Pulse and Drip Irrigation Management of Vegetables

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The digital global map of irrigation areas
February, 2007

The map depicts the area equipped for irrigation in percentage of cell area. For the majority of countries the base year of statistics is in the period 1997 - 2002.


Stefan Siebert, Petra Döll, Sebastian Feick (Institute of Physical Geography, University of Frankfurt/M., Germany) and Jipse Hoogeveen, Kares Frenken (Land and Water Development Division, Food and Agriculture Organization of the United Nations, Rome, Italy)
Non sustainable irrigation practices
Water and plants

• For every gram of organic matter (growth) made by a plant on average 500 g of water is absorbed

• Water is required for:
  – Cell expansion/growth (turgor pressure)
  – Solute transport
  – Cooling the plant
Irrigating vegetable crops

• Most horticulture crops are sold fresh
  – Contain 80-90% water by weight
  – Sold on appearance, must have high quality

"If you can't irrigate it ... don't plant it."
Water related disorders

- Blossom end rot
- Blossom drop
Irrigation Systems

- Overhead systems
  - Center pivot
  - Traveling gun
  - Fixed/Solid set
  - Drip Irrigation
Irrigation Efficiency

• Iwue- Irrigation water use efficiency-
  Water used for plant growth / Amount of irrigation water applied
  • Surface -30-50%
  • Overhead-70-90%
  • Drip- 90-95%
Drip Irrigation

- For many vegetable growers drip irrigation is the most practical solution
Drip Irrigation Systems

- Drip irrigation
  - Surface drip
  - Surface under plastic
  - Sub-surface drip
Why Drip Irrigation? Advantages...

- Reduced water
- Usually fewer weeds between rows
- Space between rows remains hard & dry for equipment, harvesting
- Low pressure low flow
Why Drip?

• Overhead irrigation can increase disease potential
  – Flooding can spread soil-borne diseases
  – Overhead can spread foliar diseases
Why Drip Irrigation? Disadvantages...

• **Expensive and labor intensive**-large fields
• Clean water needed to prevent clogging
• Rodent & insect damage
Small system costs (Annual Costs)

Annual per acre expenses:

8-10 mil drip tape + embossed black plastic mulch (1.25 mil, 4 ft wide roll): approx. 4.5 cents/ft x 7260 linear feet = $450

plus depreciation or rental costs on mulch layer, waterwheel setter, etc.
Backflow valve - a must for city water-well water
Screen Filter—good for municipal or clean well water
Disk Filter—good for municipal or clean well water creek although will clean dirtier water than a screen filter—not good for sand
Irrigation management

• Irrigation is essential in most vegetable crops
• How to manage it
  – When to irrigate
  – How long to irrigate
• Crop demand (evapotranspiration) based irrigation (checkbook method)
  – Weather and crop coefficients
• Soil moisture based irrigation
  – Maintain soil moisture between certain thresholds
How much to irrigate?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Inches/acre</th>
<th>Critical times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>8-10</td>
<td>Establishment</td>
</tr>
<tr>
<td>Carrots</td>
<td>10-15</td>
<td>Emergence</td>
</tr>
<tr>
<td>Beans</td>
<td>10-15</td>
<td>Bloom and pod set</td>
</tr>
<tr>
<td>Beets</td>
<td>10-15</td>
<td>Establishment</td>
</tr>
<tr>
<td>Melons</td>
<td>15-20</td>
<td>Vining to first net</td>
</tr>
<tr>
<td>Broccoli</td>
<td>20-25</td>
<td>Heading</td>
</tr>
<tr>
<td>Tomato</td>
<td>20-25</td>
<td>Bloom - harvest</td>
</tr>
<tr>
<td>Cabbage</td>
<td>20-30</td>
<td>Throughout growth</td>
</tr>
<tr>
<td>Onion</td>
<td>25-30</td>
<td>Bulbing</td>
</tr>
<tr>
<td>Potato</td>
<td>20-40</td>
<td>Vining-tuber initiation</td>
</tr>
<tr>
<td>Corn</td>
<td>20-35</td>
<td>Tassel formation and ear development</td>
</tr>
</tbody>
</table>
Evapotranspiration

\[ \text{climate} + \text{grass reference crop} = \text{ET}_0 \]

\[ \text{ET}_0 \times \text{K}_c \text{ factor} = \text{ET}_c \]

Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56
Evapotranspiration in Lexington

Annual distribution of Eto

Eto (mm/day)

Day of year 2010
Temporal distribution of weekly moving average of Eto during crop growth

Day of year 2010

Eto (mm/day)
Irrigating Based on Estimated Crop Use

- Crop water requirements.
  - 1 acre inch is 27,000 gallons of water
  - Usually 33-50% of land is drip irrigated
    - Crops that require 1 inch of water/wk need 13,500 gallons per acre
- Peak $E_{tc}$ (water use) usually 0.2 – 0.3 in./day.
  - 5,430 – 8,146 gal/acre/day.
  - Usually 33-50% of an acre is drip irrigated.
Determining Irrigation Time and Amounts

• If crop $E_{tc}$ (water use) is 0.20 acre inches/day then crop used ($0.2 \times 27,154 \text{ gal/acre in.} \times 0.50$ [area covered by plastic]) or 2,715 gal of water.

• If field has 6 ft rows and uses 0.42 gpm/100’ drip tape. Operating properly this is 30 gal/ac/min. Rate per hr. is 1,800 gal.

• 1.5 hrs application time ($2715 \text{ gal/acre} / 1800 \text{ gal}$.)
Consideration: *Pipe Size Requirements*

- General size requirements

<table>
<thead>
<tr>
<th>Gallons per minute</th>
<th>Pipe Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>½</td>
</tr>
<tr>
<td>10</td>
<td>¾</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>1 ¼</td>
</tr>
<tr>
<td>35</td>
<td>1 ½</td>
</tr>
<tr>
<td>55</td>
<td>2</td>
</tr>
<tr>
<td>85</td>
<td>2 1/2</td>
</tr>
<tr>
<td>125</td>
<td>3</td>
</tr>
</tbody>
</table>
Soil moisture based irrigation

• Monitor soil moisture and supply water as needed
  – How do you measure soil moisture
    • Tensiometer, watermark sensor, touch?
  – How much water do you add?
    • Irrigation shallow or deep?
    • Soil type, structure and rooting depth
Water Management and Schedule

• Available water key to crop growth.
  – Relationship between plant-soil-water
  – Soil that contains plants roots is water reservoir

• **Field Capacity** - water stored in soil 12-24 hrs after saturation.

• **Permanent Wilting Point** – water no longer available to plant.

• **Available Water Holding Capacity** - difference between Field Capacity and Wilting Point.
Available Soil Water and Soil Texture

Irrigating to saturate soil

• An ideal loam soil will be:
  – 45% “soil” ie. minerals
  – 25% micropores (small air spaces between soil particles-hold water)
  – 25% macropores (root and worm holes, etc-hold air and water)
  – 5% organic material
Soil Available Water

- **Very tightly bound**
  - Hygroscopic (unavailable) water

- **Capillary (available) water**

- **Drainage**
Sand

Silt

Clay

Sand 0.5-2.0mm  Silt 0.002 to 0.05  Clay <0.002 mm
Moisture release curve for silt loam

Soil moisture tension (cb)

Volumetric Water Content

Soil moisture Tension (cb)

Volumetric water content

Permanent Wilting Point (Death)

Saturation (Flooding)
Soil Moisture Tension (cb) vs. Volumetric Water Content %

- Clay loam
- Silt loam
- Sandy loam
How long do I irrigate?

• Irrigate deep-then have a reserve.
  – Not necessarily
    • Depends on subsoil
• Irrigate based on maximum rooting depth of vegetables
  – Peppers: Approximately 12”
  – Tomato: Approximately 18”
Irrigating too deep?

• With heavy clay subsoils irrigate more frequently and shorter duration

• How else can you influence irrigation depths and water use
  – Flow rate on drip tape
“Pulsing” irrigation

• Wanted to look at more frequent but shorter irrigation regimes to save water
  – Previous research funded by New Crops Opportunities Grant
  – NRCS funded Conservation Innovation Grant for 2010/2011
    • Tomatoes and peppers, blackberries and blueberries
### Poblano pepper research

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Number of Events</th>
<th>Total Run Time days, hours, minutes</th>
<th>Average Run Time (min.)</th>
<th>Water Used</th>
<th>Water use efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/25 cb</td>
<td>83</td>
<td>5 days 4 hrs 25 min</td>
<td>90</td>
<td>225,720</td>
<td>0.09 lbs/gallon</td>
</tr>
<tr>
<td>40/35</td>
<td>72</td>
<td>5 days 18 hrs 35 min</td>
<td>115</td>
<td>251,460</td>
<td>0.08 lbs/gallon</td>
</tr>
<tr>
<td>50/45</td>
<td>63</td>
<td>6 days 8 hrs 38 mins</td>
<td>145</td>
<td>276,900</td>
<td>0.08 lbs/gallon</td>
</tr>
<tr>
<td>50/10</td>
<td>49</td>
<td>4 days 13 hrs 48 mins</td>
<td>135</td>
<td>199,200</td>
<td>0.09 lbs/gallon</td>
</tr>
</tbody>
</table>

This suggests keeping soil slightly wetter through shorter more frequent irrigations rather than letting it dry out completely allows it to re-wet quicker and use less water.
Using flow rate or emitter spacing to better manage irrigation

- Some growers prefer to use a short 4” spacing to wet top of bed quicker
- Or-keep the same emitter spacing but use different flow rates
  - Flow rate will alter wetting pattern
Wetting patterns: High emitter discharge rate (>0.5 gpm 100’)
Wetting patterns: Low discharge rate
(<0.50 gpm 100')
Future directions

• Develop more water budgets for drip and plastic
• Automation.......to stop irrigation
Questions