Drought Management Strategies for Orchard and Row Crops

Janet Caprile
Farm Advisor
UC Cooperative Extension
Contra Costa & Alameda Counties
jlcaprile@ucdavis.edu

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2014 Drought Challenges

1. **Not enough water**
   - **Are we going to have cutbacks?**
   - **Are they predictable?**
2. **Salty water**
   - **Less runoff -> more salt in surface water**
   - **More use of groundwater**

Not Enough Water

Make every drop count!

1. Control weeds
2. Improve irrigation efficiency
   - System maintenance
   - Irrigation management
3. Use deficit irrigation

Not Enough Water

1. Control weeds
   - In the field
   - Around the edges
2. Control the cover crop
   - Winter annual cover crops:
     - terminate early
   - Permanent cover crops
     - eliminate & renew in fall

Not Enough Water

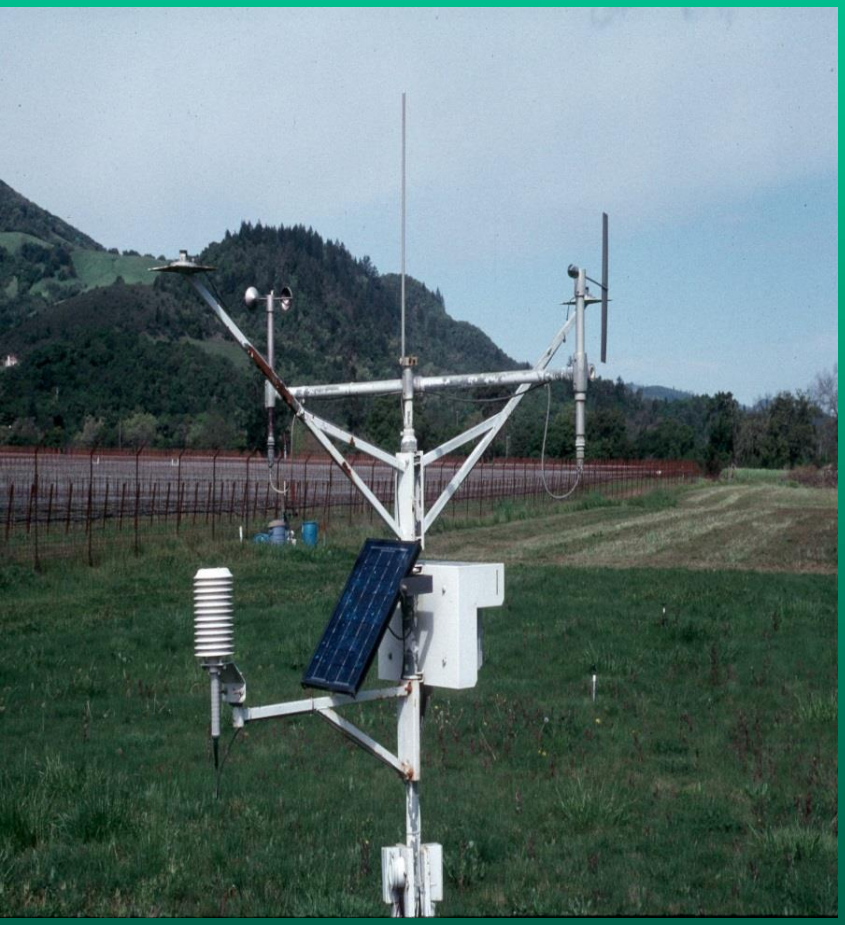
2. Improve irrigation efficiency

1. Know ETc = crop water requirement
2. Deliver just that amount
   - System evaluation & maintenance
3. Monitor soil or plants to check

Evapotranspiration

CIMIS

CALIFORNIA IRRIGATION MANAGEMENT INFORMATION SYSTEM
DEPARTMENT OF WATER RESOURCES
OFFICE OF WATER USE EFFICIENCY



ETo is available from local CIMIS weather stations:

- Pleasanton (CIMIS # 191)
- Tracy (CIMIS # 167)
- Brentwood (CIMIS # 47)

www.cimis.water.ca.gov

Evapotranspiration (ET)

ETo = Reference ET = ET of grass

How to convert ETo to Crop ET (ETc)?

- Use the crop coefficient (Kc) for your crop
  - Deciduous trees: Kc varies with growth stage
  - Evergreen trees: Kc is the same all year
  - Annual crops: Kc varies with planting date, plant size, harvest date
- ETo x Kc = Crop ET (ETc)

SEE THE HANDOUT

Deliver only the ETc amount

Efficient delivery depends on:

- Knowing how much is going on
- Maximizing the uniformity
- Strategies vary among systems
  - Surface: flood & furrow
  - Pressurized: drip & sprinklers

Improving Efficiency :

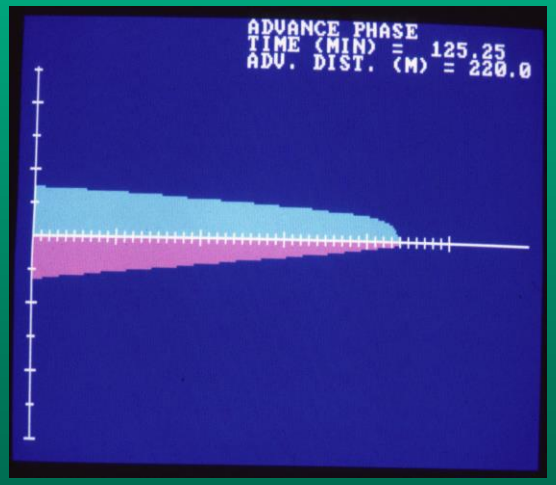
Basin & Furrow systems

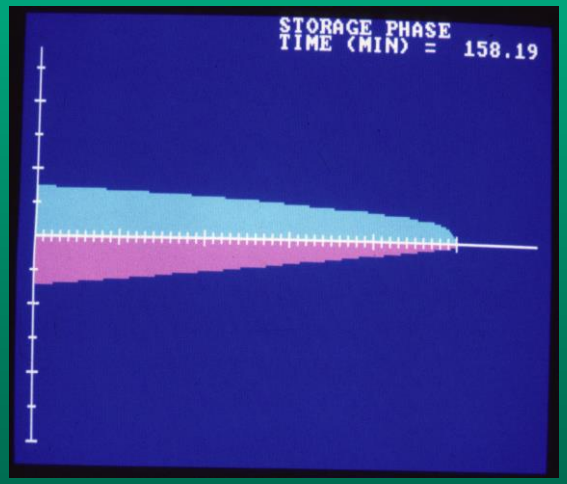
Recognizing Non-Uniform Flood or Furrow Irrigation Applications

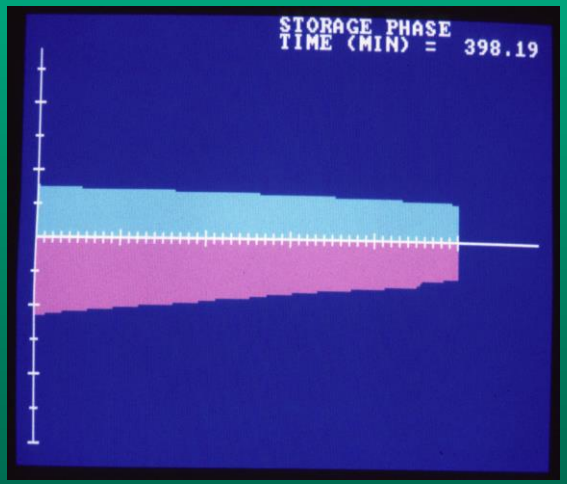
Advance Ratio = 398 minutes ÷ 158 minutes = 2.5

Total time the water ran on an irrigation set

Time it takes for water to first reach the end of the field







Advance Ratio > 2 indicates reasonable uniformity

Improving Efficiency :

Basin & Furrow systems

- Shorten the furrows (annual crops)
- Fast advance - slow storage phase
- Install a tailwater return system
- Alternate row irrigations (30% savings)
- After cultivation
  - Torpedo
  - Surge flow

Improving Efficiency :

Basin & Furrow systems

- Use furrows instead of basins (trees)

- Upgrade to a drip or sprinkler system

Improving Efficiency:
Sprinkler & Drip

- Know your application rate
  - Sprinkler/emitter flow rates
  - Flow meters
- How uniform is it?

Improving Efficiency: Sprinkler & Drip

- Causes of non-uniformity
  - Poor design
  - Leaks & breaks
  - Sprinklers/emitters with variable flows
  - Clogging
    - Clean & flush lines
    - Clean & flush filters
    - Chemical – acid for HCO_3
    - Biological –acid, chlorine, Cu

http://micromaintain.ucanr.edu

Improving Efficiency :
Monitoring Tools

These tell you WHEN to irrigate

- Soil moisture monitors
  - Shovel, auger, resistence blocks, capacitance meters, neutron probe, …
- Plant based monitors
  - Pressure chamber, infa-red thermometer

ETc tells you HOW MUCH to irrigate

Not Enough Water

Make every drop count!

1. Control weeds
2. Improve irrigation efficiency
   - System maintenance
   - Irrigation management
3. Use deficit irrigation

Deficit Irrigation

- Strategy for trees & vines
  - Better quality with deficit irrigation:
    - **Olives:** 50% of ETc Jun- mid Aug –> better oil!
    - **Grapes:** 30-70% ETc improves quality
  - Most trees: expect a yield reduction
    - Use a set % ETc or % of normal all season long
    - Yields reduced for 2 years

Deficit Irrigation

- Strategy for vegetable crops
  - Deficit irrigation reduces yields
    - During the vegetative period -> reduces plant size
    - Avoid deficit during flowering & fruit set
      - **Corn:**
        - » no stress 2 weeks before & after silking
      - **Tomatoes:**
        - » 50-100% cutback, 30-60 DBH

2014 Drought Challenges

1. **Not enough water**
   - ✓ Control weeds/cover crop
   - ✓ Improve irrigation efficiency
   - ✓ Use deficit irrigation
2. **Salty water**
   - Will it be too salty to use?

All water contains dissolved mineral salts

… but the amount and type of mineral salts vary among irrigation water sources

What salts are in the water?

- Sodium (Na^+)
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})

} Cations

- Chloride (Cl^-)
- Sulfate (SO_4^{2-})
- Bicarbonate (HCO_3^-)

} Anions

Boron (B), Carbonate (CO_3^{2-}), Nitrate (NO_3^-), Potassium (K^+)

How is salinity measured?

Electrical Conductivity (EC)

- ECw = salinity of the water
- ECe = salinity of the soil
- The units:
  - dS/m = mmhos/cm
  - uS/cm = 1000 x dS/m

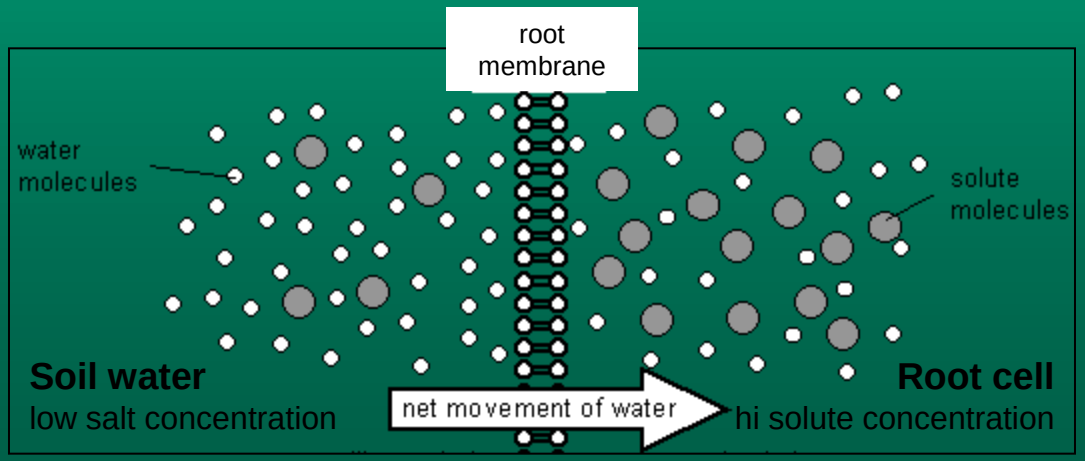
- **Total Dissolved Solids (TDS)**
  - mg/L = ppm

How does salt effect plants?

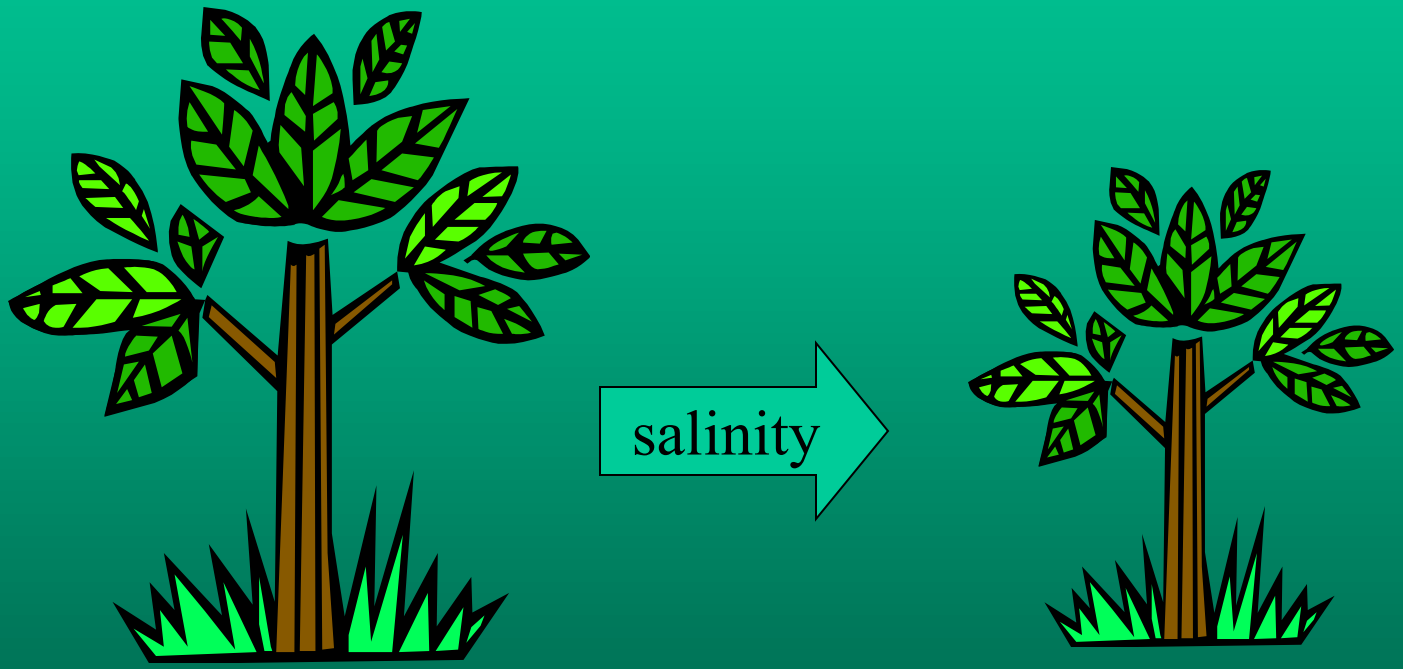
1. Overall salinity
   - EC (dS/m)
2. Specific ions
   - Toxicity (Na, Cl, B)
   - Nutrient disorders
3. Water Infiltration

How does salt effect plants?

- Overall salinity
  - High salt restricts osmotic flow
    - uses more energy to exclude salt in the root zone and take in water
  - Water stress symptoms
    - Less growth
    - Lower yields



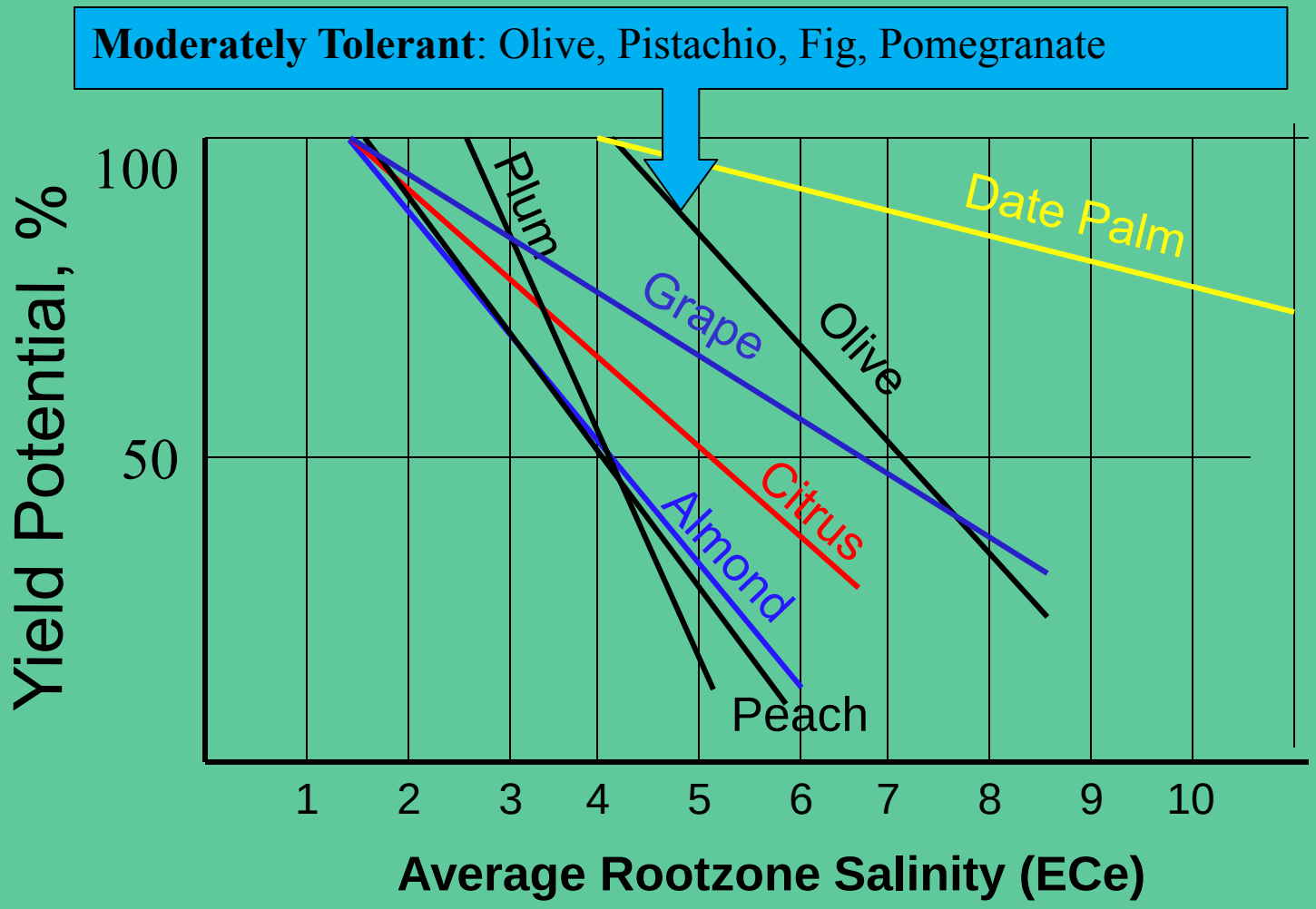
The overall osmotic effect is stunting of plant growth



Non-stressed crop

Salt-stressed crop

Tree Salt Tolerance



Maas and Grattan 1999

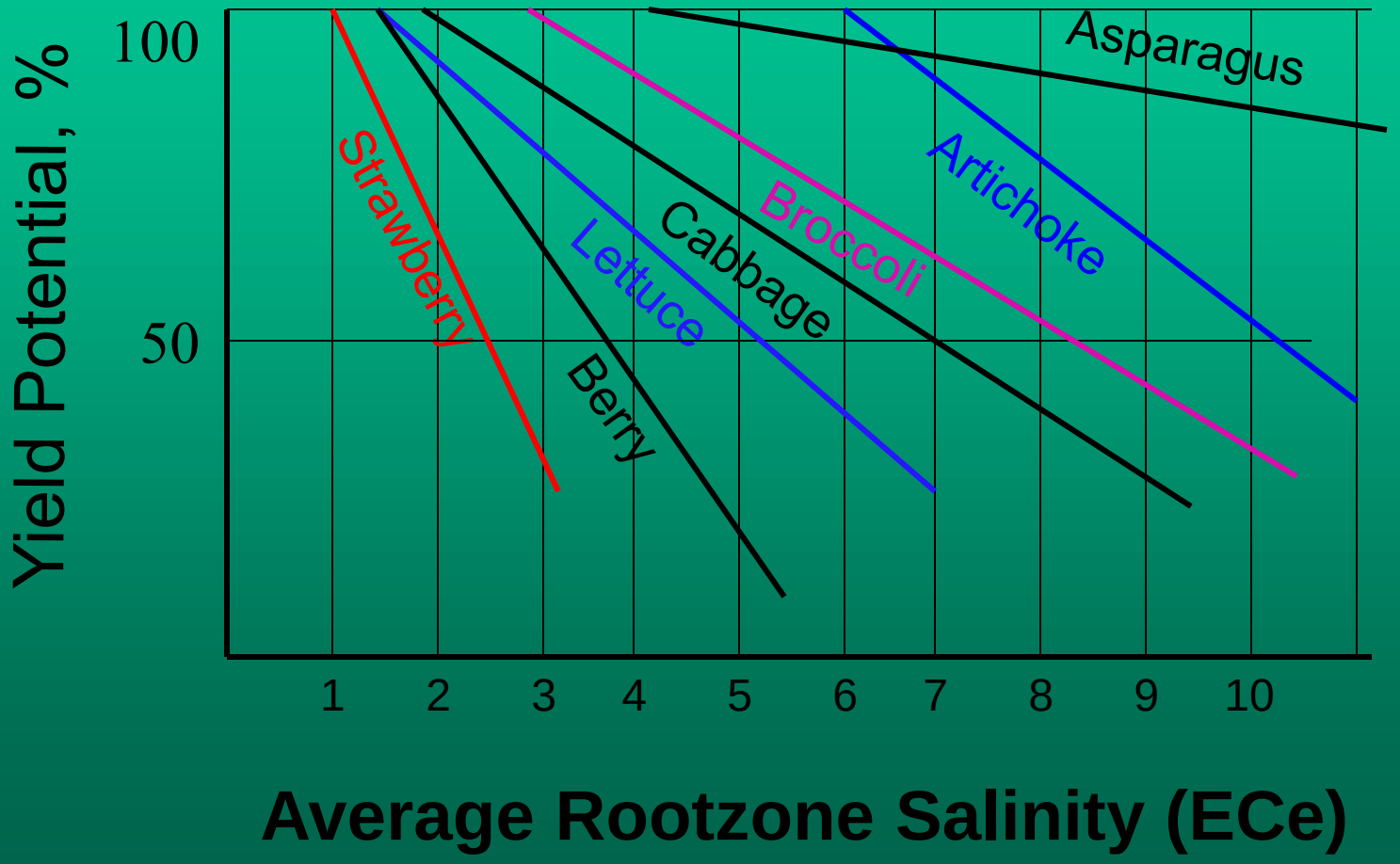
How much salt is too much ?

(for salt sensitive trees: pome fruit, stone fruit, almonds, walnuts)

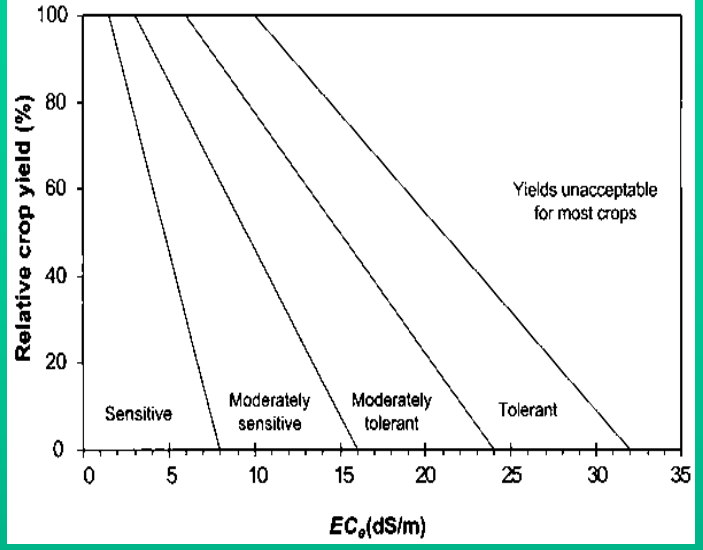
Source of Salinity	Salt Effects on Yield EC (dS/m)		
	None	Increasing	Severe
Soil/Rootzone (ECe)	<1.5	1.5-4.8	>4.8
Irrigation Water (ECw)	<1.1	1.1-3.2	>3.2

- What does “Increasing Effect” mean
  - Water: (assumes full ETc + 15% LF)
    - 1.5 ~ 10% yield reduction
    - 1.9 ~ 25 % yield reduction
    - 2.8 ~ 50% reduction

Crop salt tolerance



Maas and Grattan, 1999

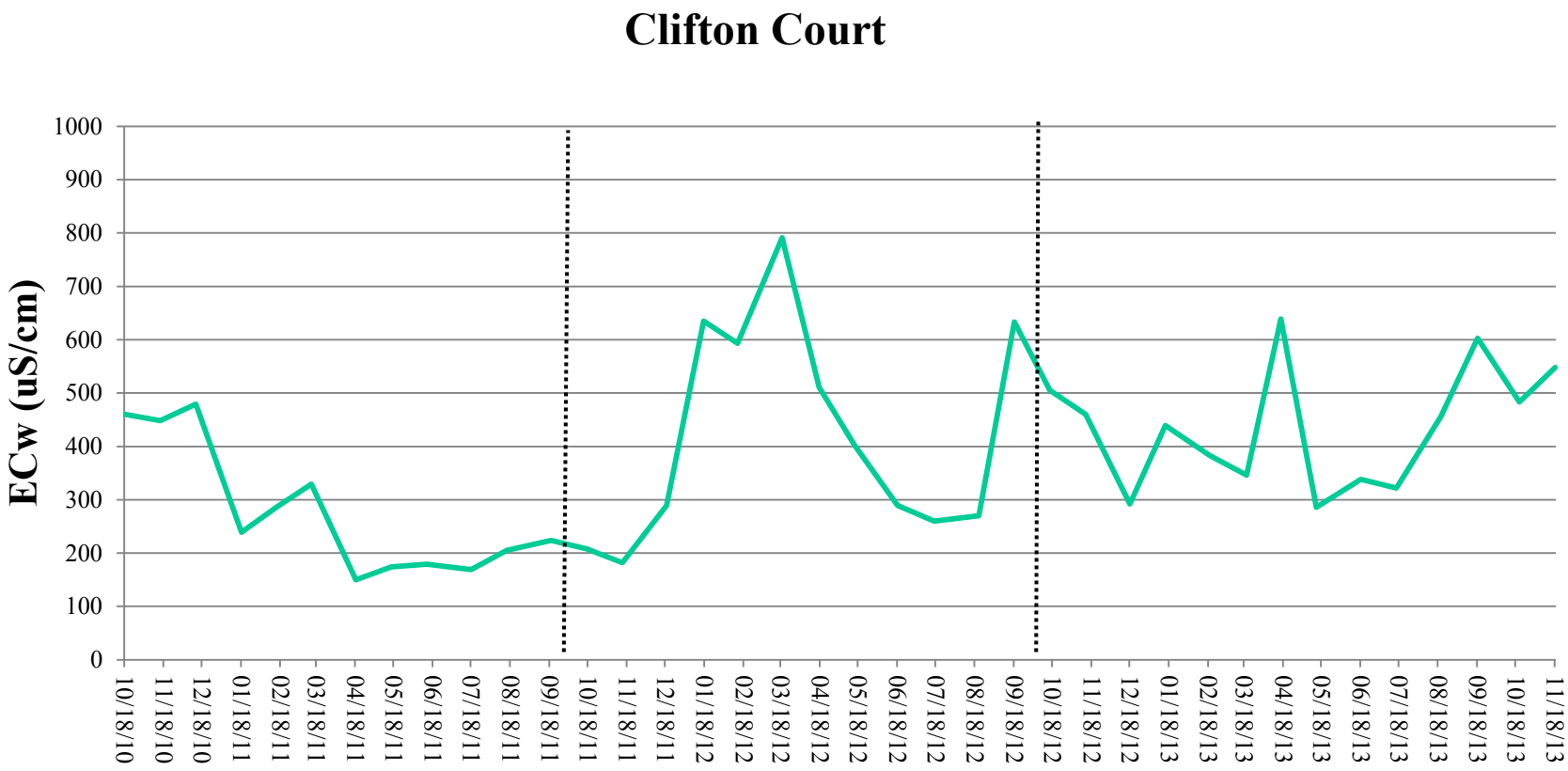


"Water quality for agriculture"

Yield Potential Charts

CROP		100%	90%	75%	50%	0%
		(ECw)				
MT	Zucchini	3.1	3.8	4.9	6.7	10
MS	Scallop Squash	2.1	2.6	3.2	4.2	6.3
MS	Tomato	1.7	2.3	3.4	5.0	8.4
MS	Cucumber	1.7	2.2	2.9	4.2	6.8
MS	Corn	1.1	1.7	2.5	3.9	6.7
MS	Pepper	1.0	1.5	2.2	3.4	5.8
S	Onion	0.8	1.2	1.8	2.9	5.0
S	Bean	0.7	1.0	1.5	2.4	4.2

ECw varies over the season



Specific Ion toxicity

Boron (B), Chloride (Cl) and sodium (Na)

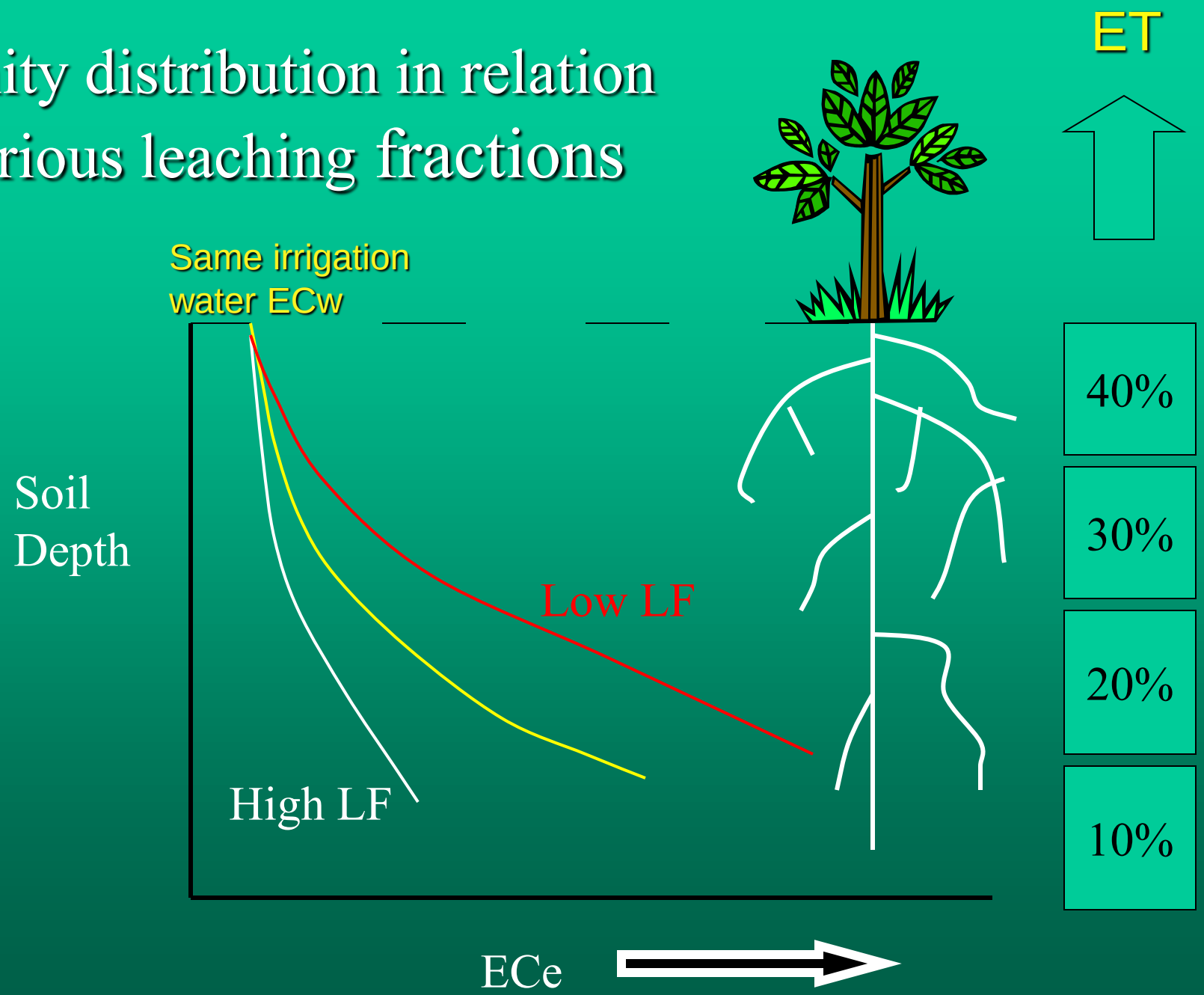
Specific Ion Toxicity (Na, Cl, B)

- Normal plant nutrients
- Accumulate in wood & leaves
  - Interfere with normal cellular processes
  - Reduced photosynthesis
- Roots can regulate uptake
- Rootstocks vary in regulation ability

Salinity Management

- Apply more water!
  - Leach salts below root zone
    - Apply the full crop water use (ETc)
    - Apply an additional 15-20% “leaching fraction”
    - Many years the rainfall provides the leaching fraction!
- More frequent in-season irrigations
  - Keep the upper root zone wetter - it will be easier for the tree to extract water and exclude the salt
- Apply fertilizer modestly (they are salts!)

Salinity distribution in relation to various leaching fractions



Salinity affects infiltration

- Electrical Conductivity (ECw)
  - Low EC -> poor water infiltration
- Sodium Absorption Ratio (SAR)
  - High SAR -> poor water infiltration

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

SAR & ECw together effect permeability

Permeability	No Problem	Increasing Problem	Severe Problem
SAR = 0-3 & ECw =	> 0.7	0.7 – 0.2	< 0.2
SAR = 3-6 & ECw =	> 1.2	1.2 – 0.3	< 0.3
SAR = 6-12 & ECw =	> 1.9	1.9 – 0.5	< 0.5
SAR = 12-20 & ECw =	> 2.9	2.9 – 1.3	< 1.3
SAR = 20-40 & ECw =	> 5.0	5.0 – 2.9	< 2.9

Amendments

- Gypsum ($CaSO_4$)
- Sulfuric Acid (H_2SO_4)
  - In soils containing lime ($CaCO^3$)

Calcium

- Improves soil aggregation & structure
- Improves root function & ion transport
- Plant can tolerate higher ECe (+ 1-3 dS/m)

WEB RESOURCES:

UC Drought Management website

http://ucmanagedrought.ucdavis.edu/

California Institute for Water Resources

http://ciwr.ucanr.edu

UC ANR Catalog

www.anrcatalog.ucdavis.edu

My UCCE website:

http://cecontracosta.ucanr.edu

->Commercial agriculture -> Crops