ABE 4236C: Irrigation and Drainage Engineering

IRRIGATION – PURPOSE AND METHODOLOGY

Uses of Irrigation Water
- Evapotranspirational demand.
- Overall consumptive use.
- Alleviation of heat stress.
- Frost protection.
- System maintenance and performance evaluation.
- Chemigation / Fertigation.
- Salinity control.
- Field preparation.

Evapotranspirational Demand
- Amount transpired to sustain plant life.
- Plus soil surface evaporation.
- Based on primarily climate parameters.
**Consumptive Use**
- Transpiration component of ET demand.
- Plus water maintained for increased plant biomass production.

**Plant Cooling**
- Alleviation of plant stress due to heat.
- Appropriate for mid-day usage.
- Slow plant development during early season warm periods.

**Cold Protection**
- For use during sporadic localized freezes
- 1 cal/g released for 1°C drop
- 80 cal/g released as water freezes
- 596 cal/g from plants
System Maintenance

- Uniformity tests
- Operational tests and general maintenance
  - Flushing
  - Leak detection and prevention
  - Clog detection and prevention

Chemigation

- Irrigation is the delivery system
  - Primarily for fertilizer delivery.
  - Herbicide.
  - Insecticide.
  - Nematicide.

Leaching

- All irrigation water contains trace amounts of salts.
- Move salts out of the root zone with excess water.
Crop Establishment

- Water absorption for underdeveloped plants.
- Especially after transplanting, but before roots have an established footprint in the soil.

Field Preparation

- Developing soil structure to compliment plant development.
- Aids in soil retention of fumigants.
- Aid in soil bed formation.

Miscellaneous

- Preventing wind erosion during period of little to no ground cover.
- Cleaning fruit and leaf surfaces prior to harvests.
Consequences of Improper Design

- Endangerment.
- Waste of natural resources.
- Pollution.
- Poor economics.

Endangerment

- Inadequate design can impact operator safety:
  - When electric circuits are not properly designed/installed to avoid potential shock hazards for a wet environment.
  - When primer movers are improperly sized, mounted, aligned, or shielded.
  - When chemical injection systems are not design/installed to prevent chemical to operator exposure.
  - When components are not appropriately sized/selected to match the require pressure of the system.

Endangerment

- Inadequate design can impact public health:
  - When required backflow prevention devices were improperly designed/installed/managed.
  - When chemical injection systems are not design/installed to excessive amounts of chemical to be released, causing a pollution/exposure hazard.
Waste of Natural Resources
- Improper design/installation can lead directly to poor uniformity.
- The concept of uniformity is to apply the requisite amount of water throughout the field as near to the required depth as economically feasible.
- The less uniform a system the more excess water (and nutrients in the case of fertigation) will be applied such the minimum requirement of water is applied throughout the field.

Pollution
- An improperly design/installed system can lead to excessive leaching of chemicals from the soil profile.
- An improperly design/installed system can lead to excessive runoff carrying chemicals and sediment from production areas into water bodies.

Poor, Poor Economics
- An improperly design/installed system can impact overall system economics negatively by:
  - Excessive use of water carries the added costs of the water and the fuel to pump it, as well as potential fines for permit violations.
  - Excessive use of water will add chemical costs during fertigation events.
  - Inadequate use of water will impact yields.
  - Impacting system longevity.
Irrigation scheduling
- When to apply water?
- How much to apply?

Irrigation Scheduling Methods
- According to the calendar.
- Plant water stress signs.
- Soil water status.

Scheduling methods based on soil moisture status:
1. A water budget procedure based on the estimated crop water use rate (ET) and soil water storage.
2. A direct measurement procedure based on instrumentation to measure the soil water status.
3. A combination of 1 and 2.
All soil moisture based irrigation scheduling procedures require knowledge of:

1. crop water requirement,
2. effective root zone,
3. water holding capacity of the soil and
4. irrigation system capabilities.

Water holding capacity of the root zone

The difference between field capacity and the permanent wilting point is the water available to the plant.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Maximum Allowable Depletion (in)</th>
<th>Maximum Root Depth not Limited by Soil Depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>0.65</td>
<td>6.0</td>
</tr>
<tr>
<td>Apples (with/without cover)</td>
<td>0.65</td>
<td>6.0</td>
</tr>
<tr>
<td>Beans, dry</td>
<td>0.40</td>
<td>3.0</td>
</tr>
<tr>
<td>Beans, green</td>
<td>0.50</td>
<td>3.0</td>
</tr>
<tr>
<td>Carrots</td>
<td>0.50</td>
<td>3.0</td>
</tr>
<tr>
<td>Clover</td>
<td>0.65</td>
<td>2.0</td>
</tr>
<tr>
<td>Corn, grain</td>
<td>0.65</td>
<td>4.0</td>
</tr>
<tr>
<td>Corn, sweet</td>
<td>0.65</td>
<td>4.0</td>
</tr>
<tr>
<td>Crucifers</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>0.50</td>
<td>4.0</td>
</tr>
<tr>
<td>Grapes</td>
<td>0.65</td>
<td>6.0</td>
</tr>
<tr>
<td>Mint</td>
<td>0.35</td>
<td>2.0</td>
</tr>
<tr>
<td>Onions, dry</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td>Onions, green</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td>Pasture/turf</td>
<td>0.65</td>
<td>2.0</td>
</tr>
<tr>
<td>Peaches (with/without cover)</td>
<td>0.65</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Maximum Allowable Depletion

The level at which the decision is made to turn on the irrigation is called the allowable depletion.

Allowable depletions of 1/3 to 2/3 of available soil water are commonly used in irrigation scheduling. As a "rule of thumb", an allowable depletion of 1/2 of AW should be used if other specific date is not available.

Soil Water Retention

Drainage Water

Capillary Water

Hygroscopic Water

Field Capacity (FC) = 0.3 bar (4.5 psi)
Available water holding capacity (AHHC)
Permanent Wilting Point (PWP) = 15 bar (220 psi)
Field capacity (FC) = 0.3 bar (4.5 psi)
**Maximum Allowable Depletion (MAD)**

Field Capacity

90%–60% of AW

MAD

Available water (AW)

Permanent Wilting Point

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**Available water (AW)**

<table>
<thead>
<tr>
<th>Type of Soil</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands and fine sands</td>
<td>0.4 to 1.00</td>
<td>0.75</td>
</tr>
<tr>
<td>Moderately coarse-textured sand loams and fine sandy loams</td>
<td>1.00 to 1.50</td>
<td>1.25</td>
</tr>
<tr>
<td>Medium texture very fine sandy loams to silty clay loam</td>
<td>1.25 to 1.75</td>
<td>1.5</td>
</tr>
<tr>
<td>Fine and very fine tex-ture silty clay to clay</td>
<td>1.50 to 2.50</td>
<td>2</td>
</tr>
<tr>
<td>Peats and mucks</td>
<td>2.00 to 3.00</td>
<td>2.5</td>
</tr>
</tbody>
</table>

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**The Water Budget Method of Irrigation Scheduling**

1. When...
2. How much... Apply 1.5 inches of water
   (efficiency considerations)

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1.00

1.00
Irrigation Methods based on Soil Moisture Measurements
- tensiometers
- electrical resistance blocks (gypsum blocks)
- neutron probe
- TDR.

Water Potential Measurement

TDR Soil Moisture Measurement
**Combination methods**

Tensiometers (or other soil moisture indicators) used in combination with ET measurements or estimation. The soil meter is read to determine when to irrigate, and the ET data are used to calculate the volume of water lost since the last irrigation which is the net amount of water necessary to apply to the crop.

A general rule for vegetable irrigation, is to provide irrigation before 50% of this water is used in order to avoid plant stress. Frequent, low-volume application allows the soil moisture content in the root zone to be maintained near the optimal levels.

If possible, 33% depletion should be used for scheduling drip irrigation. This requires frequent (once or more per day), short water applications.

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**Guide to irrigation for Florida sandy soils (0.72 in/ft) (tape discharge of 0.5 gpm/100ft assumed) 50% depletion**

<table>
<thead>
<tr>
<th>Depth of the root zone</th>
<th>Available water per 100 ft of row</th>
<th>50% of available water</th>
<th>Maximum duration of irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 ft</td>
<td>90 gal</td>
<td>45 gal</td>
<td>1 hr 30 min</td>
</tr>
<tr>
<td>1.5 ft</td>
<td>135 gal</td>
<td>68 gal</td>
<td>2 hr 15 min</td>
</tr>
<tr>
<td>2.0 ft</td>
<td>180 gal</td>
<td>90 gal</td>
<td>3 hr</td>
</tr>
</tbody>
</table>
Guide to irrigation for Florida sandy soils (0.72 in/ft) (tape discharge of 0.5 gpm/200 ft assumed) 33% depletion

<table>
<thead>
<tr>
<th>Depth of the root zone</th>
<th>Available water per 100 ft of row</th>
<th>33% of available water</th>
<th>Maximum duration of irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 ft</td>
<td>90 gal</td>
<td>30 gal</td>
<td>1 hr</td>
</tr>
<tr>
<td>1.5 ft</td>
<td>135 gal</td>
<td>45 gal</td>
<td>1 hr 30 min</td>
</tr>
<tr>
<td>2.0 ft</td>
<td>180 gal</td>
<td>60 gal</td>
<td>2 hr</td>
</tr>
</tbody>
</table>

Frequent, short irrigations (once a day or more) are always better than infrequent and long irrigation cycles.

Tensiometers should be used to monitor soil moisture and avoid water stress to the plants. They are relatively inexpensive and have been proven to be very reliable in Florida’s sandy soils.
For most vegetables, it is recommended that irrigations be scheduled when the tensiometer reading reaches 10 cbars for a tensiometer placed at the 6-inch depth.

For typical Florida sandy soils, this corresponds to 50% water depletion. A reading of 7-8 cbars is approximately a 33% depletion.