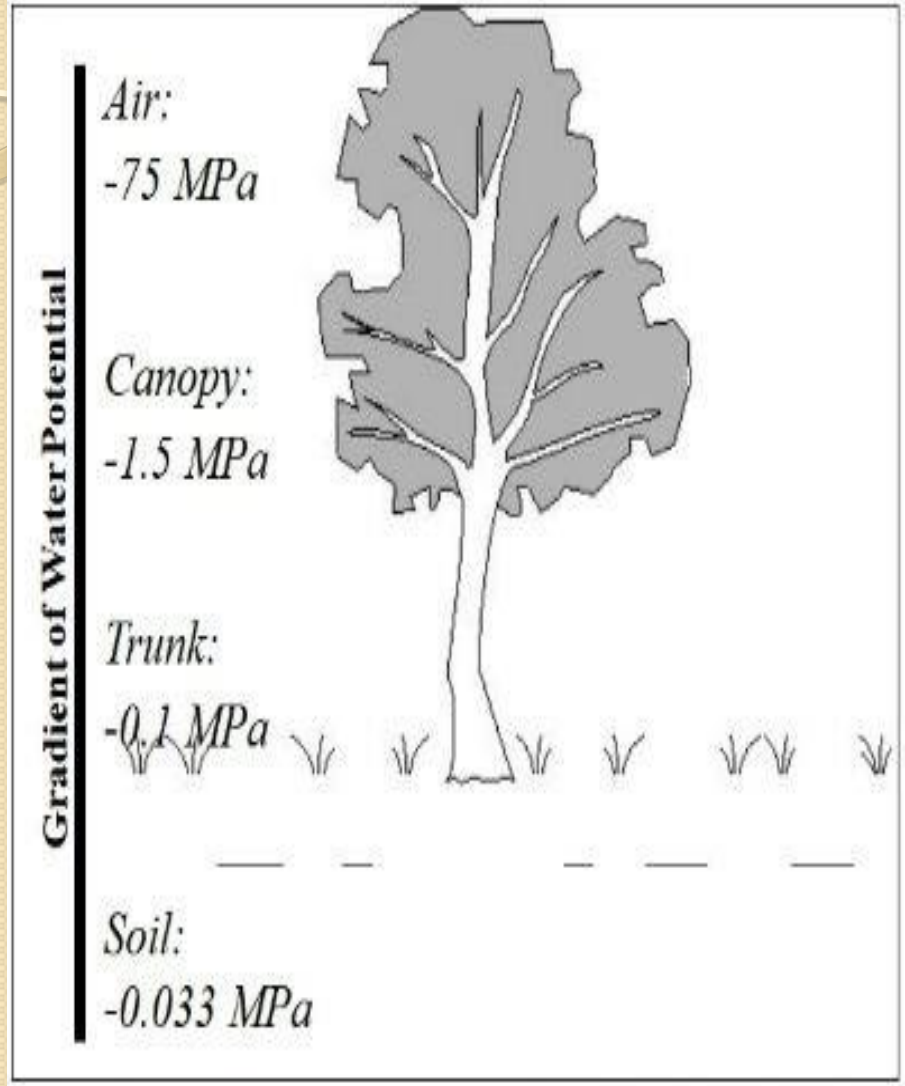
Soil, Water & Plant Relationships



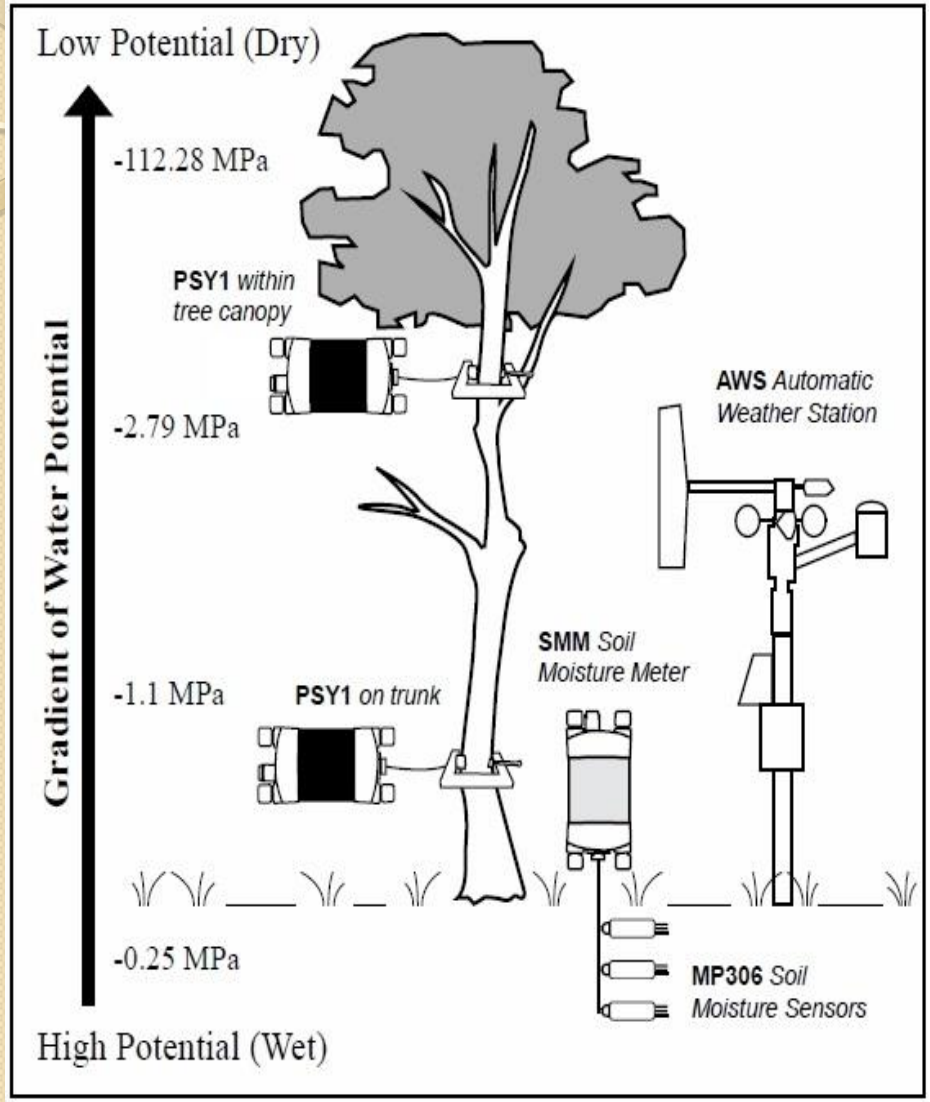
Lecture note for Soil and Water Management Course
Prepared by Dr ND Nang

Soil-Plant-Atmosphere Continuum (SPAC)



- The SPAC is defined as the movement of water from the soil, through the plant and to the atmosphere along an interconnected film of liquid water (Lambers et al 2008)

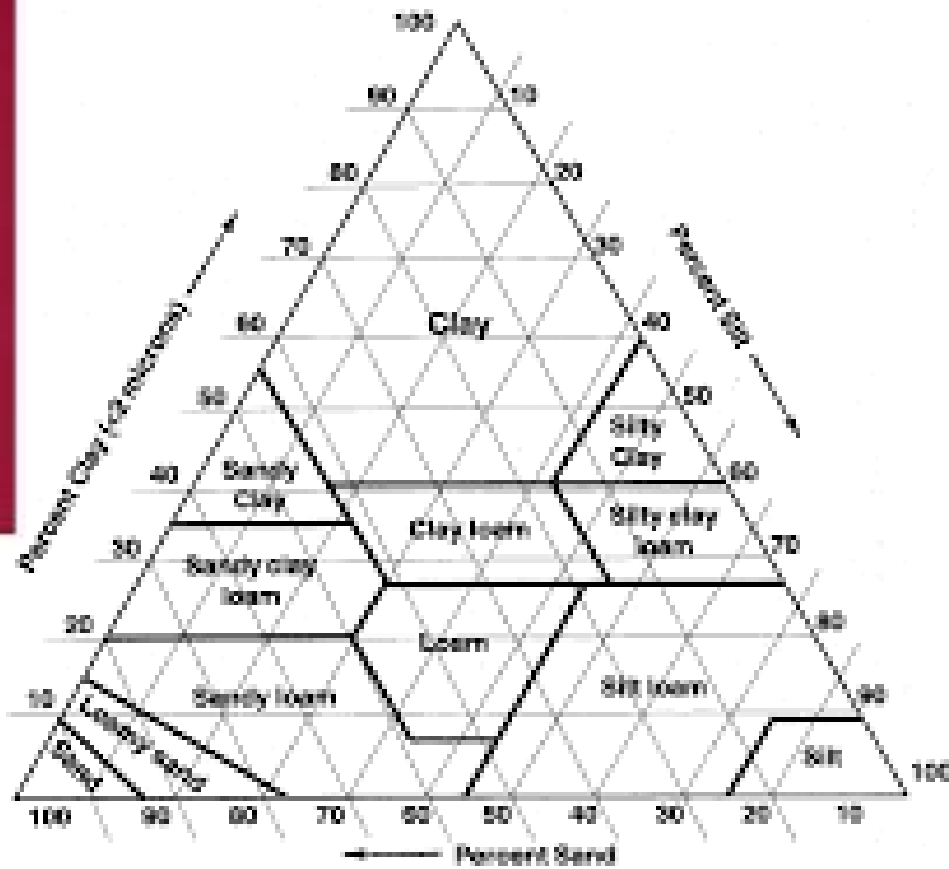
Soil-Plant-Atmosphere Continuum (SPAC)



- Flow of watr in the SPAC occur from region of higher total potential energy to regions of lower total potential energy.

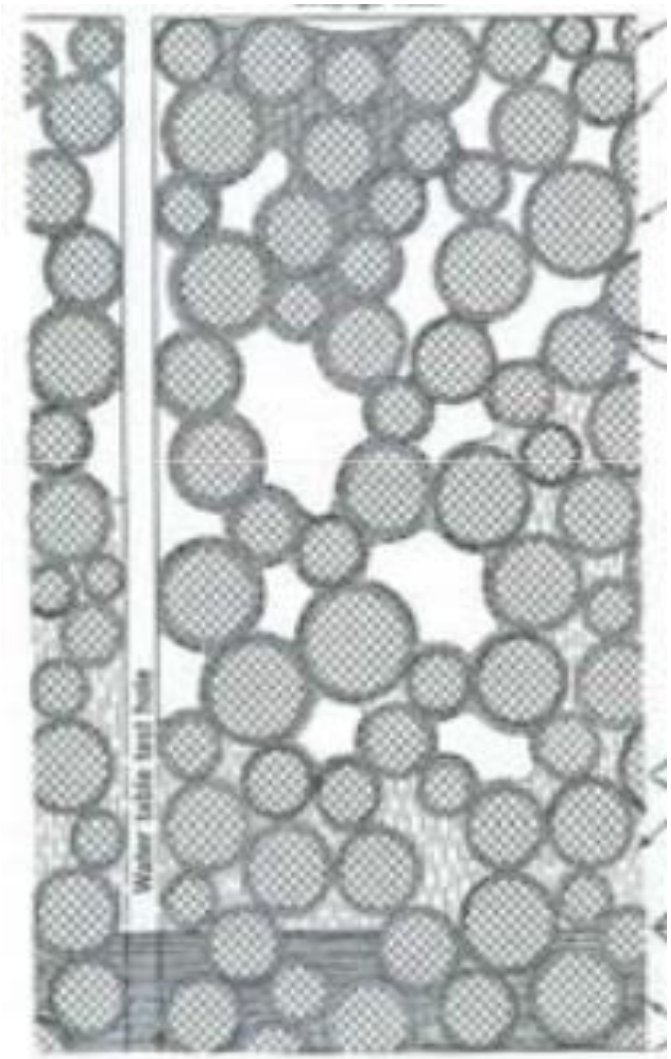
Understanding Water Holding Capacity

- Soil textural classification:
  - Sand, silt, clay content



Understanding Water Holding Capacity

- Soil textural classification:
  - Voids (air space) in the soil
  - How water is held in the soil
    - Due to adhesion and cohesion forces
    - Capillary rise



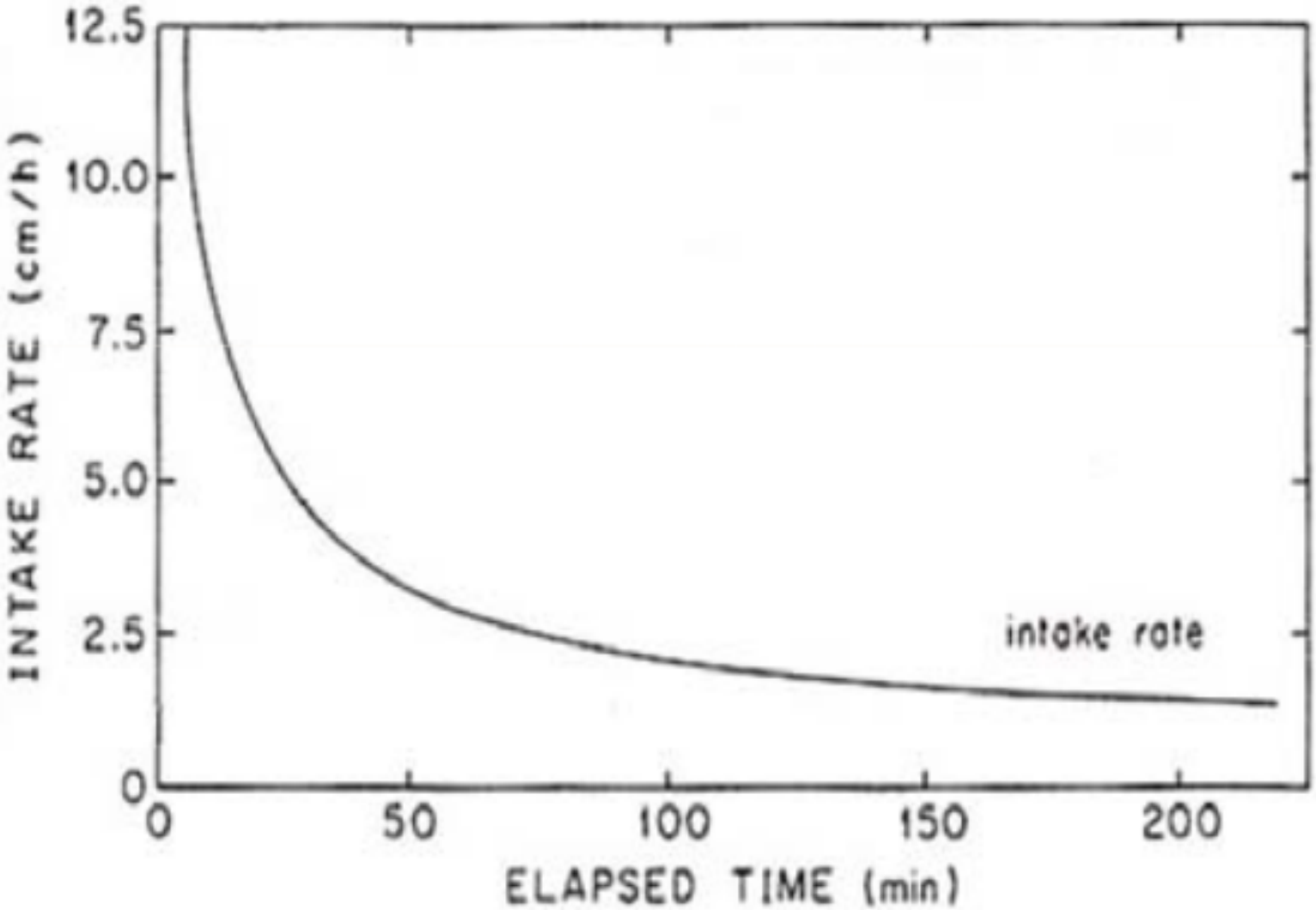
Porosity

- Porosity is a measure of how much pore space exist in the soil
- Volume of pores/volume of the soil x 100
- Porosity is given as % and may be 30% to 40% in soil and higher in artificial media
- Porosity of a clay and a silt loam can be the same

Permeability

- How fast can water move into/through the soil (cm/hour or inches/hour)?
- Higher in dry soil/lower in wet soil
- Higher in soils with larger pore spaces (sands, loams, amended soil, potting mix)
- Lower in soils with smaller pore spaces (silts, clays, compacted soil or soil layer)

Soil Intake Rate



Permeability

- Saturated permeability for clay soils may be < 0,15 cm/hour (0.06 inches/hour)
- Saturated permeability for silt loam soils may be < 0, 5 cm/hour (0.2 inches/hour)
- Permeability generally declines with compaction, rainfall, irrigation, increased moisture content, decreased organic matter or amendments, and increased density

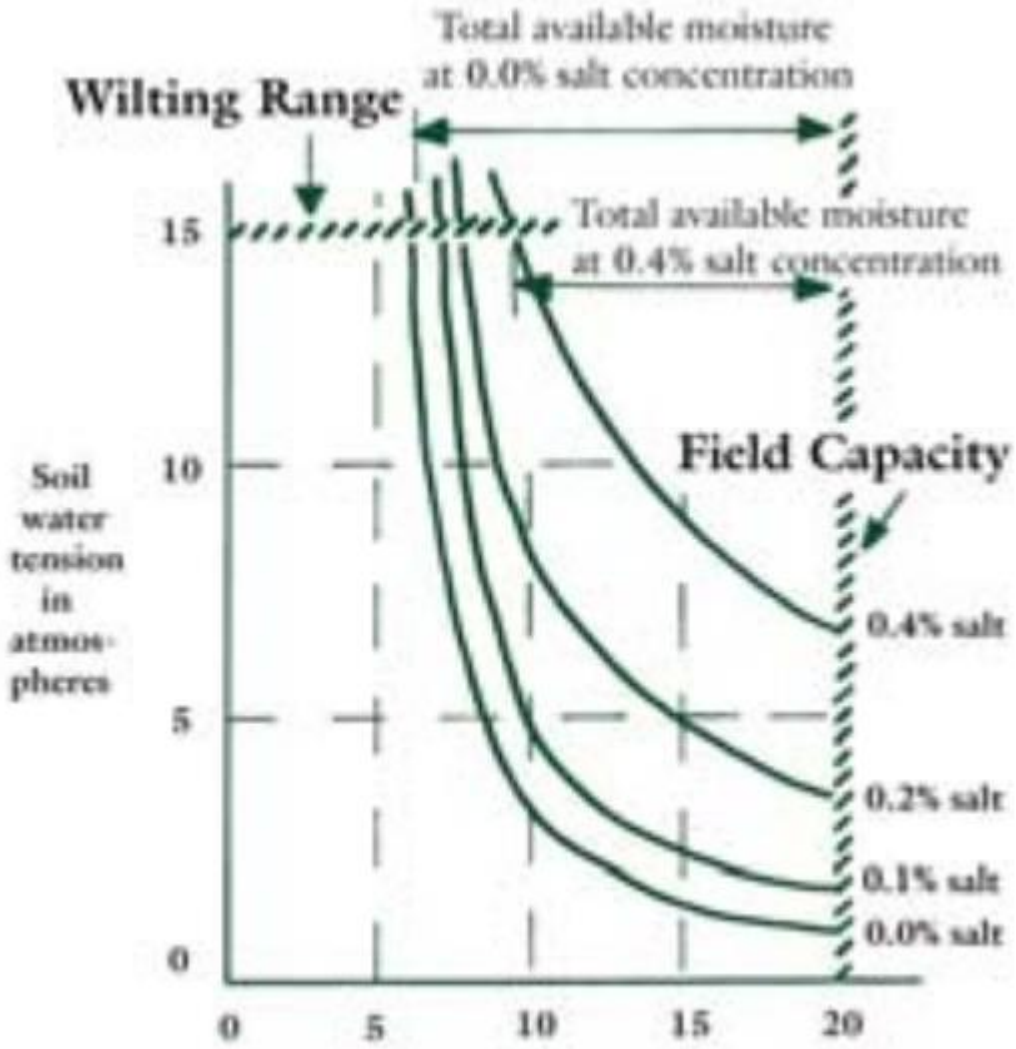
Compaction

- Compaction reduces porosity, infiltration, and water holding capacity
- Compaction can be increased by traffic, tillage, impact (mechanical or hydraulic), and chemical changes (sodium, calcium)

Salts

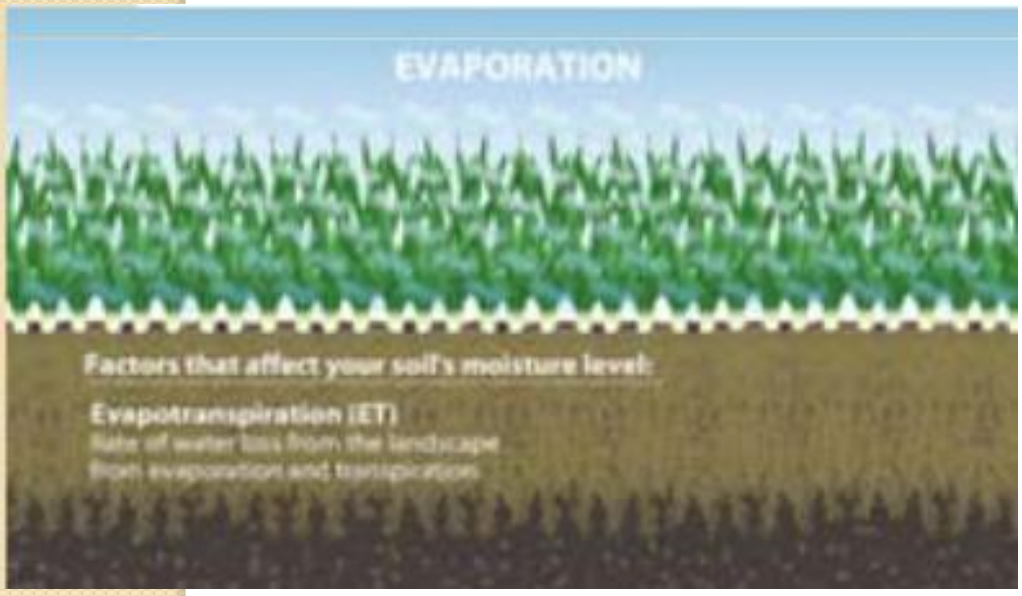
- Due to the dissolved ions in salty water it takes more pressure for water taken up into plants
- As salt concentrations increase it reduces the availability of water to plants

Salt and Water intake



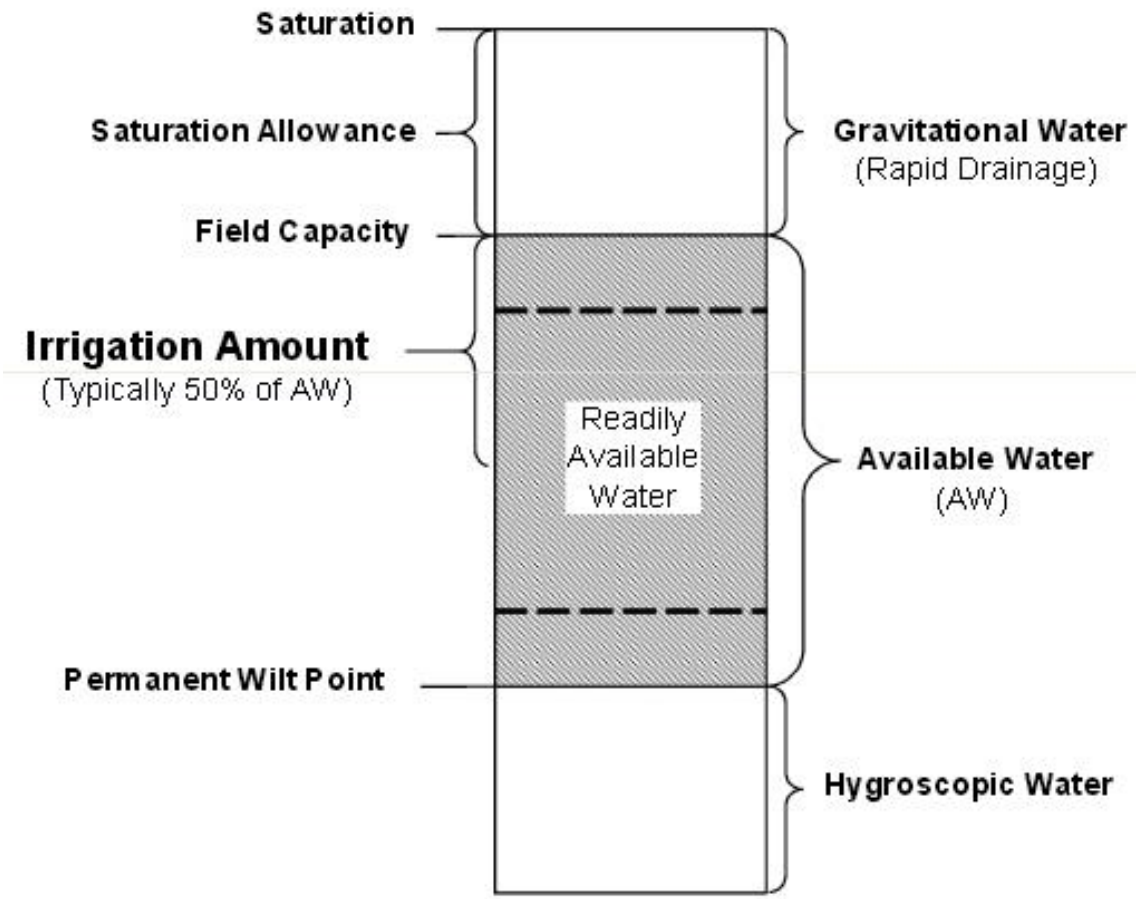
Soil is reservoir

- Capacity
  - Soil type
  - Root depth



- Moisture level
  - Evaporation
  - Raill
  - Irrigation

Soil is reservoir



Why we want to irrigate? To replace rain water that has evaporated.

Evapotranspiration (ET)

- Evaporation of water from the soil or plants surfaces and transpired from leaves
  - It is typically measured in mm or inches
- Weather conditions affect ET
  - Solar radiation
  - Temperature
  - Wind
  - Humidity

Effective Rain fall

- Measurement of rain is as important as the measurement of ET
- Rainfall replenishes soil moiture
- Rainfall that runs off is NOT effective rain
  - Soil percolation rate and slope limit effective rain
- Rain that soaks below the roots is NOT effective rain
  - A soil moisture balance calculation determines when the root zones is saturated

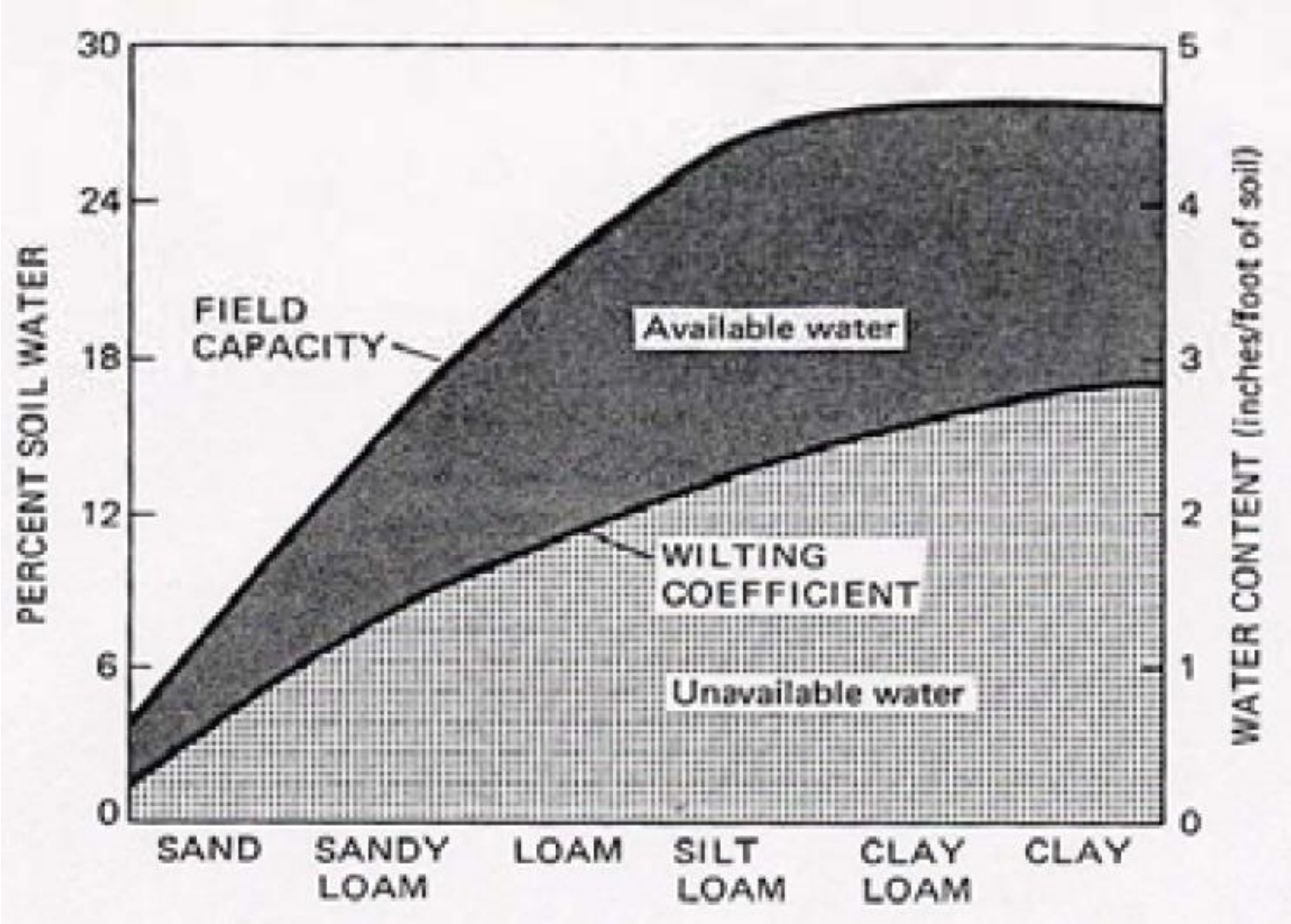
Irrigation Requirement

- ET – Effective rain = Irrigation Requirement
- The irrigation requirement is met when sprinklers run long enough to return the soil moisture level back to desired level – no more/no less

Benefits of ET-based Water Management

- Efficient use of water
  - Save money
  - Preserve Natural Resource
- Health lanscape
  - Watered when needed
  - Watered right

The Soil Reservoir

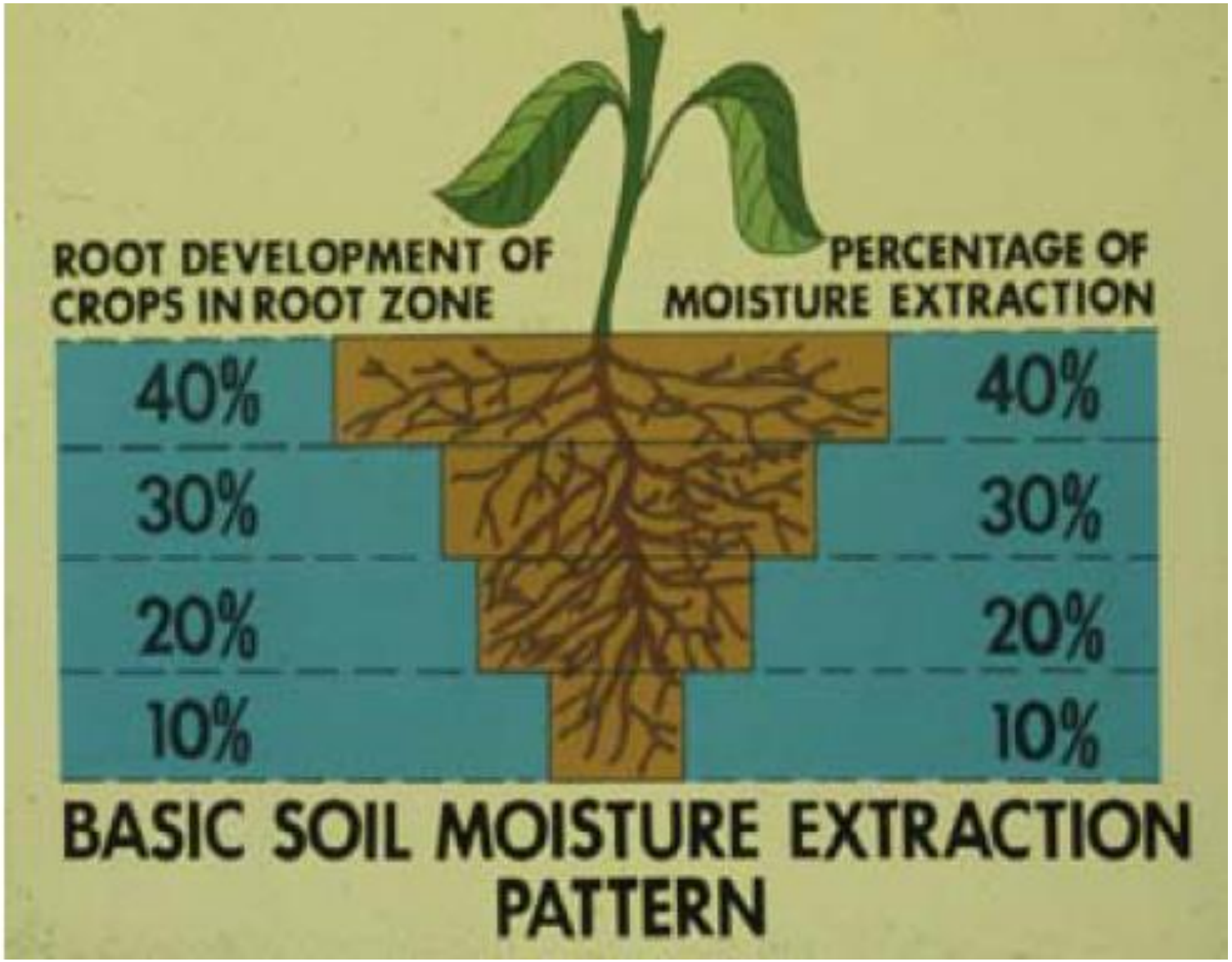


Soil, Water and Plant Relationships

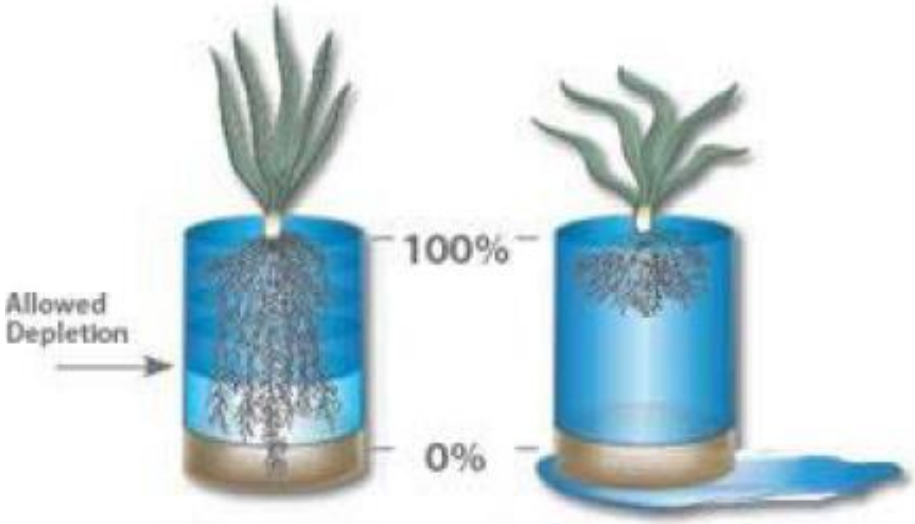
Table 3.1. Range in available water-holding capacity of soils of different texture

Soil texture	Water-holding capacity Range mm/m	Water-holding capacity Average mm/m
1. Very coarse texture—very coarse sands	33 to 62	42
2. Coarse texture—coarse sands, fine sands, and loamy sands	62 to 104	83
3. Moderately coarse texture—sandy loams	104 to 145	125
4. Medium texture—very fine sandy loams, loams, and silt loams	125 to 192	167
5. Moderately fine texture—clay loams, silty clay loams, and sandy clay loams	145 to 208	183
6. Fine texture—sandy clays, silty clays, and clays	133 to 208	192
7. Peats and mucks	167 to 250	208

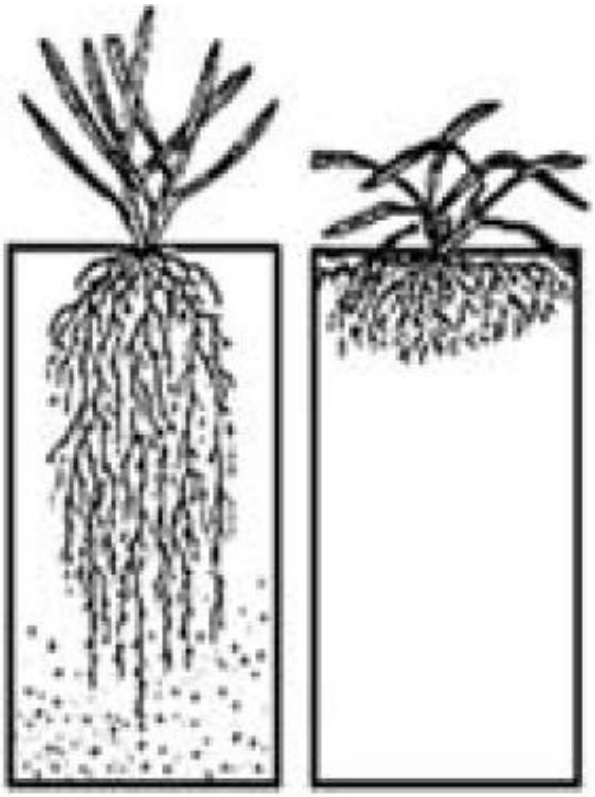
Moisture extraction



Water Management



w/ Water Management Frequent Irrigation



w/ Water Management Frequent Irrigation

Soil, Water and Plant Relationships

- Concept:

  MAD – Management-allowed deficit/depletion

  Percentage of available water within the soil that you will allow to be removed before you irrigate
- MAD%
  - 25 – 40% shallow rooted, high value fruit or vegetable crops
  - 40 – 50% vineyards, berries, medium rooted row crops
  - 50%, mature trees, forage crops, grain crops, deep-rooted row crops

Soil, Water and Plant Relationships

- How much do you apple during irrigation?

$$d_x = (MAD/100) * W_a * Z$$

  - d_x: maximum net depth of water to be applied during irrigation (mm or inches)
  - MAD: management-allowed depletion
  - W_a : available water-holding capacity of the soil (mm/m)
  - Z : effective root depth (m)

Slope effects

- Sloping terrain will increase the chance of runoff and will decrease water infiltration
- The greater the slope, the greater the problems will be
- Consider splitting irrigation in multiple cycles