


# Drip Irrigation Management of Vegetables: Tomatoes and Peppers



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# Outline

- Plant water relations
- Irrigation systems
  - Drip irrigation
- Irrigation Management
  - Evapotranspiration water budget
  - Soil water depletion

# Irrigation history

- Irrigation dates to at least 6000 BC (Egypt and Mesopotamia)
- 2000 BC cement pipes used by Romans to carry water
- Irrigation opens up arid lands



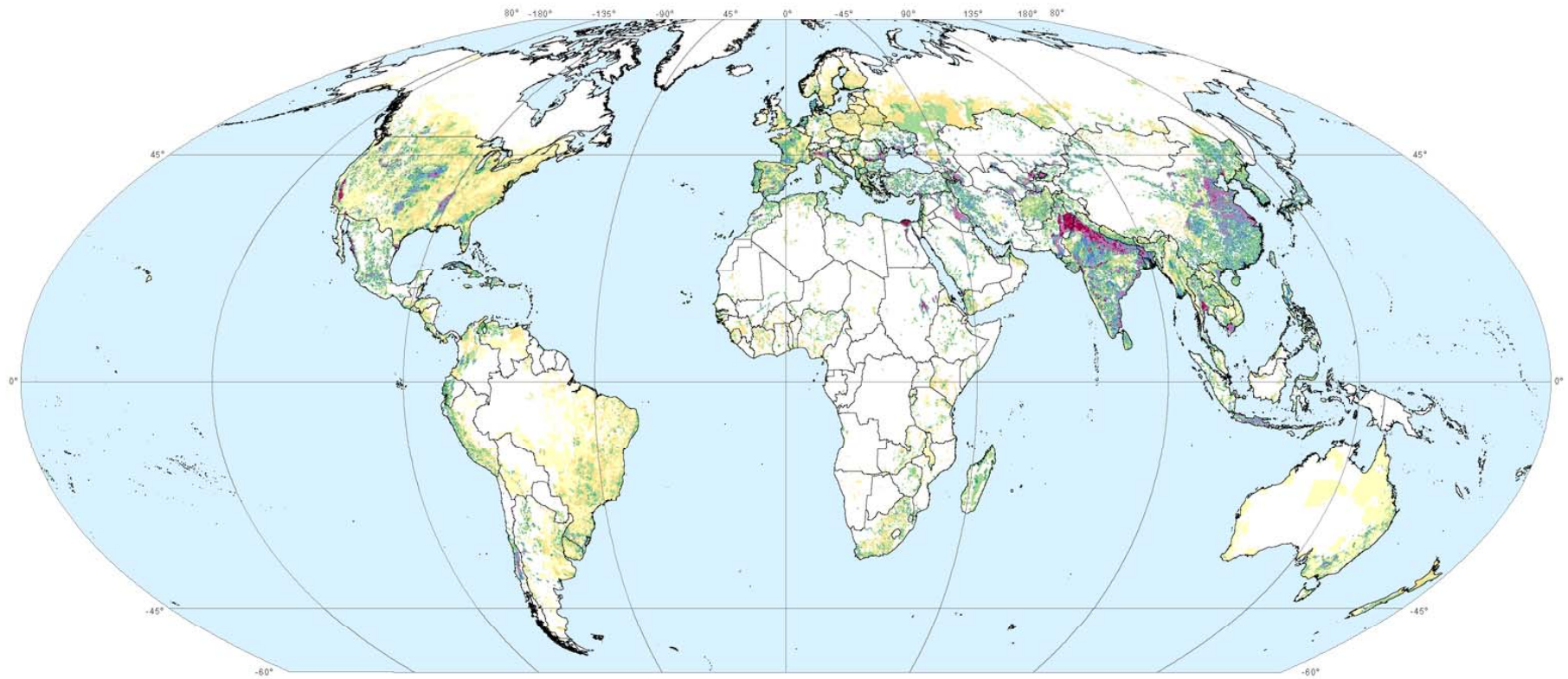
# Irrigation

- About 16% of farmed land is irrigated
  - This accounts for about 40% of productivity
- About 80% of the water used in the world is for irrigation
- We are at about 600,000,000 acres of irrigated land in the world



# The digital global map of irrigation areas

February, 2007



Area under irrigation in  
percentage of land area

0	10 - 20
<0.1	20 - 35
0.1 - 1	35 - 50
1 - 5	50 - 75
5 - 10	75 - 100

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.

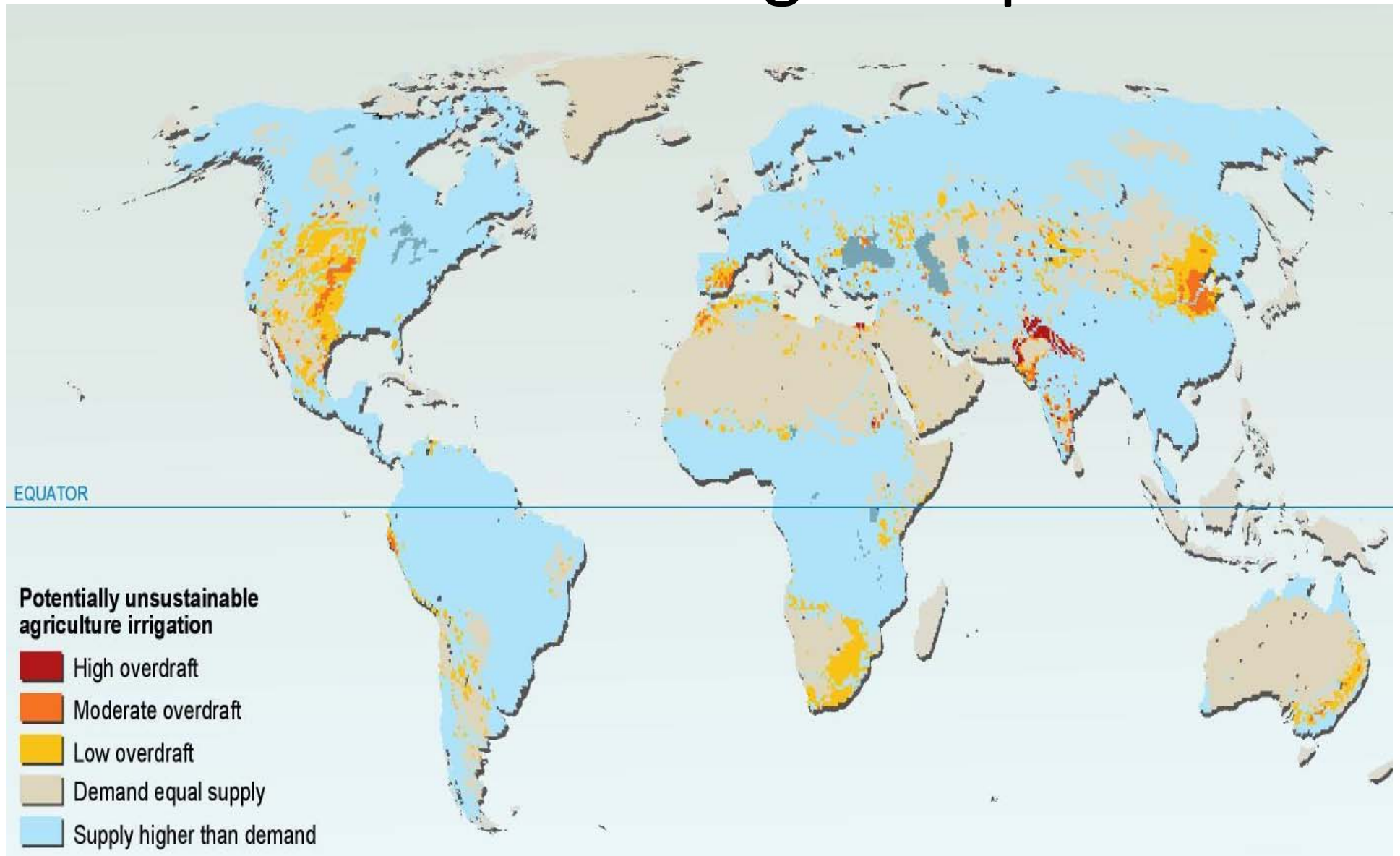
<http://www.fao.org/ag/agl/aglw/aquastat/irrigationmap/index.stm>

Projection: Mollweide

Stefan Siebert, Petra Döll, Sebastian Feick (Institute of Physical Geography, University of Frankfurt/M., Germany) and  
Jippe Hoozeven, Karen Frenken (Land and Water Development Division, Food and Agriculture Organization of the United Nations, Rome, Italy)

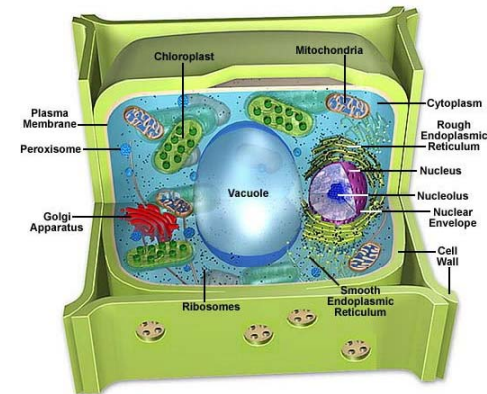


# Non sustainable irrigation practices



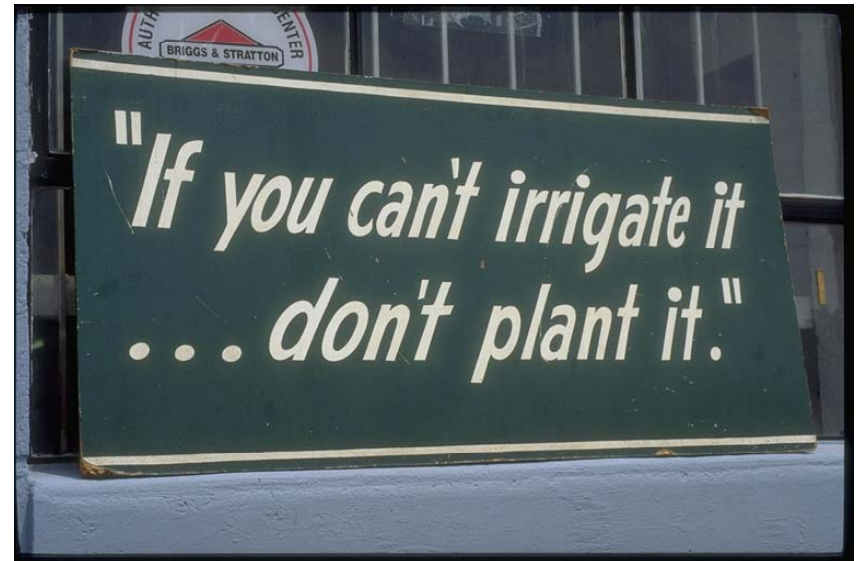
# Water and plants

- 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





# Water related disorders

- Blossom end rot
- Blossom drop



# 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 Systems

- Drip irrigation
  - Surface drip
  - Surface under plastic
  - Sub-surface drip













# Drip Irrigation

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



# 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.

# Considerations: *Water Meter*



- Sized to match system flow rate.

Water Meter Size	GPM
5/8	12
3/4	20
1	30

# Consideration: *Pipe Size Requirements*

- General size requirements

Gallons per minute	Pipe Size
5	$\frac{1}{2}$
10	$\frac{3}{4}$
15	1
25	1 $\frac{1}{4}$
35	1 $\frac{1}{2}$
55	2
85	2 $\frac{1}{2}$
125	3



Backflow valve-a must for city water-well water



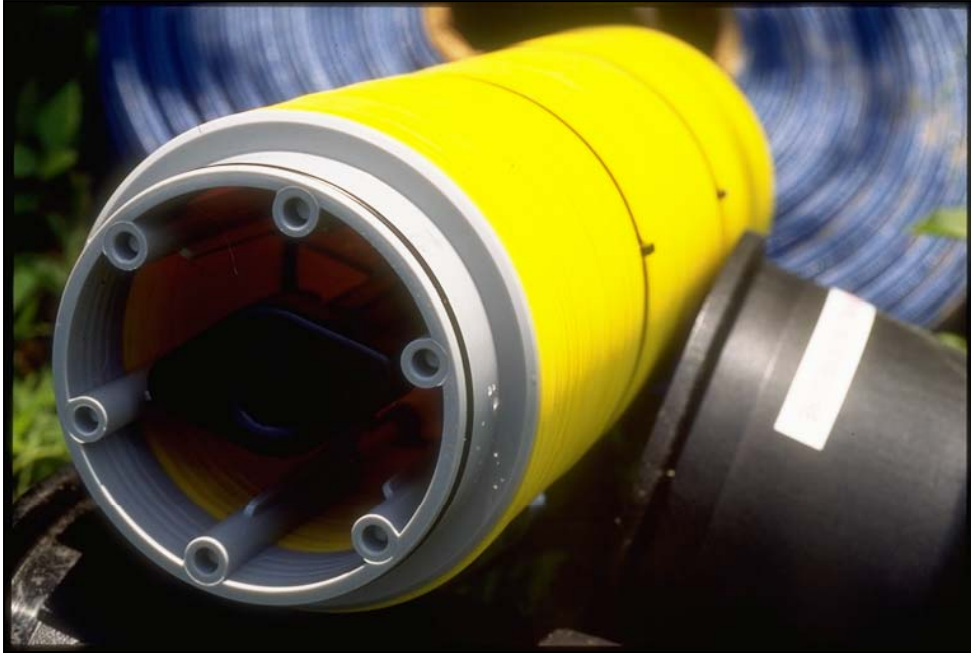






**Screen Filter-good for  
municipal or clean well water**





**Disk Filter-good for  
municipal or clean well  
water creek although will  
clean dirtier water than a  
screen filter-not good for  
sand**





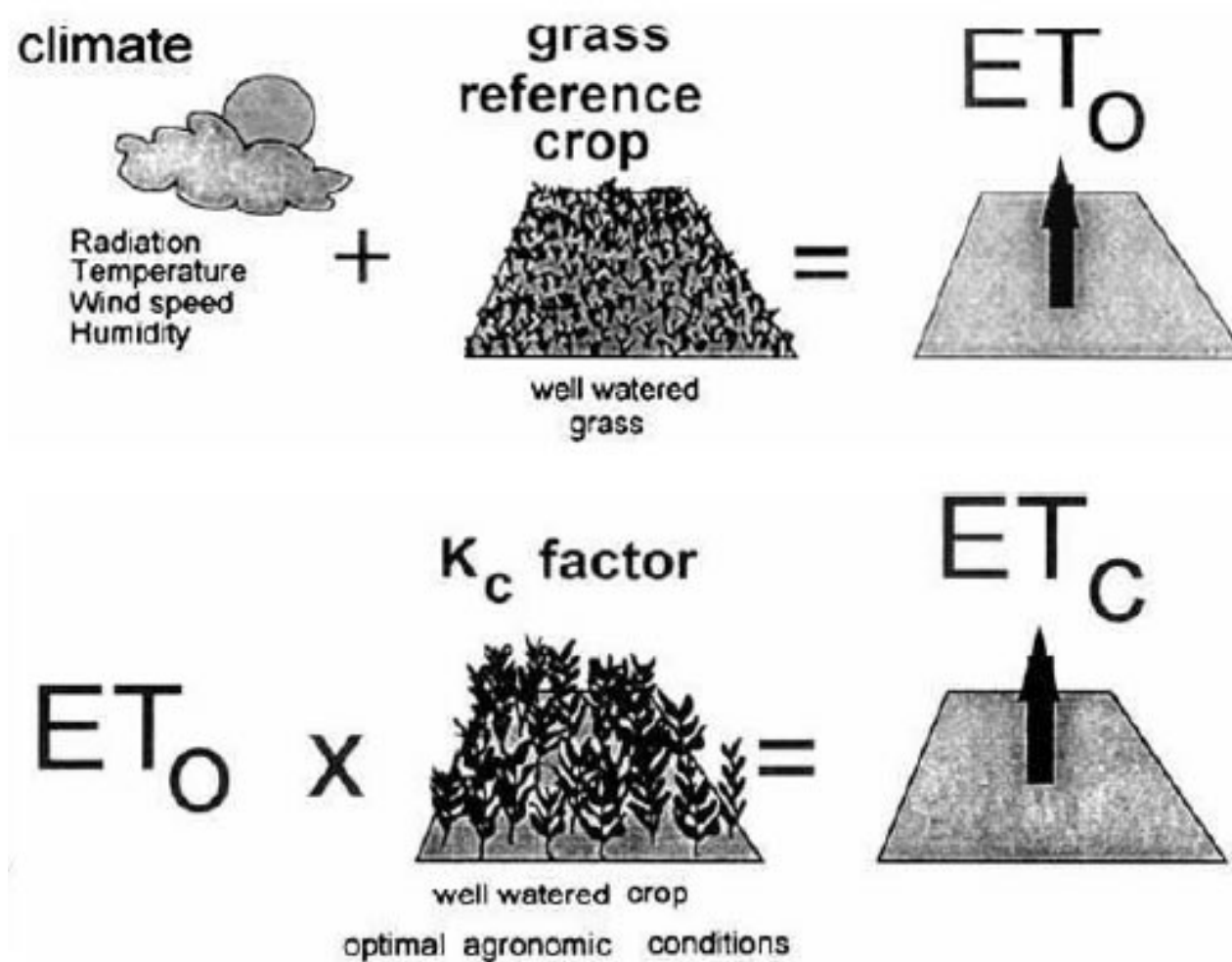
# Irrigation management

- 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?

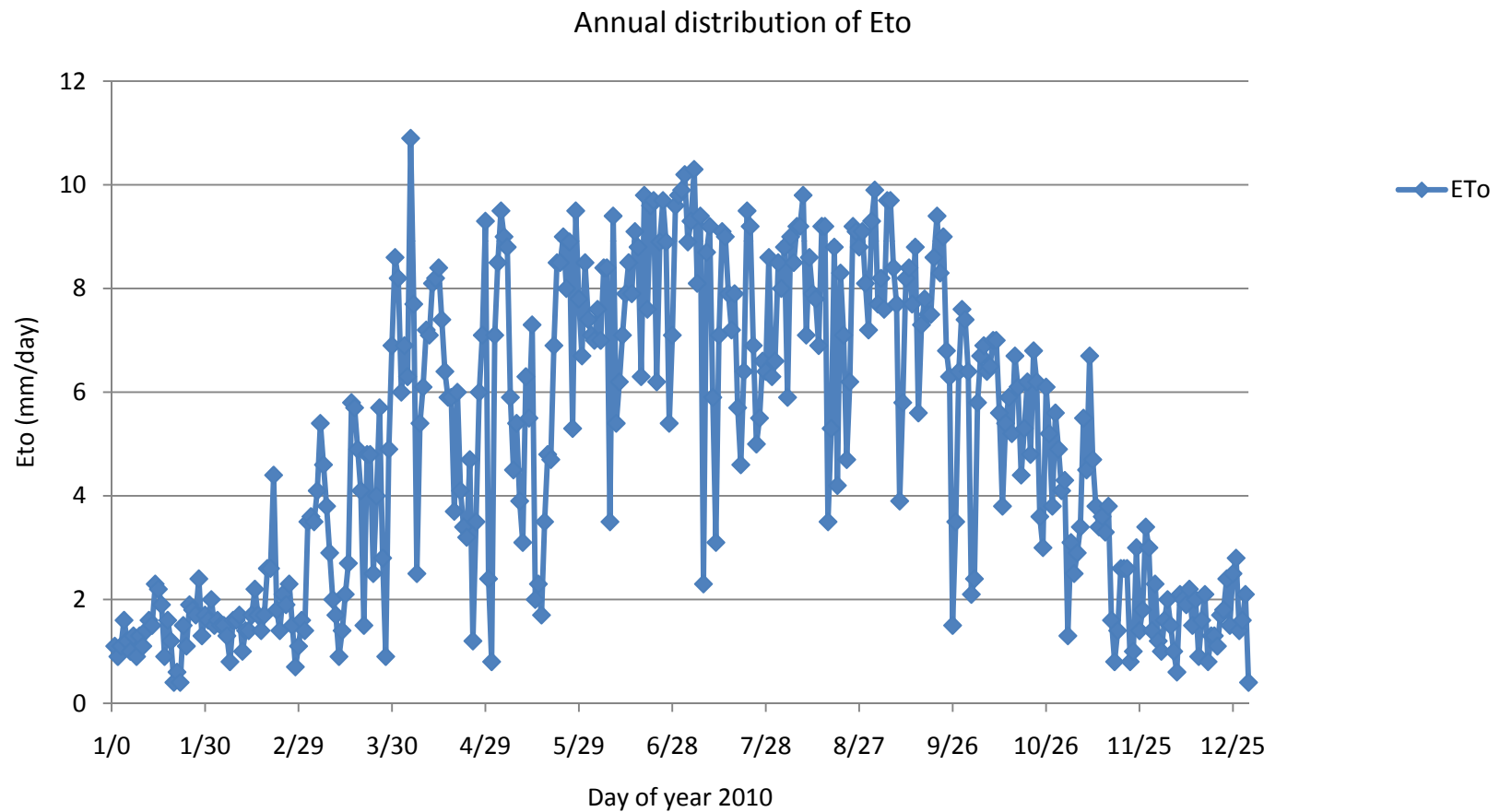
<b>Crop</b>	<b>Inches/acre</b>	<b>Critical times</b>
<b>Lettuce</b>	<b>8-10</b>	<b>Establishment</b>
<b>Carrots</b>	<b>10-15</b>	<b>Emergence</b>
<b>Beans</b>	<b>10-15</b>	<b>Bloom and pod set</b>
<b>Beets</b>	<b>10-15</b>	<b>Establishment</b>
<b>Melons</b>	<b>15-20</b>	<b>Vining to first net</b>
<b>Broccoli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

# Evapotranspiration

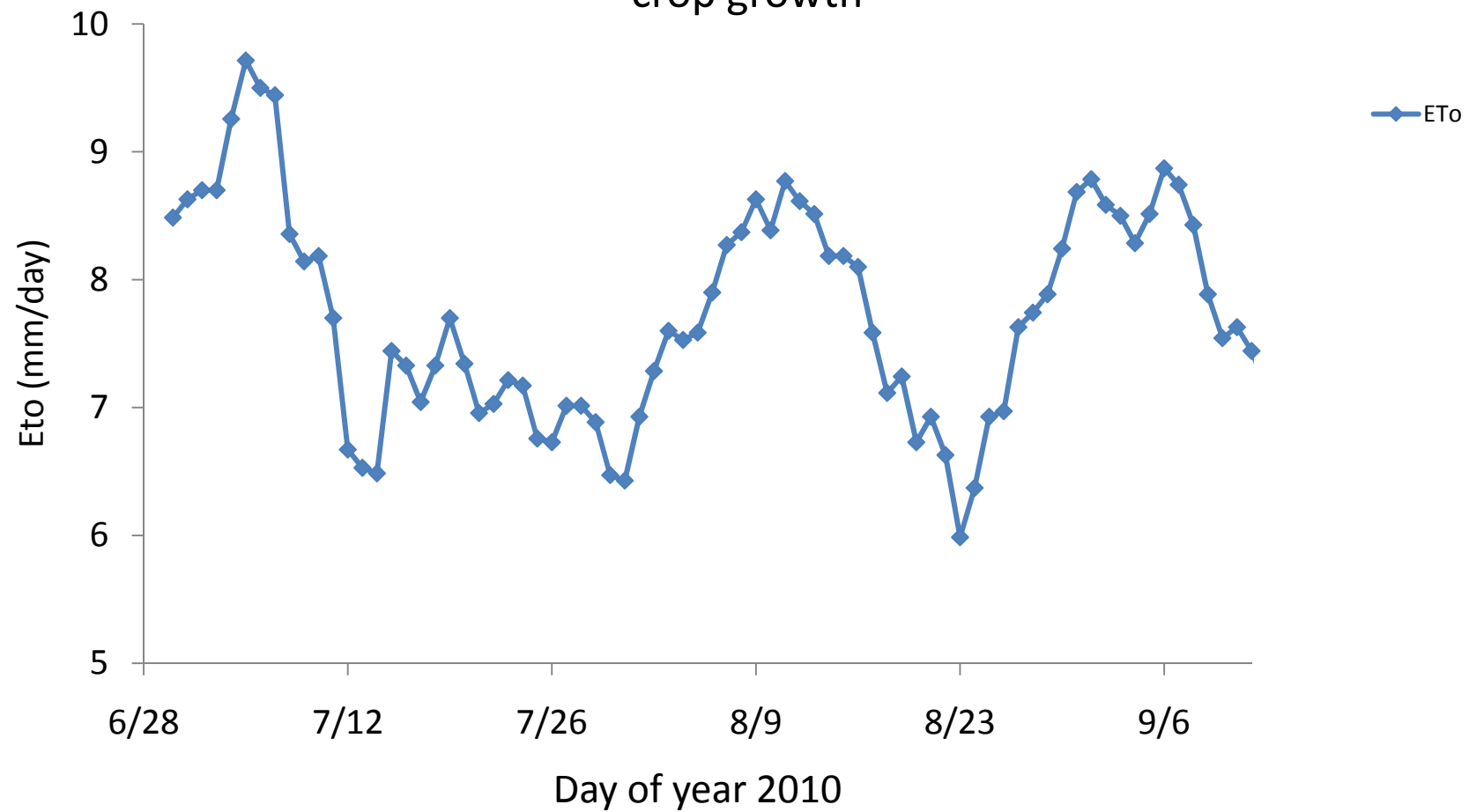




# Evapotranspiration in Lexington



Temporal distribution of weekly moving average of Eto during crop growth



# 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  $Et_c$  (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.

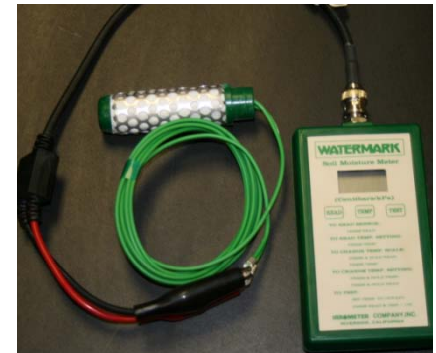


# Determining Irrigation Time and Amounts

- If crop  $Et_c$  (water use) is 0.20 acre inches/day then crop used ( $0.2 \times 27,154 \text{ gal/acre in.} \times .50$  [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 ( $2715 \text{ gal/acre} / 1800 \text{ gal.}$ )

# 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



# 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



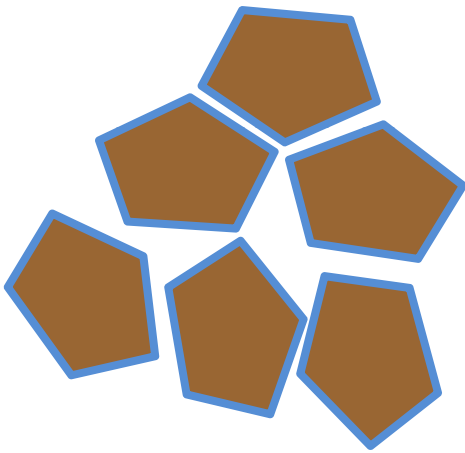


# Water Management and Schedule

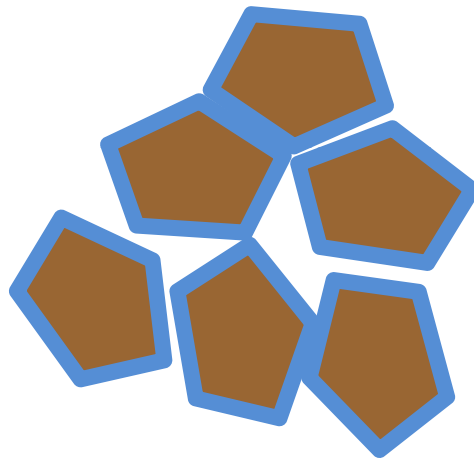
- Available water key to crop growth.
  - Relationship between plant-soil-water
  - Soil that contains plants roots is water reservoir
- Field Capacity - water stored in soil 12-24 hrs after saturation.
- Permanent Wilting Point – water no longer available to plant.
- Available Water Holding Capacity -difference between Field Capacity and Wilting Point.

# Soil Available Water

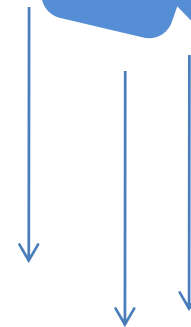
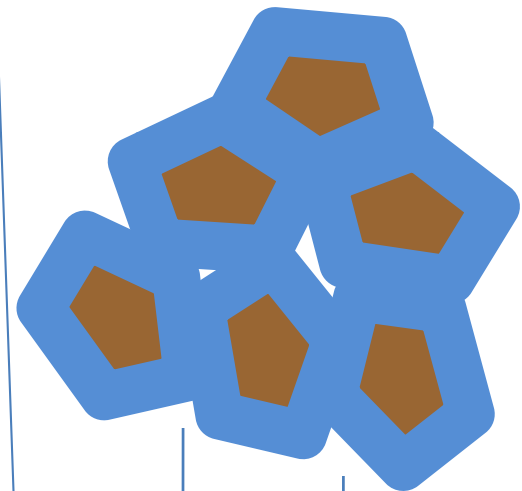
**Very tightly bound**



Hygroscopic (unavailable)  
water



Capillary (available) water



Drainage

## Available Soil Water and Soil Texture

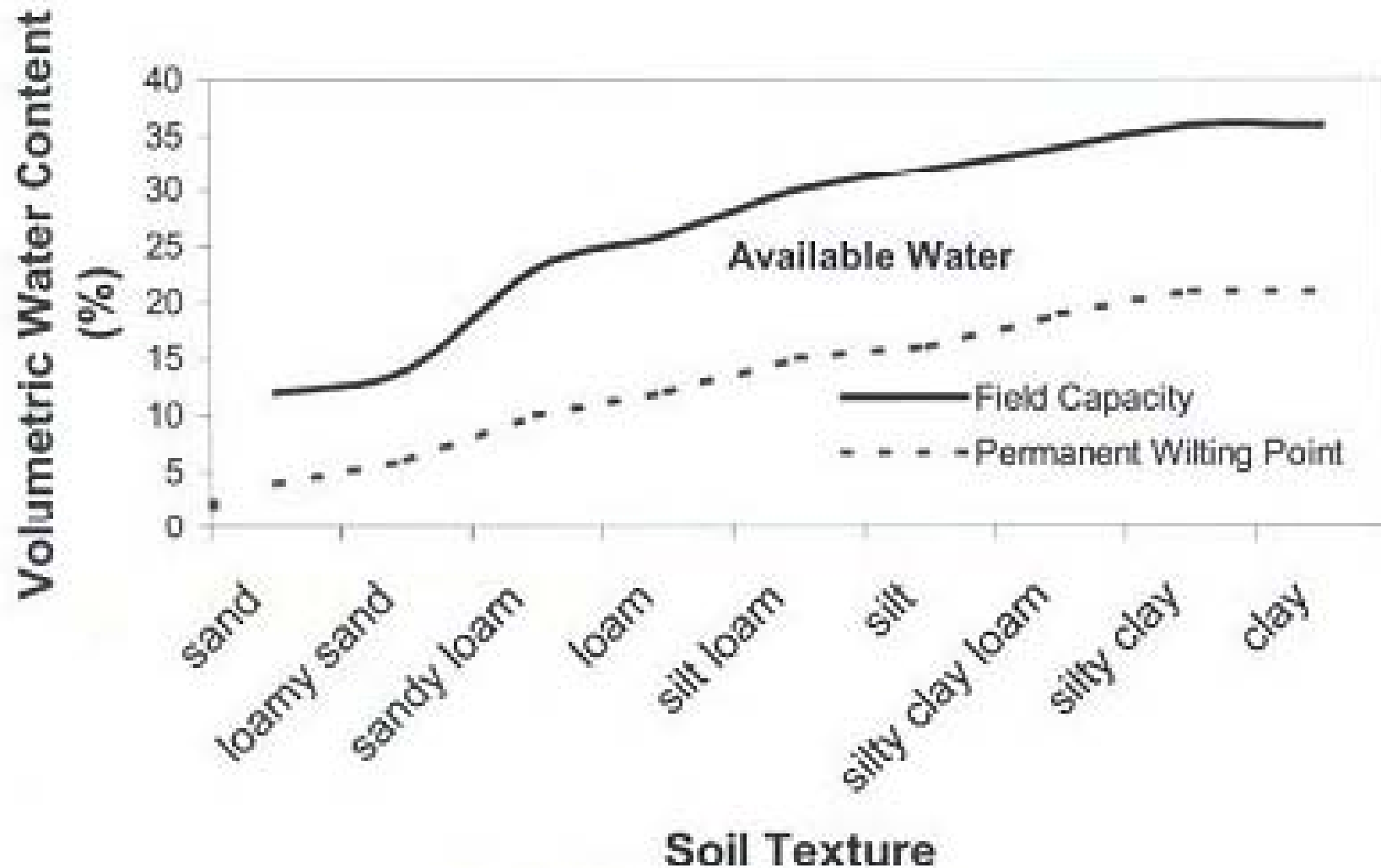
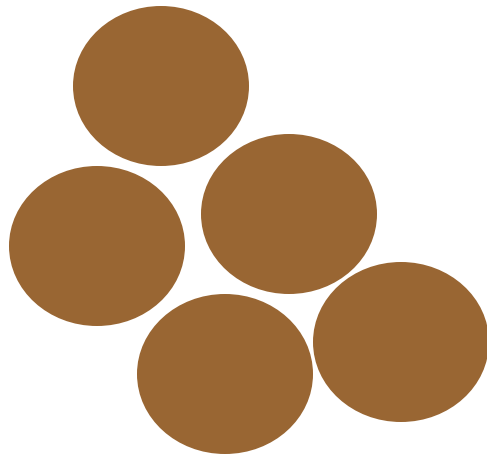
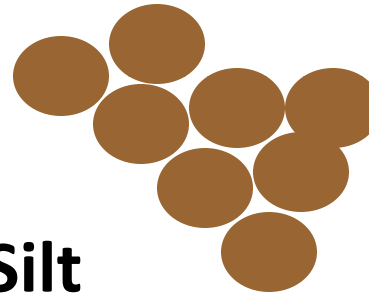


Table 3.5-1 Soil water contents for agricultural soils. Jensen, M.E., R.D. Burman, and R.G. Allen, 1990. *Evapotranspiration and Irrigation Water Requirements*. ASCE Manuals and Reports on Engineering Practice No. 70. American Society of Civil Engineers, New York, NY.

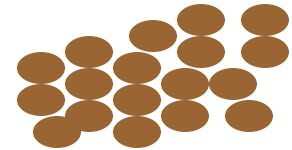




**Sand**



**Silt**



**Clay**



**Sand 0.5-2.0mm**

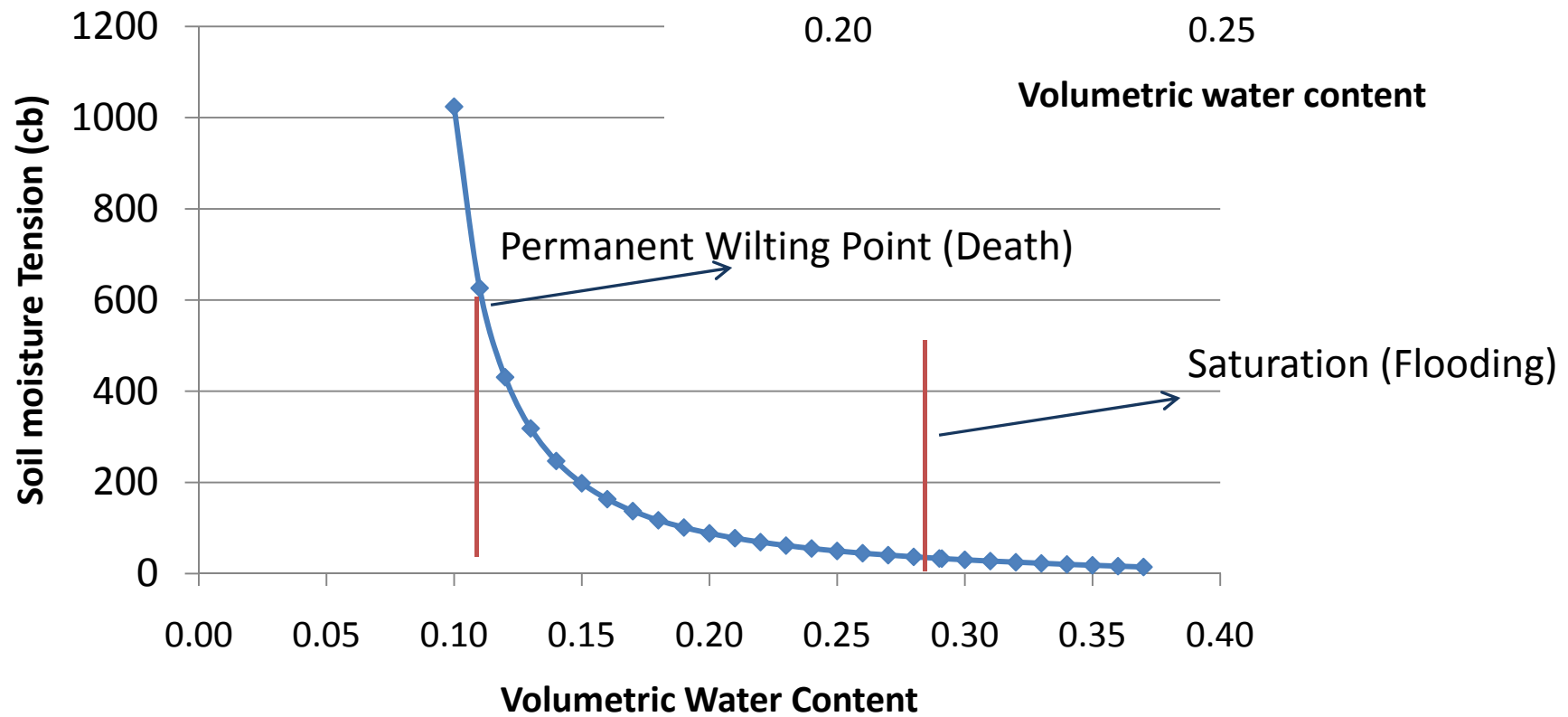
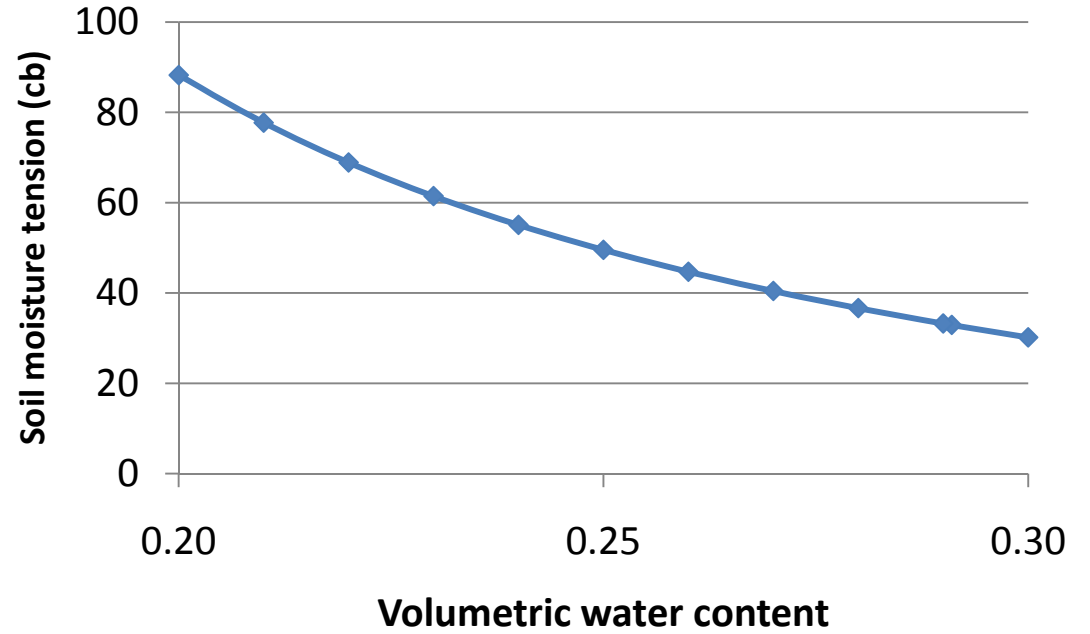


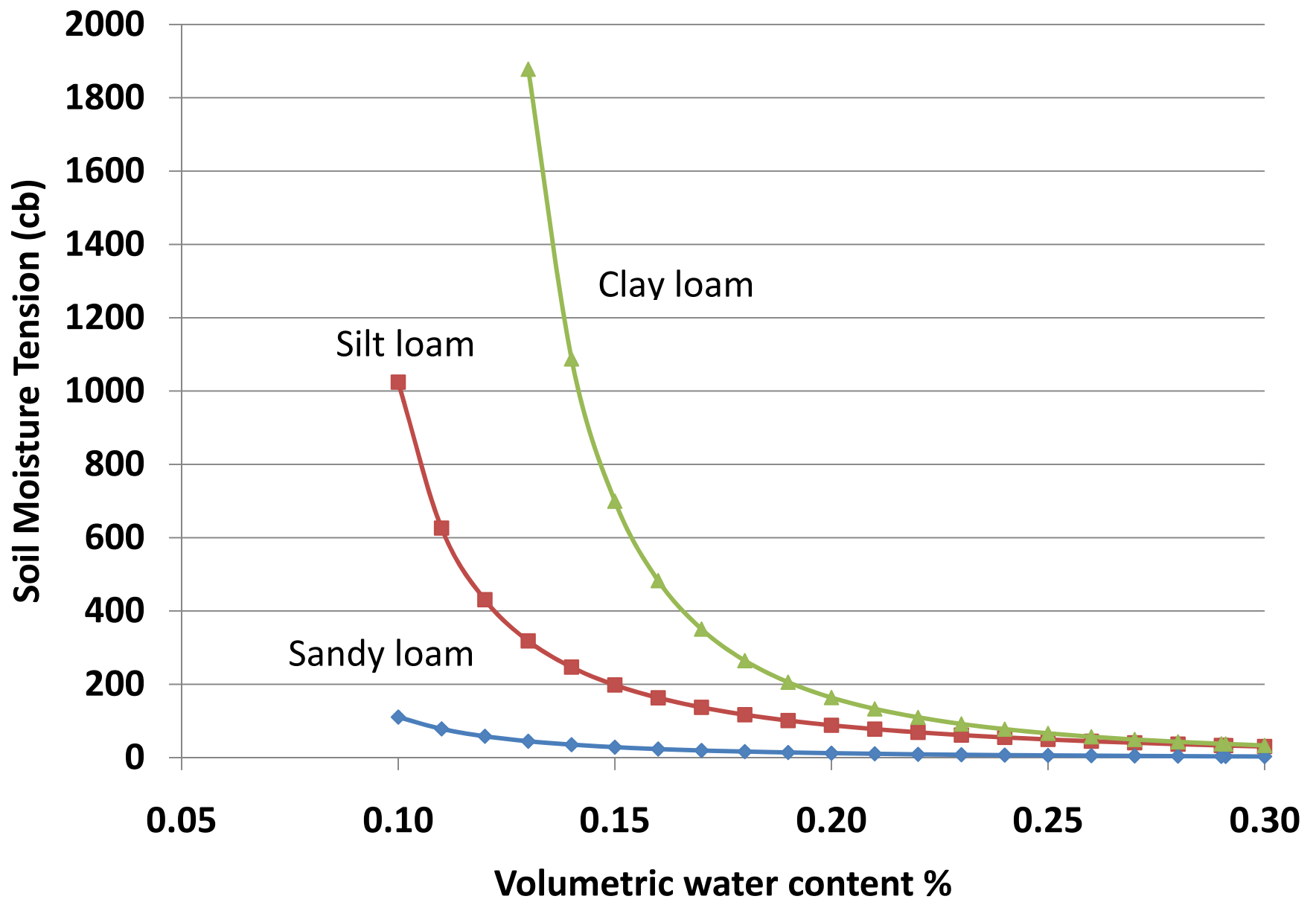
**Silt 0.002 to 0.05**



**Clay <0.002 mm**

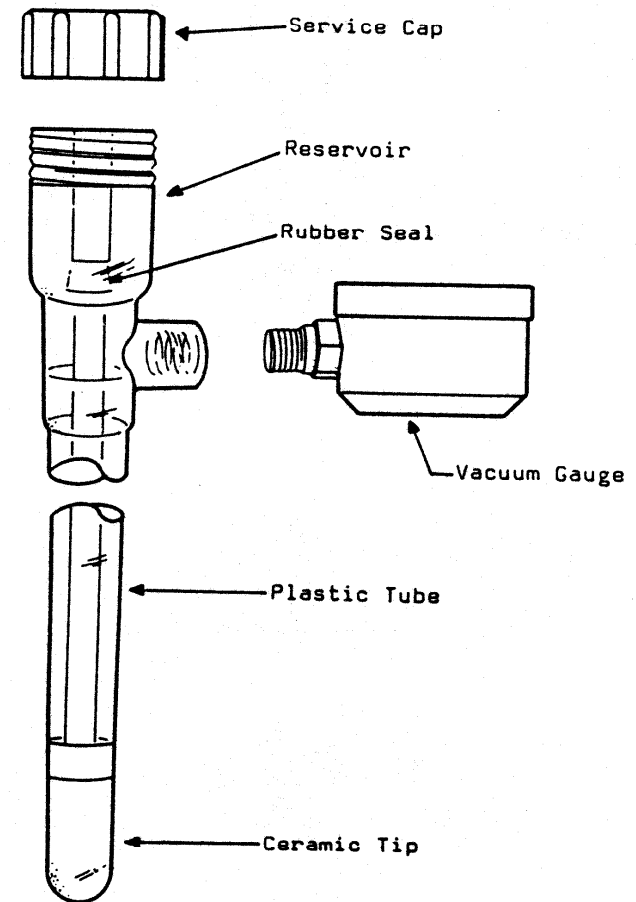
**Moisture release curve for silt loam**





# Tensiometer

- Tensiometer measures soil moisture tension (centibar)
  - Basically a sealed tube with a porous ceramic tip and vacuum gauge
  - As soil surrounding tensiometer gets drier water is pulled from the tensiometer





# Soil Moisture Sensors

**Watermark Sensors**



**Soil Moisture Probe**



# When to irrigate

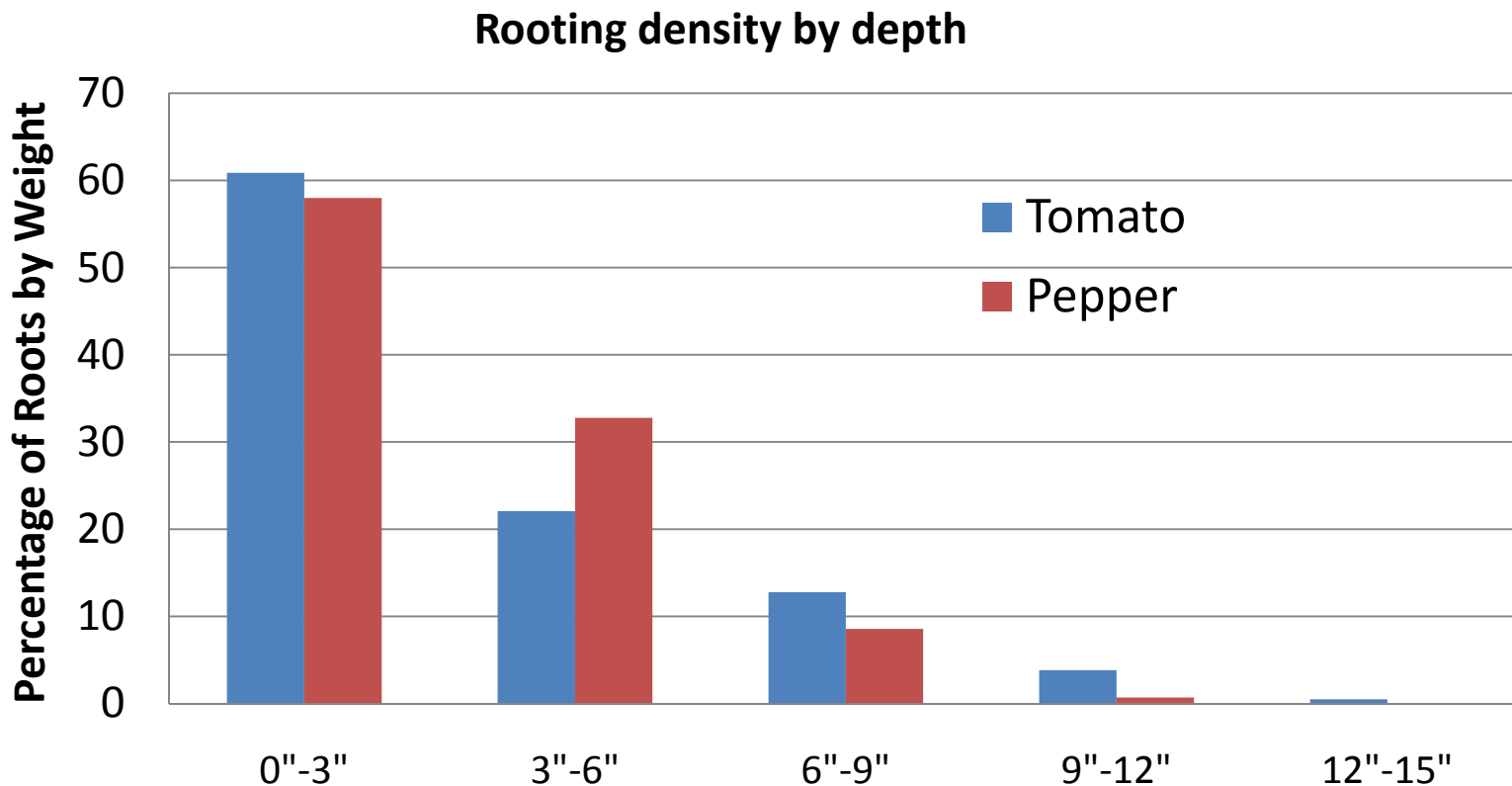
	Sand	Sandy Loam	Clay Loam	Clay
When you are at 50% water holding capacity	Feels dry cannot form a ball in hand	Feels dry will form a ball but only under pressure, will not stay together	Crumbly, but will form a rough ball under pressure	Will form a ball under pressure, but still hard and crumbly

# How long do I irrigate?

- Irrigate deep-then have a reserve.
  - **Not necessarily**
    - Depends on subsoil

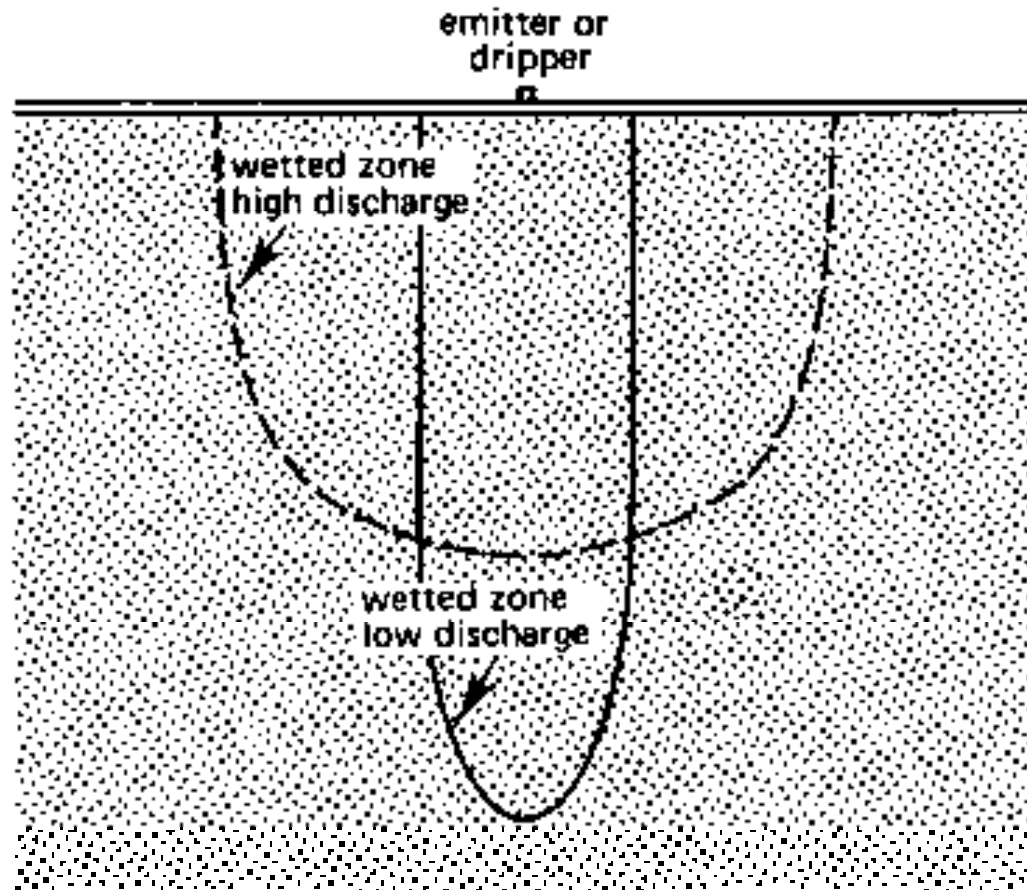


- Irrigate based on maximum rooting depth of vegetables
  - Peppers: Approximately 12"
  - Tomato: Approximately 18"

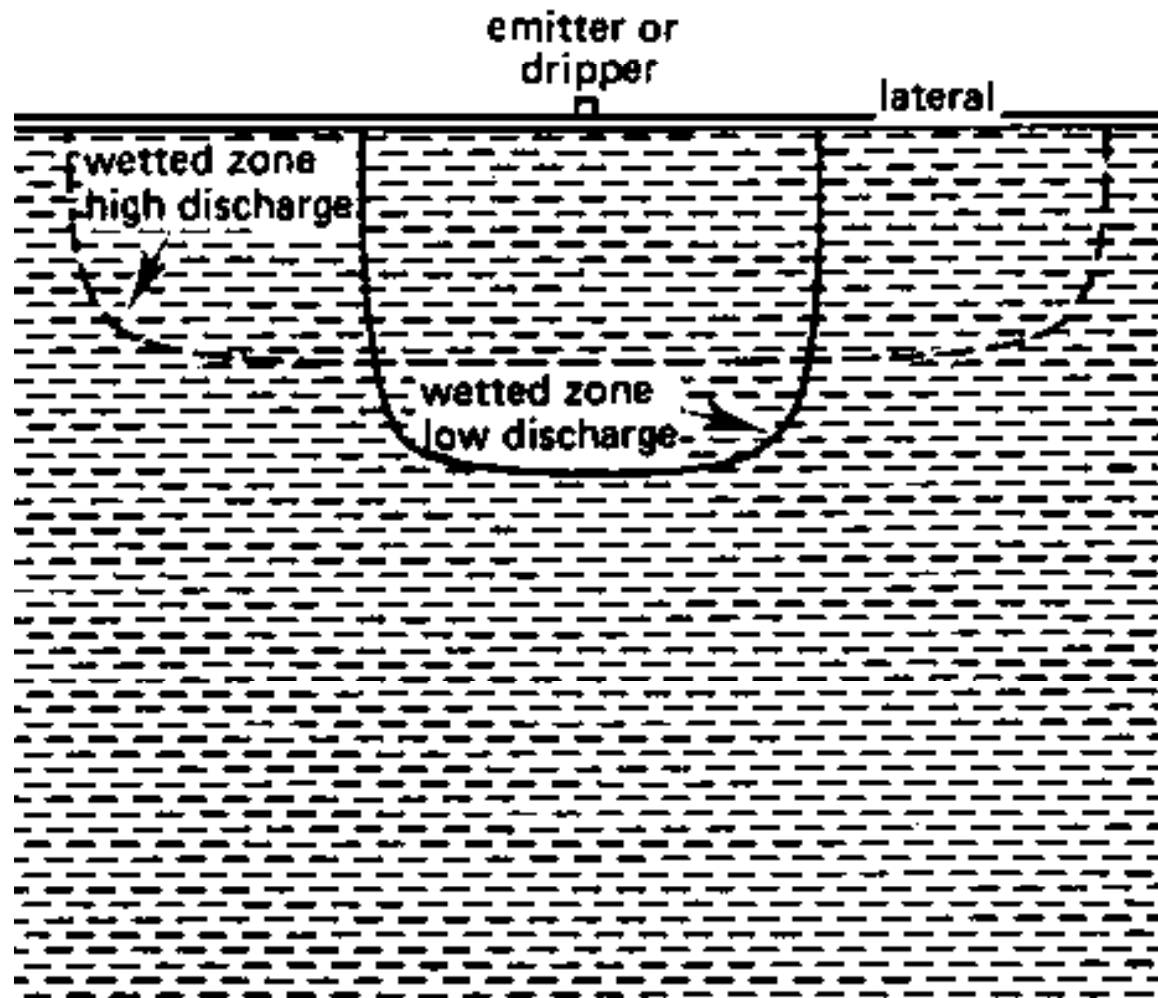




# Wetting patterns: High emitter discharge rate ( $>0.5$ gpm 100')



# Wetting patterns: Low discharge rate ( $<0.50$ gpm 100')



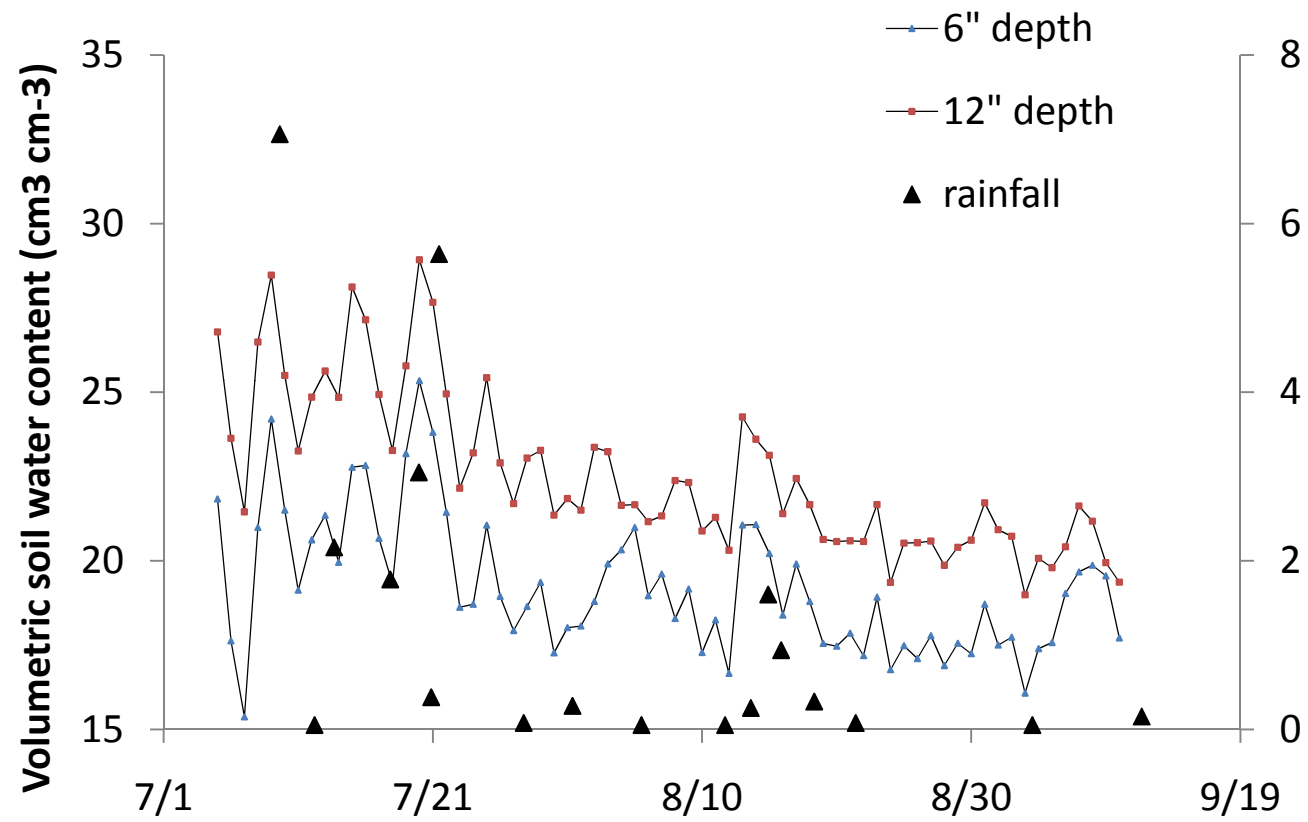
# “Pulsing” irrigation

- 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

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

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

# Future directions

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





# Thanks



- Joel and Beth Wilson-Wilson's Cedar Point Farm
- Dwight Faulkner & Lloyd Derosssett-D&F farms
- Susmitha Surendren Post Doc
- Lucas Hanks, Richard Warner, Otto Hoffman
- NRCS CIG



# Questions



# Prepping a tensiometer

- Fill with water (dye solution)
- Let sit in a bucket of water and pull using suction device
  - This will get air out of tensiometer
- Let sit overnight if possible
- Carry to field in bucket of water-if allowed to sit in air too long will lose water and air bubbles form

# Correctly Installing a Tensiometer

- Where to put tensiometer
  - Put on edge of bed, not middle
- How many
  - At least one per “zone”
  - Or At least one per crop





# Tensiometer Installation

- Make a hole using a soil probe or 7/8" pipe
- Make a mud slurry and fill hole about ½ way
- Push in tensiometer mud should squirt out forming a tight seal





# Tensiometer instalation

- After installed and mud seal dries make sure tensiometer is sealed...does not move easily
  - If not sealed it will read artificially dry regardless of how much you irrigate



# Tensiometer troubleshooting

- Check tensiometer and service routinely
  - If you open cap you will lose the vacuum, use suction device to get any air out and ensure the water column hasn't broken
- If it reads zero, but you haven't just irrigated you have a problem
  - Could have gotten too dry and water column snapped- no more vacuum
  - Solution could have run out