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 water 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 Rainfall

- Measurement of rain is as important as the measurement of ET
- Rainfall replenishes soil moisture
- 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

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Water-holding capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range mm/m</td>
</tr>
<tr>
<td>1. Very coarse texture—very coarse sands</td>
<td>33 to 62</td>
</tr>
<tr>
<td>2. Coarse texture—coarse sands, fine sands, and loamy sands</td>
<td>62 to 104</td>
</tr>
<tr>
<td>3. Moderately coarse texture—sandy loams</td>
<td>104 to 145</td>
</tr>
<tr>
<td>4. Medium texture—very fine sandy loams, loams, and silt loams</td>
<td>125 to 192</td>
</tr>
<tr>
<td>5. Moderately fine texture—clay loams, silty clay loams, and sandy clay loams</td>
<td>145 to 208</td>
</tr>
<tr>
<td>6. Fine texture—sandy clays, silty clays, and clays</td>
<td>133 to 208</td>
</tr>
<tr>
<td>7. Peats and mucks</td>
<td>167 to 250</td>
</tr>
</tbody>
</table>
Moisture extraction

<table>
<thead>
<tr>
<th>Root Development of Crops in Root Zone</th>
<th>Percentage of Moisture Extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

BASIC SOIL MOISTURE EXTRACTION PATTERN
Water Management
Soil, Water and Plant Relationships

• Concept:
  \textit{MAD} – \textit{Management-allowed deficit/depletion}
  Percentage of available water within the soil that you will allow to be removed before you irrigate

• MAD%
  \begin{itemize}
    \item 25 – 40\% shallow rooted, high value fruit or vegetable crops
    \item 40 – 50\% vineyards, berries, medium rooted row crops
    \item 50\%, mature trees, forage crops, grain crops, deep-rooted row crops
  \end{itemize}
Soil, Water and Plant Relationships

- How much do you apply during irrigation?

\[ d_x = \left( \frac{\text{MAD}}{100} \right) \times W_a \times Z \]

- \(d_x\): maximum net depth of water to be applied during irrigation (mm or inches)
- \(\text{MAD}\): 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