Irrigation Management for Trees and Vines

Louise Ferguson
LFerguson@ucdavis.edu
Department of Plant Sciences
University of California Davis

Agriculture & Natural Resources
University of California Cooperative Extension
Irrigation Management for Trees and Vines

• Consists of two major parts:
• I: Factors affecting irrigation efficiency
• II: Irrigation Scheduling
Irrigation Management for Trees and Vines

• I: Factors affecting irrigation efficiency
Irrigation Systems

Drip

Microsprinklers

Flooding Basins or Furrows
Irrigation Management for Trees and Vines

• Factors affecting irrigation efficiency
  – Climate
  – Crop
  – Soil characteristics
  – Water quality
  – Irrigation System
Factors Affecting Irrigation Efficiency:

- Climate: determines evapotranspiration
  - Humidity
  - Average wind speed
  - Temperature
  - Solar radiation
Factors Affecting Irrigation Efficiency:

- Crop Type:
  - Crop Architecture
  - Rooting depth
  - % coverage
  - Season length
Factors Affecting Irrigation Efficiency:

- Water Quality: affects infiltration
  - Salinity
  - Ca:Na ratio
  - Specific ion concentration
Factors Affecting Irrigation Efficiency:

- Irrigation System: water availability
  - Interacting with rooting depth and cover
    - Flood
    - Furrow
    - Basin

- Wetting patterns
- Costs
  - capital
  - energy
Irrigation Management for Trees and Vines

- Consists of two major parts:
- I: Factors affecting irrigation efficiency
- II: Irrigation scheduling
Major Principal of Irrigation Management

Evapotranspiration
Evapotranspiration

The Water Balance of a Field

- Evaporation
- Rainfall
- Runoff
- Changes in Soil Water Storage
- Operational Waste
- Operational Waste
- Canal Seepage
- Water Diverted for Irrigation at the Farm
- ΔW
- Changes in Soil Water Storage
- Bottom of the Root Zone
- Deep Percolation
- Usable Return Flow (Groundwater)
1st Principle of Irrigation Management

• Evapotranspiration = Crop Water Use = Yield

• Evapotranspiration = Yields maximum

• Poorly Irrigated Well Irrigated
2nd Principle of Irrigation Management

• Insufficient soil moisture Evapotranspiration
  – Insufficient soil moisture *is almost always* the reason for poor or decreased evapotranspiration

• Function of irrigation is to:
  – Maintain optimal evapotranspiration

• The method is irrigation scheduling
  – delivering water when needed
Irrigation Scheduling

- When to irrigate
- How much to irrigate
- How to monitor soil moisture
- When to adjust
- Determining total amount applied
Furrow Irrigation Systems
Water Budget Method

• When to irrigate
• How much to irrigate
The Water Budget Method of Irrigation

1. When? -------- After 7 days
2. How much? -- Apply 2.10 inches of water + losses
   (Efficiency consideration)

ET Loss to the Atmosphere

<table>
<thead>
<tr>
<th>ET inches/day</th>
<th>days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>0.30</td>
<td>3</td>
</tr>
<tr>
<td>0.30</td>
<td>4</td>
</tr>
<tr>
<td>0.35</td>
<td>5</td>
</tr>
<tr>
<td>0.35</td>
<td>6</td>
</tr>
<tr>
<td>0.30</td>
<td>7</td>
</tr>
<tr>
<td><strong>2.10</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>
Irrigation Scheduling

• When to irrigate:
  – Determine available soil moisture for soil type
    • From reference tables
# Available Soil Moisture (cm/m) for Various Soil Textures

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Field Capacity</th>
<th>15 Bars</th>
<th>Available Soil Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>1.2</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>1.9</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>2.5</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Loam</td>
<td>3.2</td>
<td>1.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Irrigation Scheduling

• When to irrigate:
  – Determine available soil moisture for soil type
  – Determine crop rooting depth
    • Direct measurement or reference tables
Dig below tree to see rooting depth
## Crop Rooting Depth

<table>
<thead>
<tr>
<th>Crop</th>
<th>Rooting Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>1.25 m</td>
</tr>
<tr>
<td>Citrus</td>
<td>1.5 m</td>
</tr>
<tr>
<td>Grapes</td>
<td>0.75 m</td>
</tr>
<tr>
<td>Olives</td>
<td>1.25 m</td>
</tr>
</tbody>
</table>
Irrigation Scheduling

• When to irrigate:
  – Determine available soil moisture for soil type
  – Determine crop rooting depth
  – Calculate total available soil moisture (AM)
  
  • AM = (available soil moisture) X (root depth)
Calculate Total Available Moisture

Total Available Soil Moisture (AM) =

Available Soil Moisture per cm/m X root depth (m)

1.1 cm/m X 1.25 m = 1.375 cm
The Water Budget Method of Irrigation

ET Loss to the Atmosphere

<table>
<thead>
<tr>
<th>ET inches/day</th>
<th>days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>0.30</td>
<td>3</td>
</tr>
<tr>
<td>0.30</td>
<td>4</td>
</tr>
<tr>
<td>0.35</td>
<td>5</td>
</tr>
<tr>
<td>0.35</td>
<td>6</td>
</tr>
<tr>
<td>0.30</td>
<td>7</td>
</tr>
<tr>
<td>2.10</td>
<td>7</td>
</tr>
</tbody>
</table>

IRRIGATE

1. When?-------After 7 days
2. How much?--Apply 2.10 inches of water + losses
               (Efficiency consideration)
Irrigation Scheduling

• When to irrigate:
  – Determine available soil moisture for soil type
  – Determine crop rooting depth
  – Calculate available soil moisture (AM)
    • \( AM = (\text{available soil moisture}) \times (\text{root depth}) \)
  – Calculate allowable depletion = \( AD \)
    • \( AD = (AM) \times (\% \text{ allowable depletion}/100) \)
The Water Budget Method of Irrigation

ET Loss to the Atmosphere

<table>
<thead>
<tr>
<th>ET inches/day</th>
<th>days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>0.30</td>
<td>3</td>
</tr>
<tr>
<td>0.30</td>
<td>4</td>
</tr>
<tr>
<td>0.35</td>
<td>5</td>
</tr>
<tr>
<td>0.35</td>
<td>6</td>
</tr>
<tr>
<td>0.30</td>
<td>7</td>
</tr>
<tr>
<td>2.10</td>
<td>7</td>
</tr>
</tbody>
</table>

1. When?--------After 7 days
2. How much?--Apply 2.10 inches of water + losses (Efficiency consideration)
<table>
<thead>
<tr>
<th>Crop</th>
<th>% Allowable Depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus</td>
<td>50%</td>
</tr>
<tr>
<td>Dates</td>
<td>50%</td>
</tr>
<tr>
<td>Grapes</td>
<td>35%</td>
</tr>
<tr>
<td>Olives</td>
<td>65%</td>
</tr>
</tbody>
</table>
Calculating % Allowable Depletion

\[ AD = \text{Allowable Depletion (cm)} \]
\[ AM = \text{Total Available Soil Moisture (cm)} \]

\[ AD = (AM) \times \left(\frac{\% \text{ allowable depletion}}{100}\right) \]
\[ AD = (1.375 \text{ cm}) \times \left(\frac{65}{100}\right) \]
\[ AD = 0.89 \text{ cm} \]
The Water Budget Method of Irrigation

ET Loss to the Atmosphere

<table>
<thead>
<tr>
<th>ET inches/day</th>
<th>days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>0.30</td>
<td>3</td>
</tr>
<tr>
<td>0.30</td>
<td>4</td>
</tr>
<tr>
<td>0.35</td>
<td>5</td>
</tr>
<tr>
<td>0.35</td>
<td>6</td>
</tr>
<tr>
<td>0.30</td>
<td>7</td>
</tr>
<tr>
<td>2.10</td>
<td></td>
</tr>
</tbody>
</table>

1. When? -- After 7 days
2. How much? -- Apply 2.10 inches of water + losses (Efficiency consideration)

Soil Available Water

Allowable Depletion

IRRIGATE
Irrigation Scheduling

• When to irrigate:
  – Determine available soil moisture for soil type
  – Determine crop rooting depth
  – Calculate available soil moisture (AM)
  – Calculate allowable depletion = AD
  – Determine evapotranspiration from your weather station: ETo
The Water Budget Method of Irrigation

ET Loss to the Atmosphere

<table>
<thead>
<tr>
<th>ET in cm/day</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>0.30</td>
<td>3</td>
</tr>
<tr>
<td>0.30</td>
<td>4</td>
</tr>
<tr>
<td>0.35</td>
<td>5</td>
</tr>
<tr>
<td>0.35</td>
<td>6</td>
</tr>
<tr>
<td>0.30</td>
<td>7</td>
</tr>
</tbody>
</table>

IRRIGATE

1. When?------After 7 days
2. How much?--Apply 2.10 inches of water + losses (Efficiency consideration)

2.10/10 = .30
Irrigation Scheduling

• When to irrigate:
  – Determine available soil moisture for soil type
  – Determine crop rooting depth
  – Calculate available soil moisture (AM)
  – Calculate allowable depletion = AD
  – Obtain weather station evapotranspiration
  – Calculate daily crop evapotranspiration
• $ET_c = (ETo) \times (Kc)$
Calculate Daily Crop Evapotranspiration

\[ ETc = (Kc) \times (ETo) \]
\[ ETc = (.75) \times (.30 \text{ cm/day}) \]
\[ ETc = .225 \text{ cm/day} \]

* Experimentally determined
Irrigation Scheduling

- Now you know water in root zone initially
  - 1.375 CM
- How fast you are losing it
  - .225 cm/day
- How much loss before tree is harmed
  - .89 cm
Irrigation Scheduling

• So – when do you irrigate?
• And how much do you apply?
Irrigation Scheduling

- When to irrigate:
  - Determine available soil moisture for soil type
  - Determine crop rooting depth
  - Calculate available soil moisture (AM)
  - Calculate allowable depletion = AD
  - Obtain weather station evapotranspiration
  - Calculate daily crop evapotranspiration
  - Calculate the interval between irrigations
    - IN (days) = AD (cm) / ETc (cm/day)
Calculate the Interval Between Irrigations

IN = interval between irrigations (days)
AD = allowable depletion (cm)
ETc = daily crop evapotranspiration (cm/day)

\[ IN \text{ (days)} = \frac{AD \text{ (cm)}}{ETc \text{ (cm/day)}} \]

\[ IN \text{ (days)} = \frac{.89 \text{ cm}}{.225 \text{ cm/day}} \]

4 days

4 days between irrigations
Irrigation Scheduling

• When to irrigate?
  – after four days (under these conditions)
• How much water to apply?
• Replace .89 cm lost to ETc
Irrigation Scheduling

- When to irrigate
- How much to irrigate
- How to monitor soil moisture
Irrigation Scheduling

• When to irrigate
• How much to irrigate
• How to monitor soil moisture
• When to adjust
Irrigation Scheduling

• When to irrigate
• How much to irrigate
• How to monitor soil moisture
• When to adjust
• Determining total amount applied
Irrigation Management for Trees and Vines

Post Lecture Questions

Agriculture & Natural Resources
University of California
Cooperative Extension
Irrigation Management for Trees and Vines

- Name five factors affecting irrigation efficiency:
Irrigation Management for Trees and Vines

- Factors affecting irrigation efficiency
  - Climate
  - Crop
  - Soil characteristics
  - Water quality
  - Irrigation System
What is Evapotranspiration
Major Principal of Irrigation Management Evapotranspiration
What is primary factor that decreases evapotranspiration and what is the best way to prevent it.
2nd Principle of Irrigation Management

- Insufficient soil moisture \( \downarrow \) Evapotranspiration
- Function of irrigation is to:
  - Maintain optimal evapotranspiration
- The method is irrigation scheduling
  - Delivering water when needed
Name a method of irrigation scheduling and name two ways it directs irrigation.
Irrigation Scheduling

- Water Budget Method
  - When to irrigate
  - How much to irrigate