Drip Irrigation and Soil Salinity

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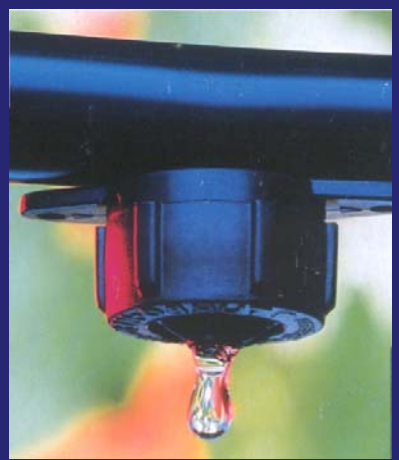
"Drip Irrigation"

- Microsprinklers – trees, grapes
- Drip emitters – trees, vines, berry
- Drip tape (surface, subsurface) – row crops



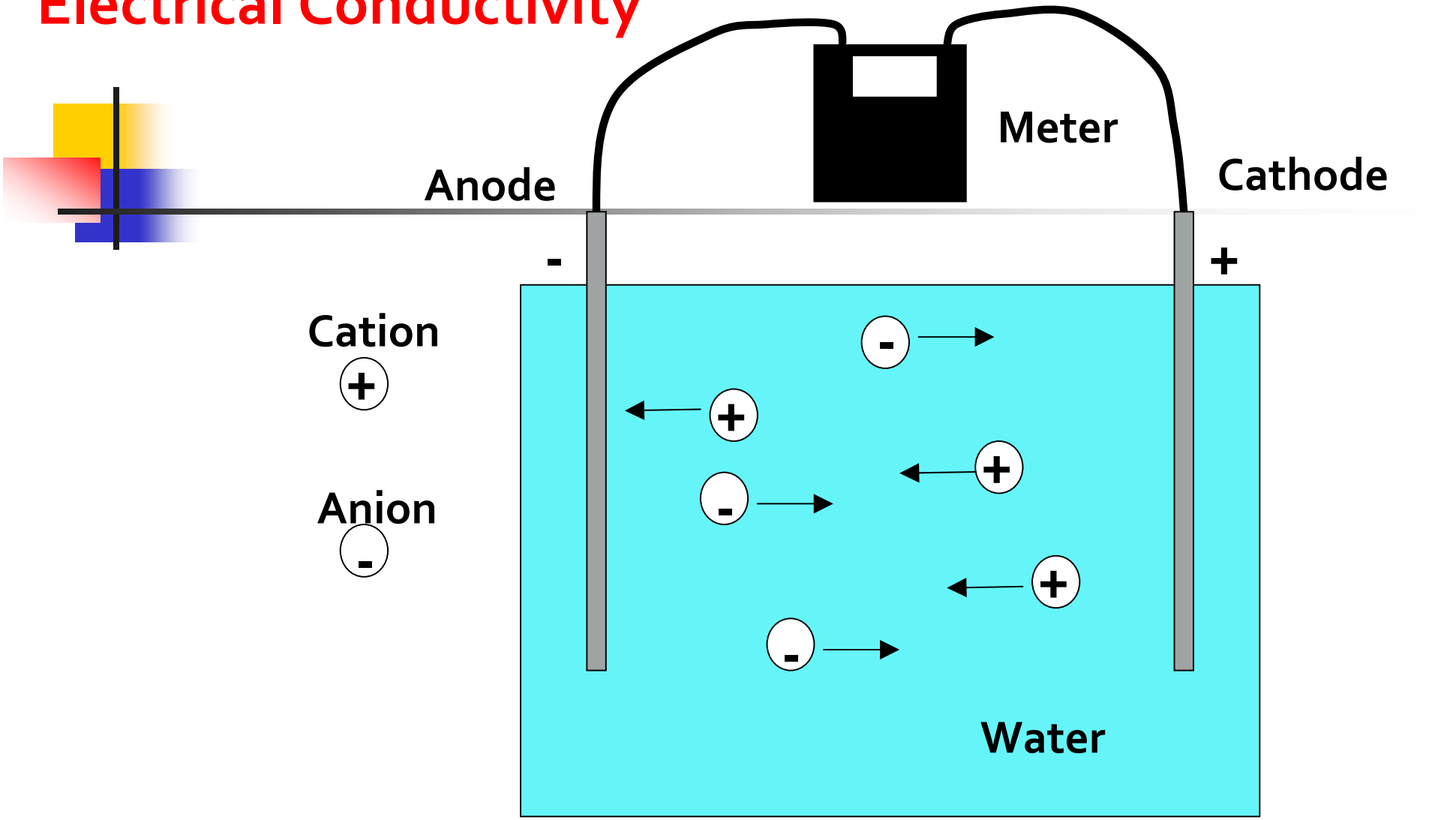
Where Do Salts in the Soil Come From?

- Irrigation water
- Upward flow from a saline, shallow water table
- Fertilizers – short term only

Salinity - Total Dissolved Salts (TDS)

- Calcium
- Magnesium
- Sodium
- Chloride
- Sulfate
- Bicarbonate/carbonate
- Minor - nitrate, potassium

Electrical Conductivity



Electrical Conductivity (EC)

- Measure of the ability of a solution to conduct electricity
- The larger the salt concentration, the larger the EC
  - Doubling the concentration does not double the EC
- Units of EC
  - millimhos per centimeter - mmhos/cm
  - micromhos per centimeter -μmhos/cm
  - decisiemens per meter - dS/m (equals mmhos/cm)

TDS (ppm) = K x EC (dS/m, mmho/cm)

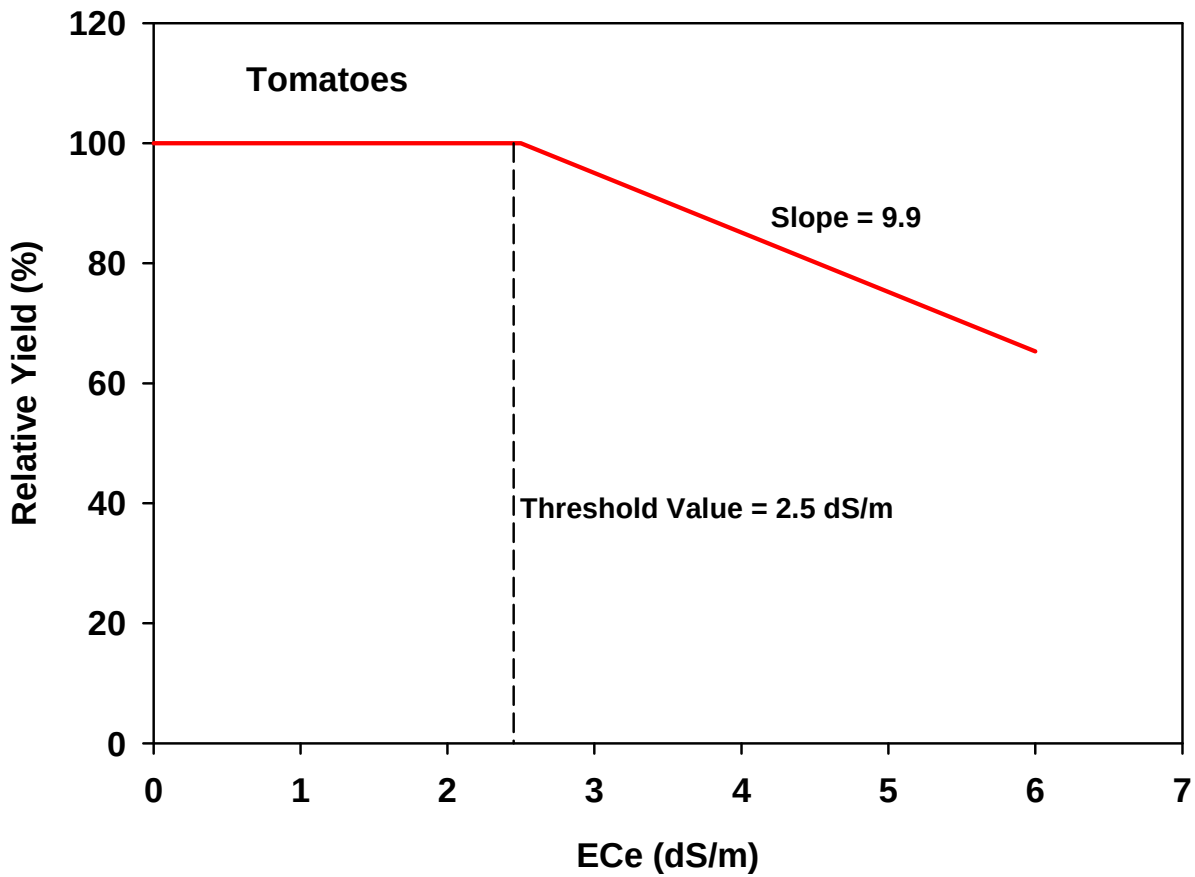
- Generalized
  - K = 640: EC less than 5 dS/m
  - K = 800: EC more than 5 dS/m
- San Joaquin Valley Drainage Water
  - K = 740: EC less than 5 dS/m
  - K = 840:EC between 5 and 10 dS/m
  - K = 920: EC greater than 10 dS/m
- Santa Maria Valley
  - K = 740

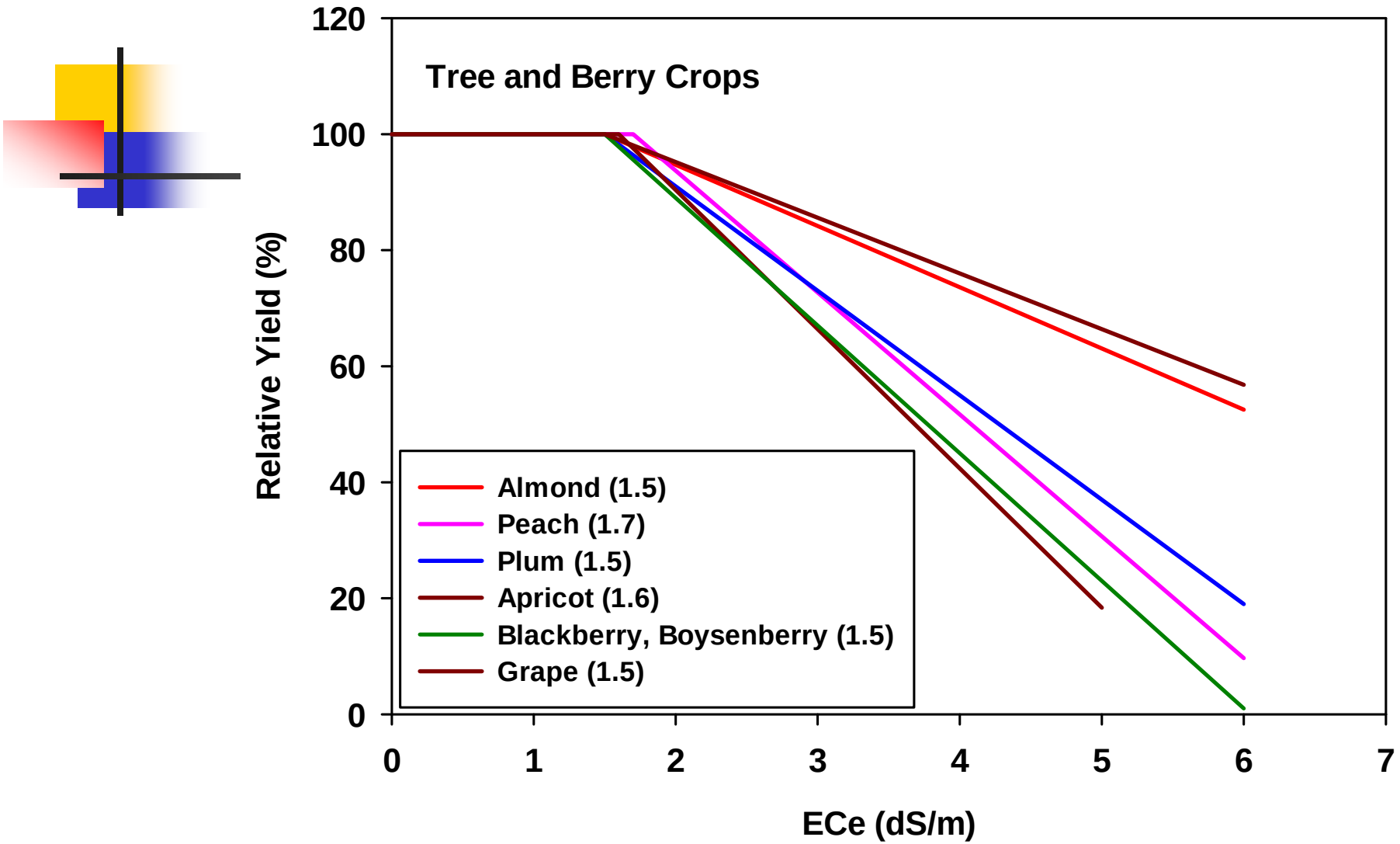
Measuring soil salinity

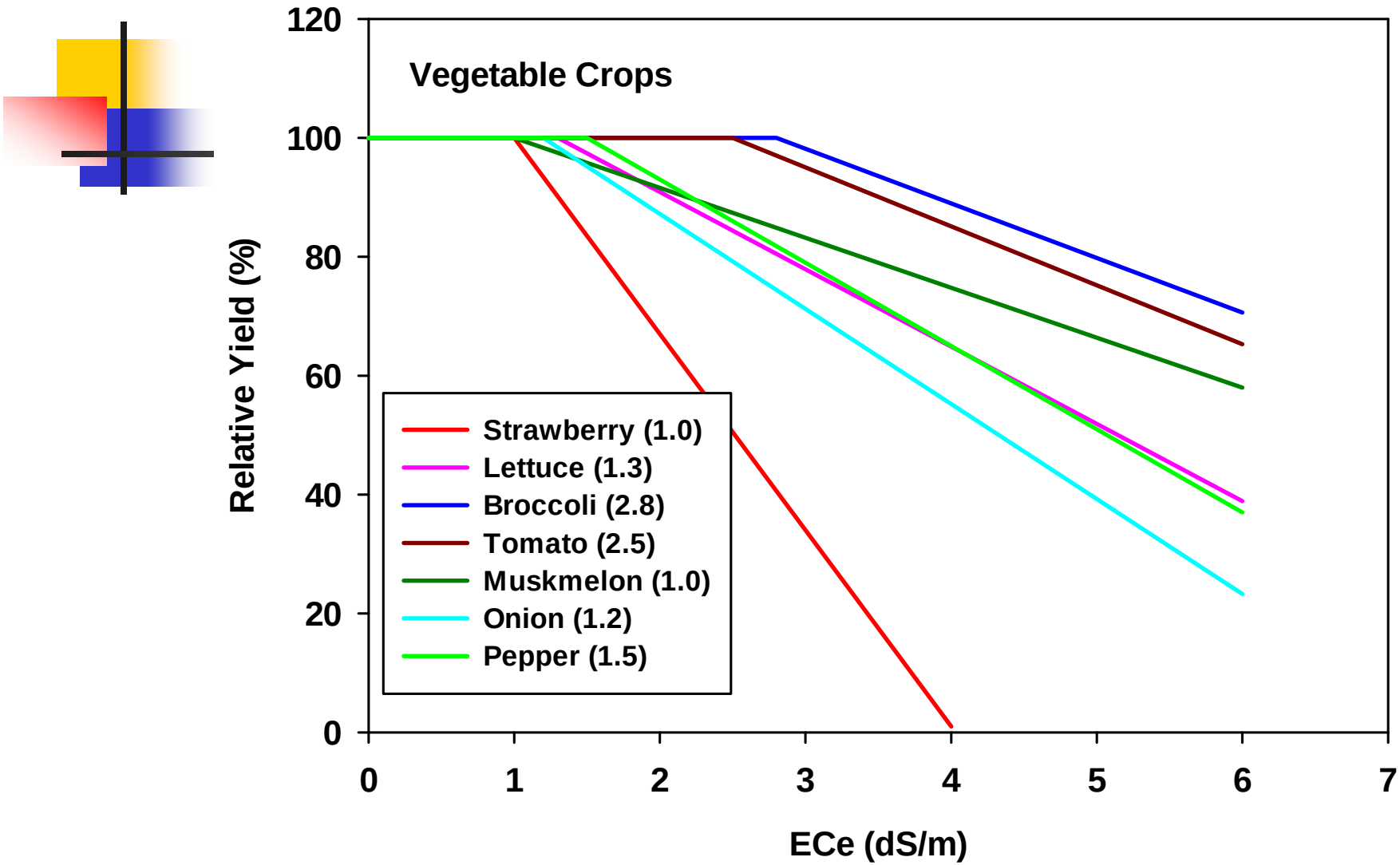
- EC of saturated extract (ECe)
  - Collect soil samples in the root zone
  - Dry the soil and then grind it
  - Add distilled water until the soil is saturated
  - Extract the solution from the soil with a vacuum extraction apparatus
  - ECe can be related to crop tolerance values
- Soil EC expressed as a 1:1, 1:5, or 1:10 soil/water ratios
  - Monitor soil salinity over time
  - Not very useful for assessing soil salinity impact on crop yield

Crop tolerance to soil salinity

$Y_r = 100 - \text{Slope} \times (EC_e - \text{Threshold})$




Tree and Berry Crops
Relative Yield (%)
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
ECe (dS/m)
Almond (1.5)
Peach (1.7)
Plum (1.5)
Apricot (1.6)
Blackberry, Boysenberry (1.5)
Grape (1.5)

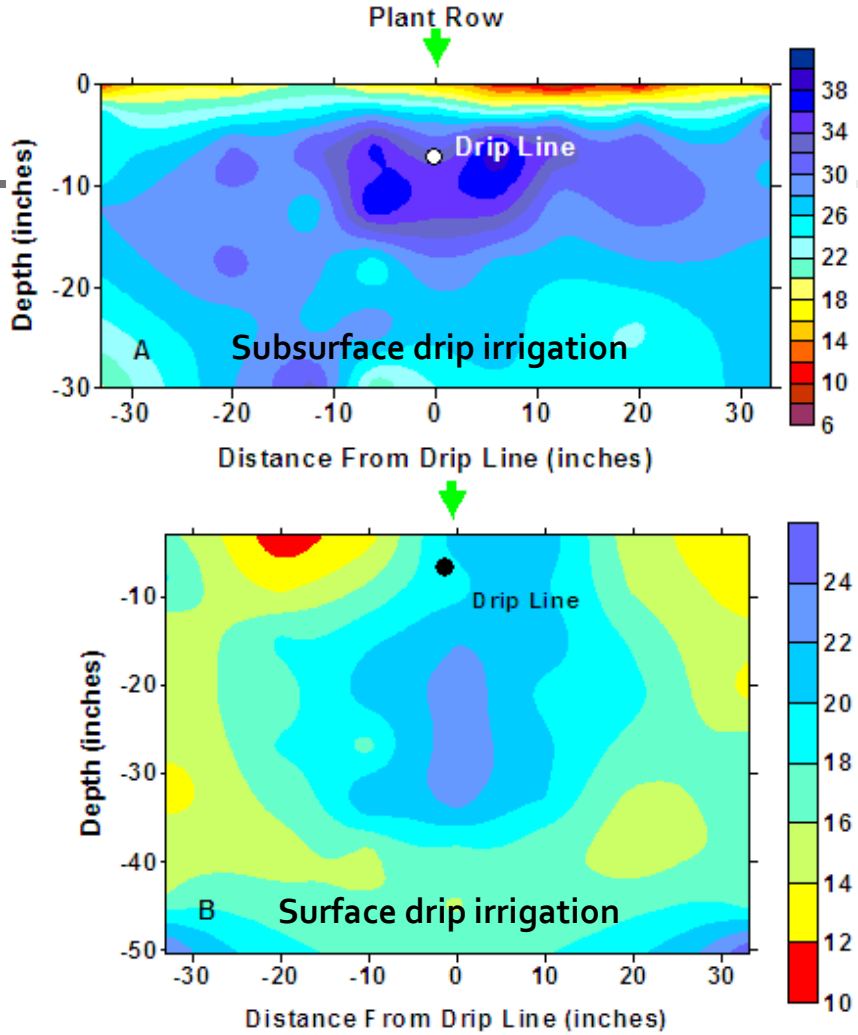

Vegetable Crops
Relative Yield (%)
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
ECe (dS/m)
Strawberry (1.0)
Lettuce (1.3)
Broccoli (2.8)
Tomato (2.5)
Muskmelon (1.0)
Onion (1.2)
Pepper (1.5)

Concerns about crop salt tolerance data

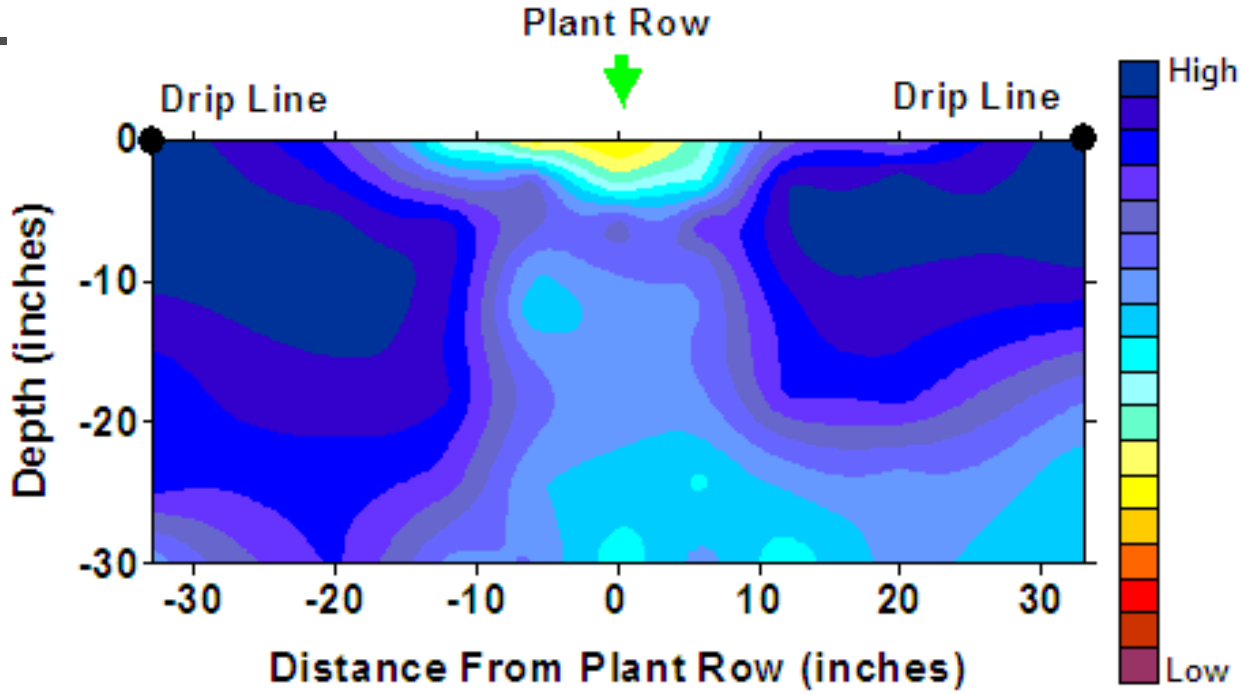
- Most of the crop tolerance data were developed 20+ years ago
- Furrow/sprinkle irrigation
- Different varieties compared to today
- Tolerance data reflect an average determined from a few experiments
- Questions
  - Do those values reflect the response of today's varieties to salinity?
  - Are those values appropriate for drip irrigation?

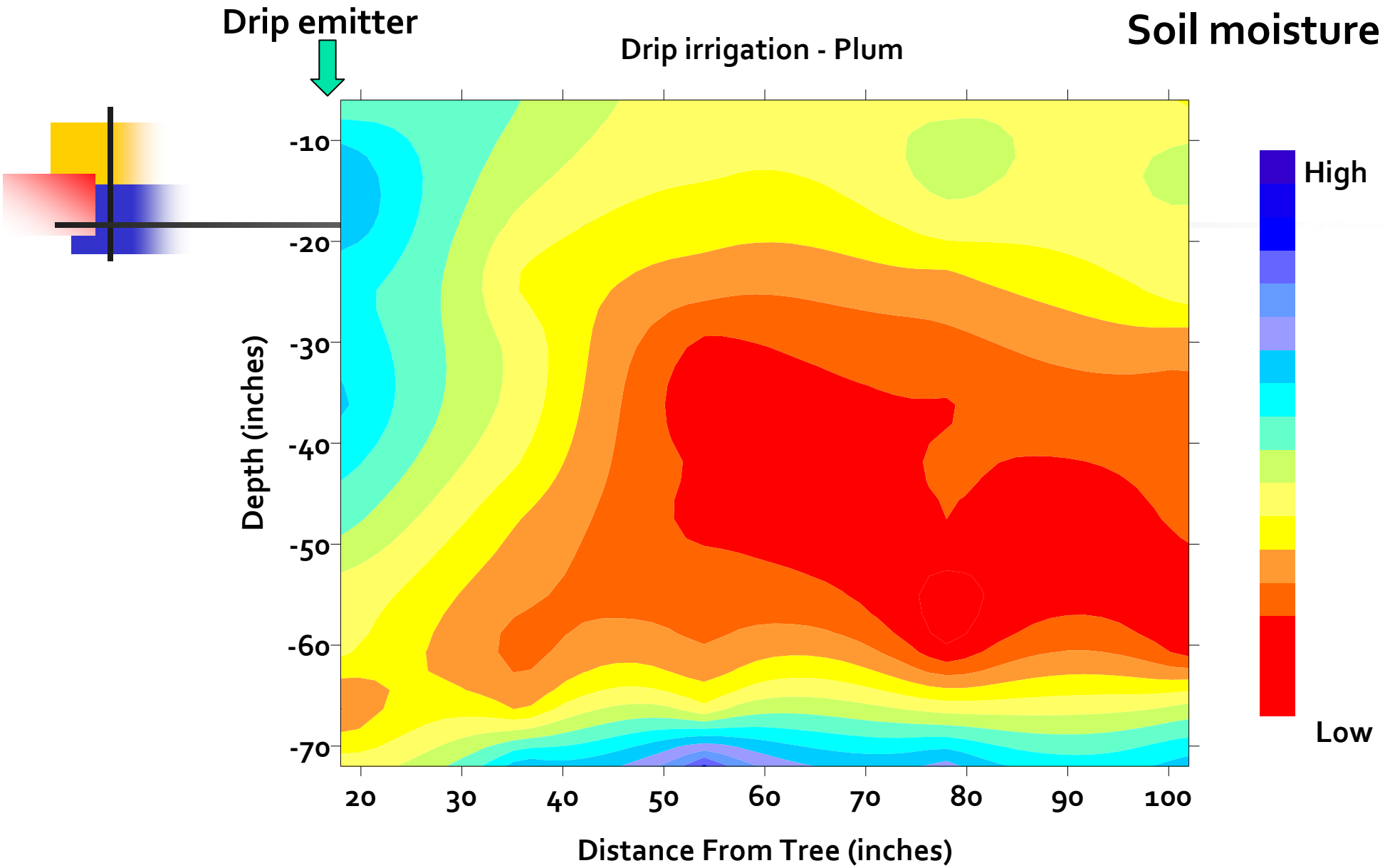
Patterns of soil moisture, roots, and soil salinity under drip irrigation

Soil moisture



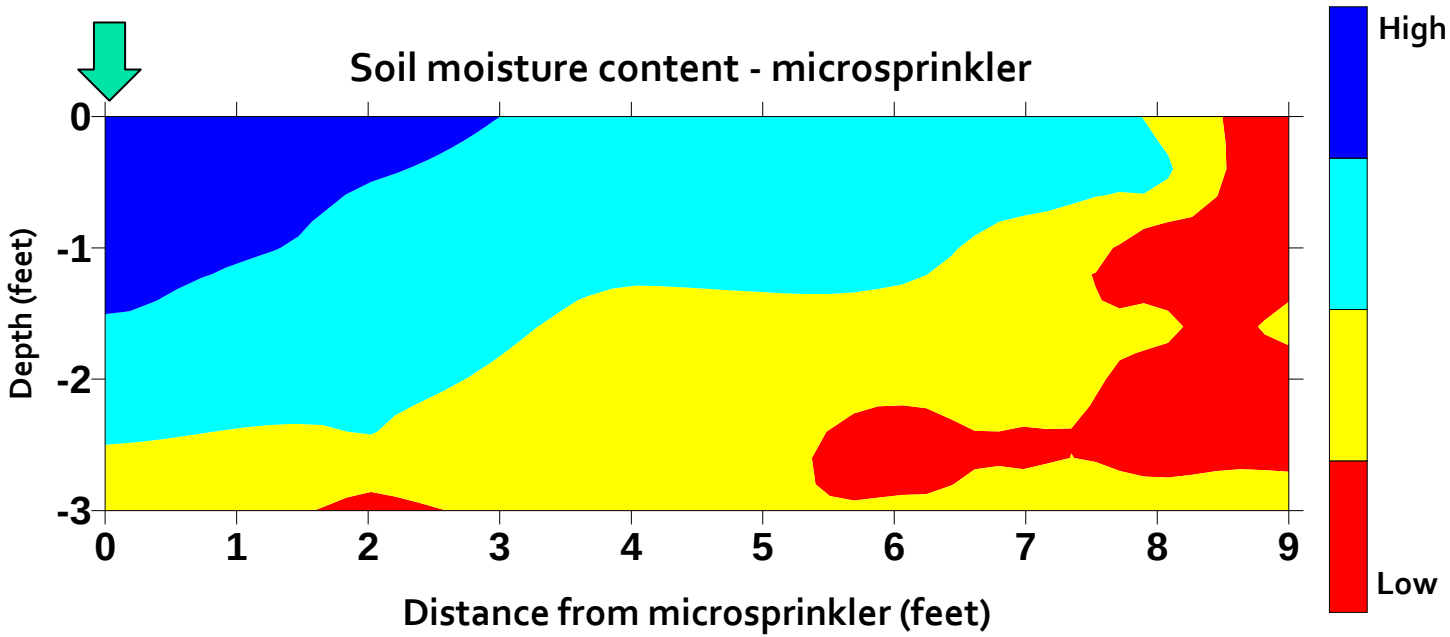
Soil moisture



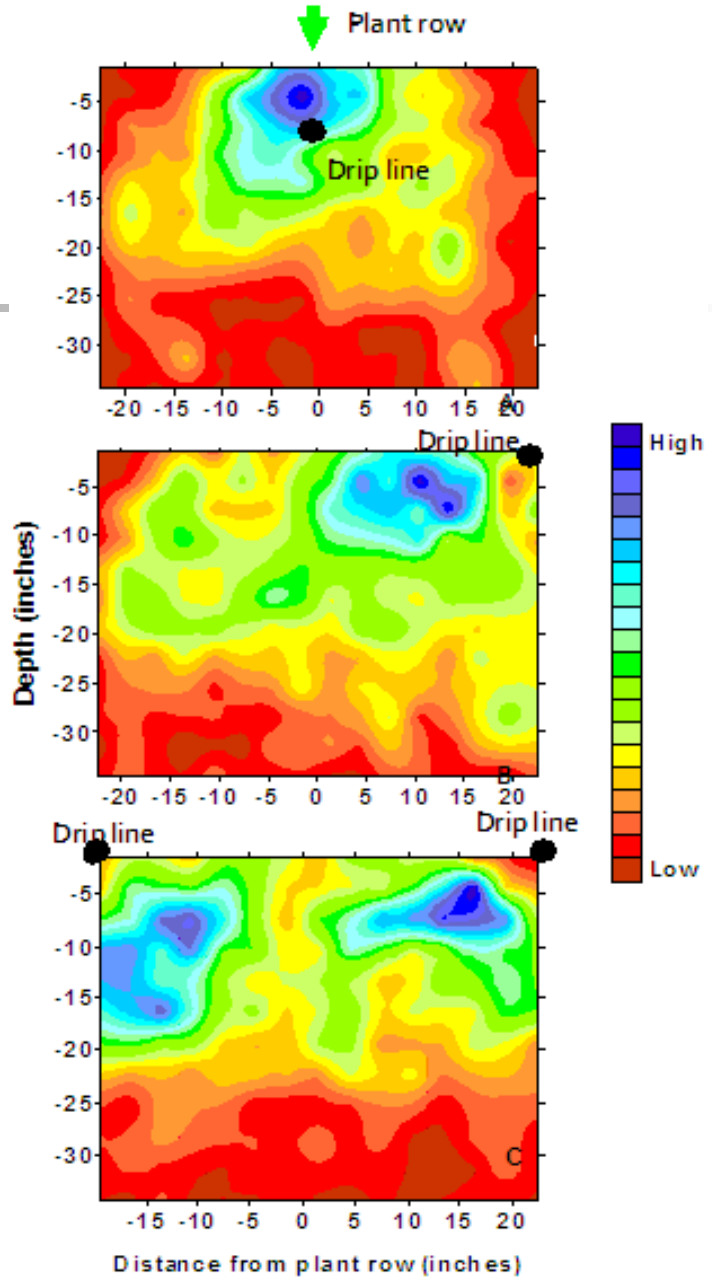

Drip emitter
Drip irrigation - Plum
Soil moisture
-10
-20
-30
-40
-50
-60
-70
Depth (inches)
20
30
40
50
60
70
80
90
100
Distance From Tree (inches)
High
Low

Soil moisture

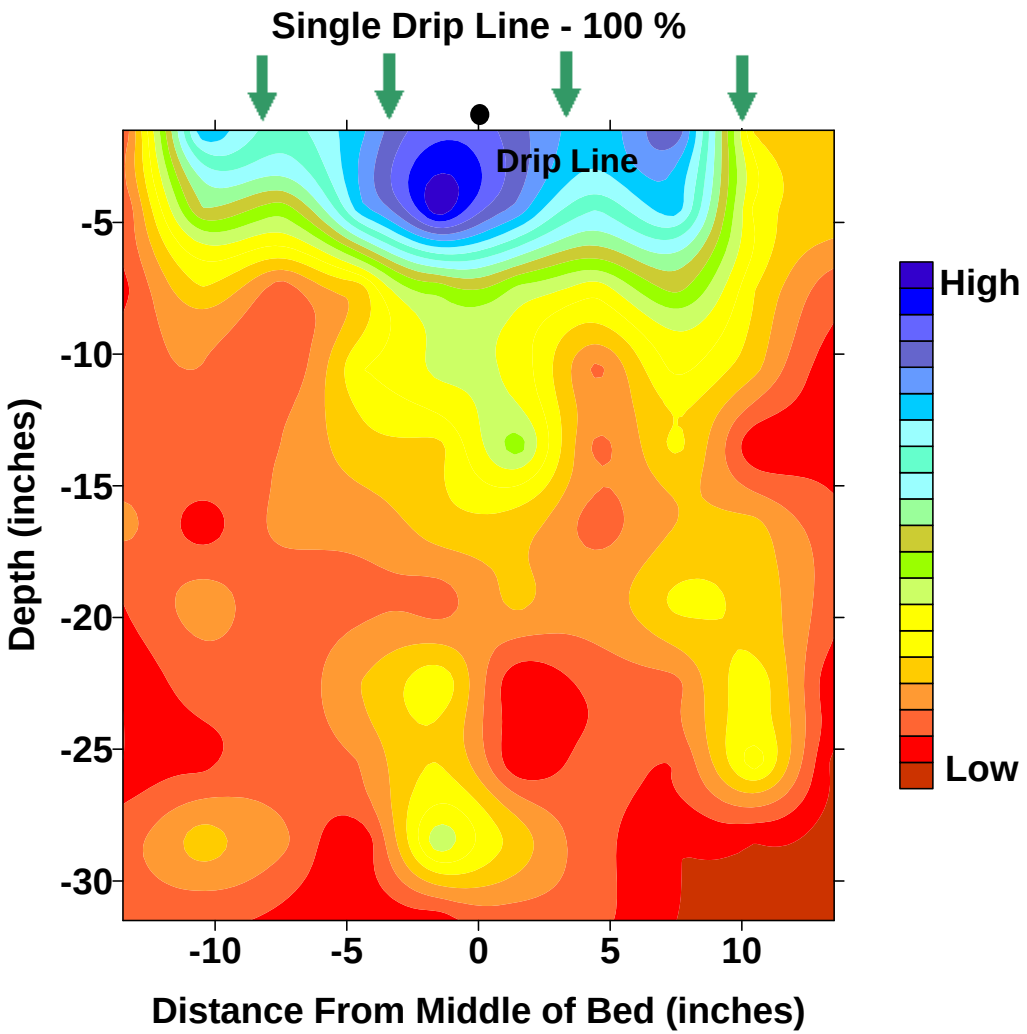
Microsprinkler



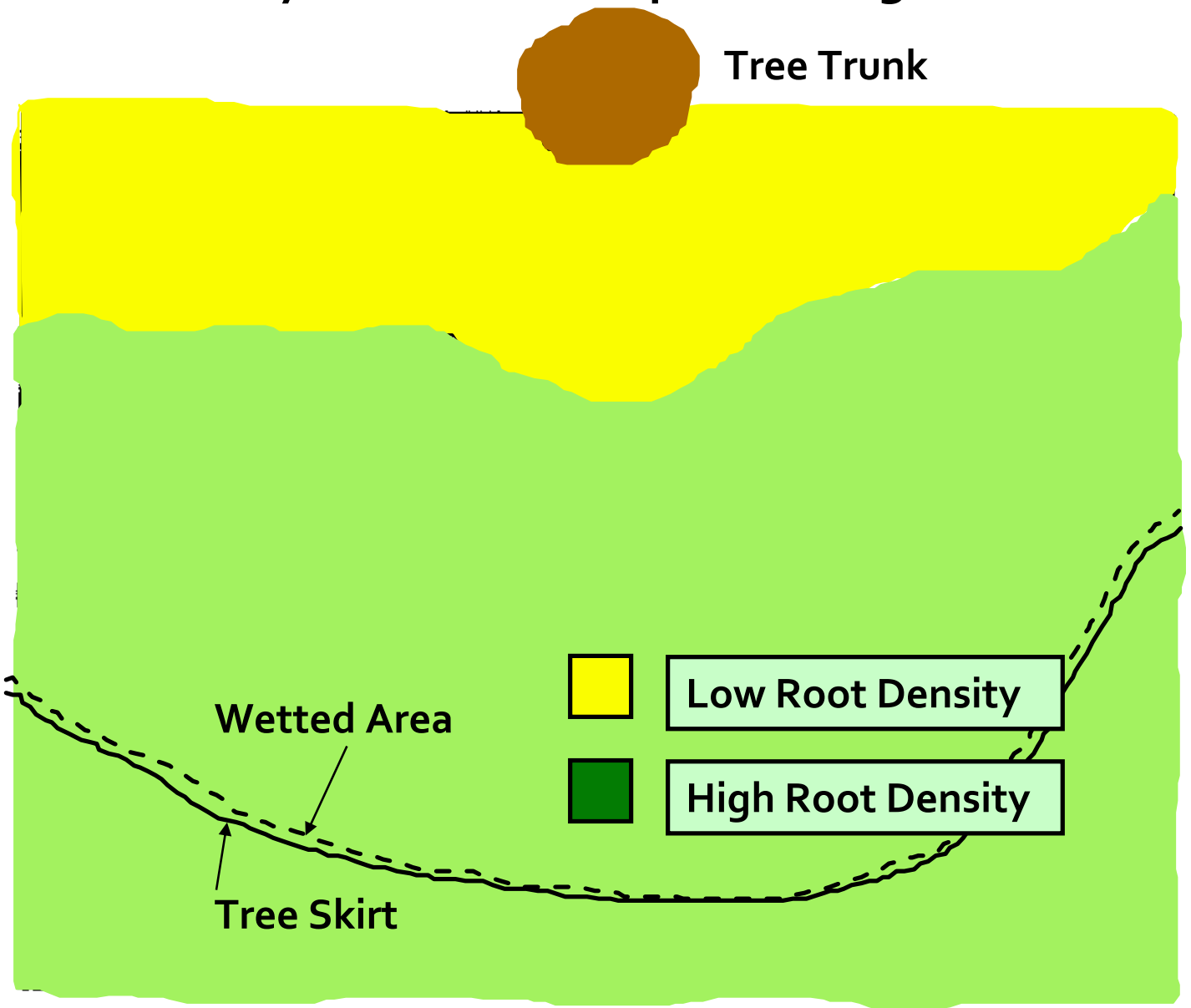
Tomato root patterns



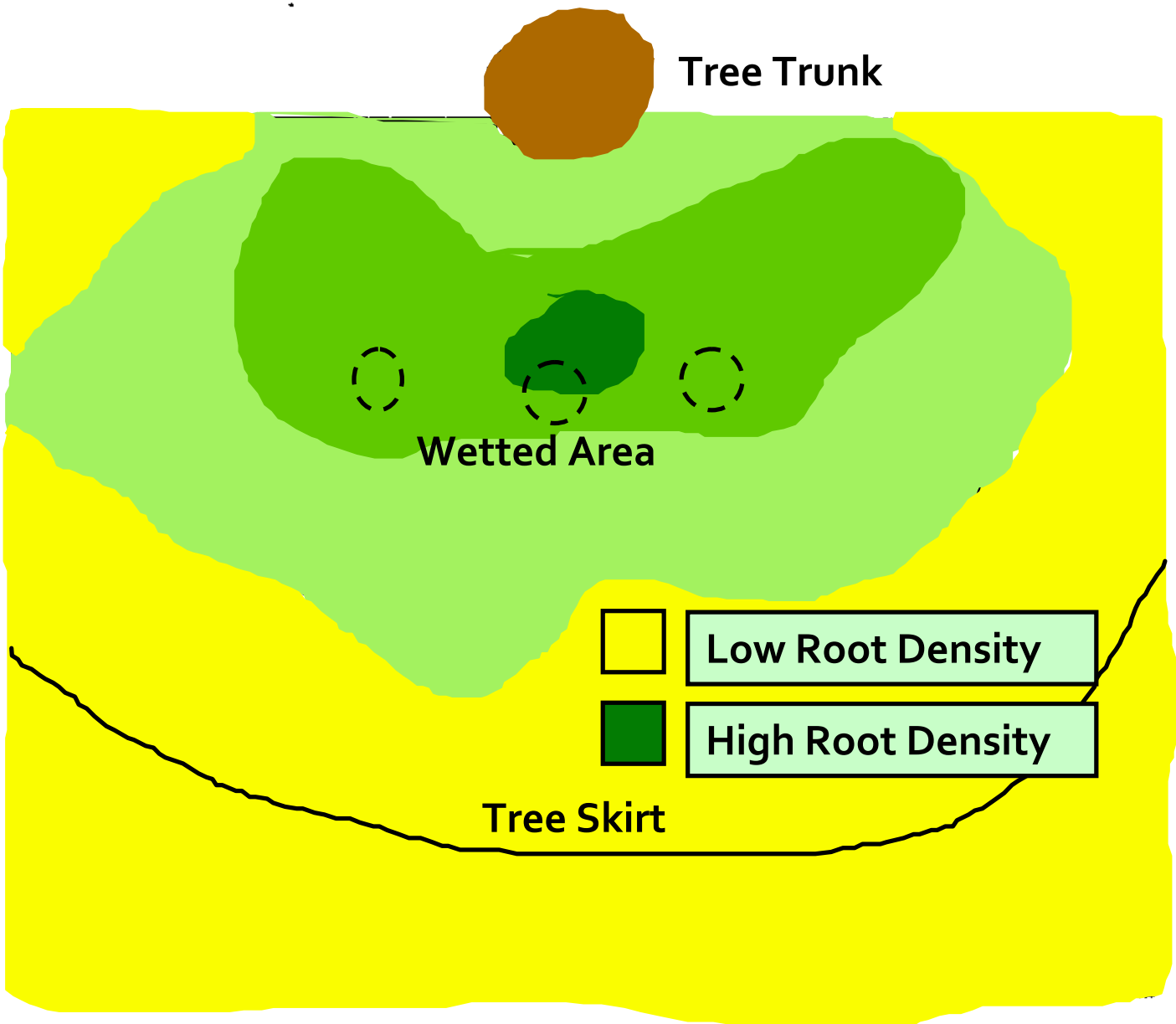
Onion root pattern



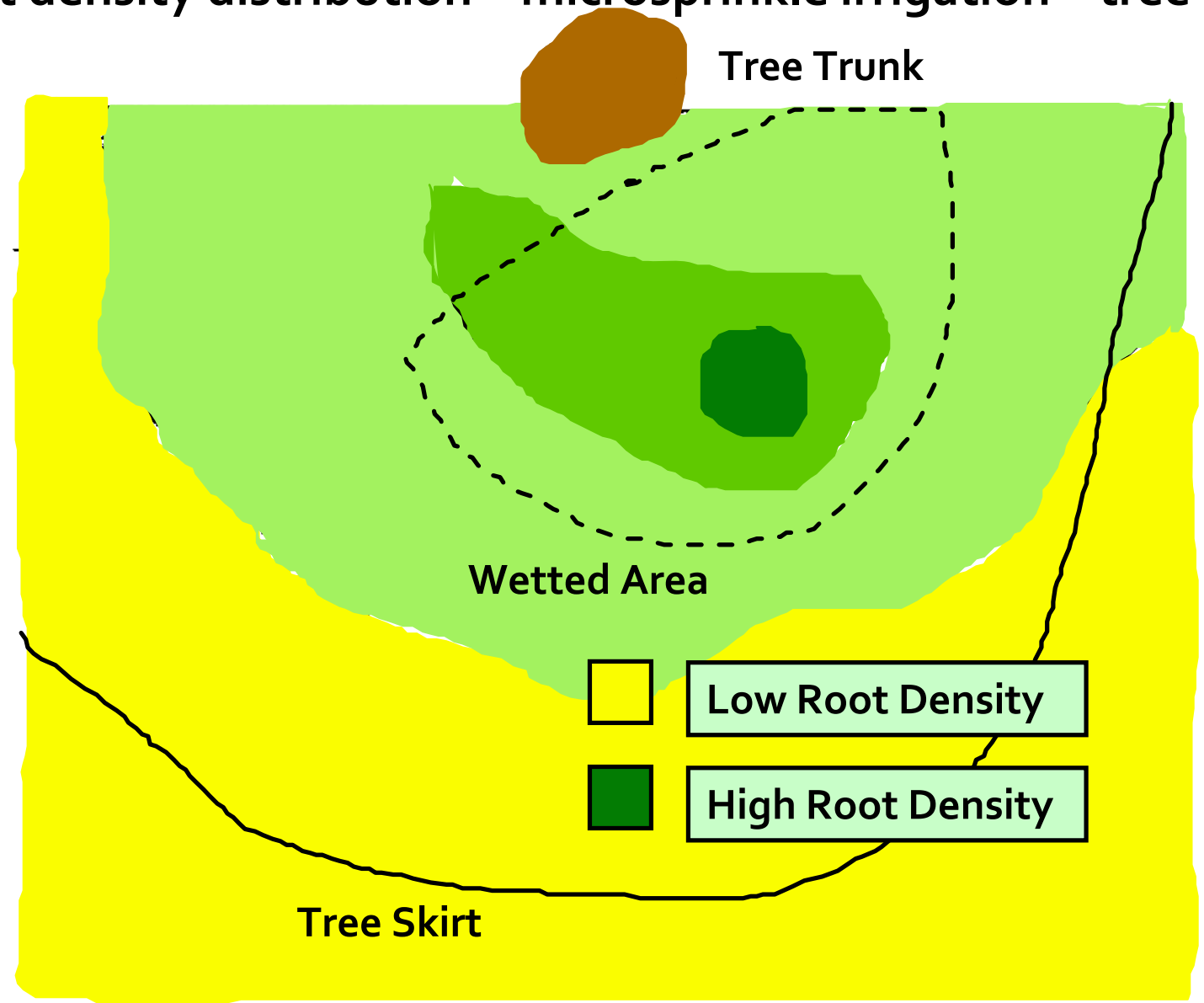
Root density distribution – sprinkle irrigation – tree crop



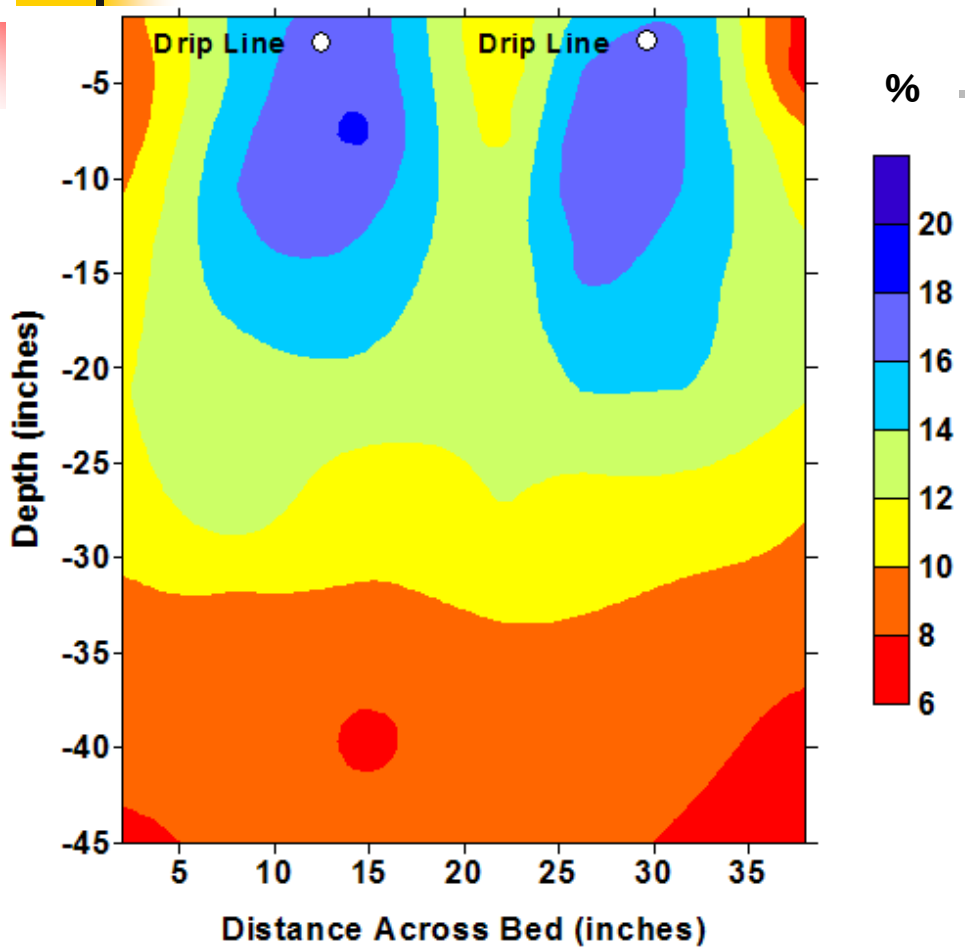
Root density distribution – drip irrigation – tree crop



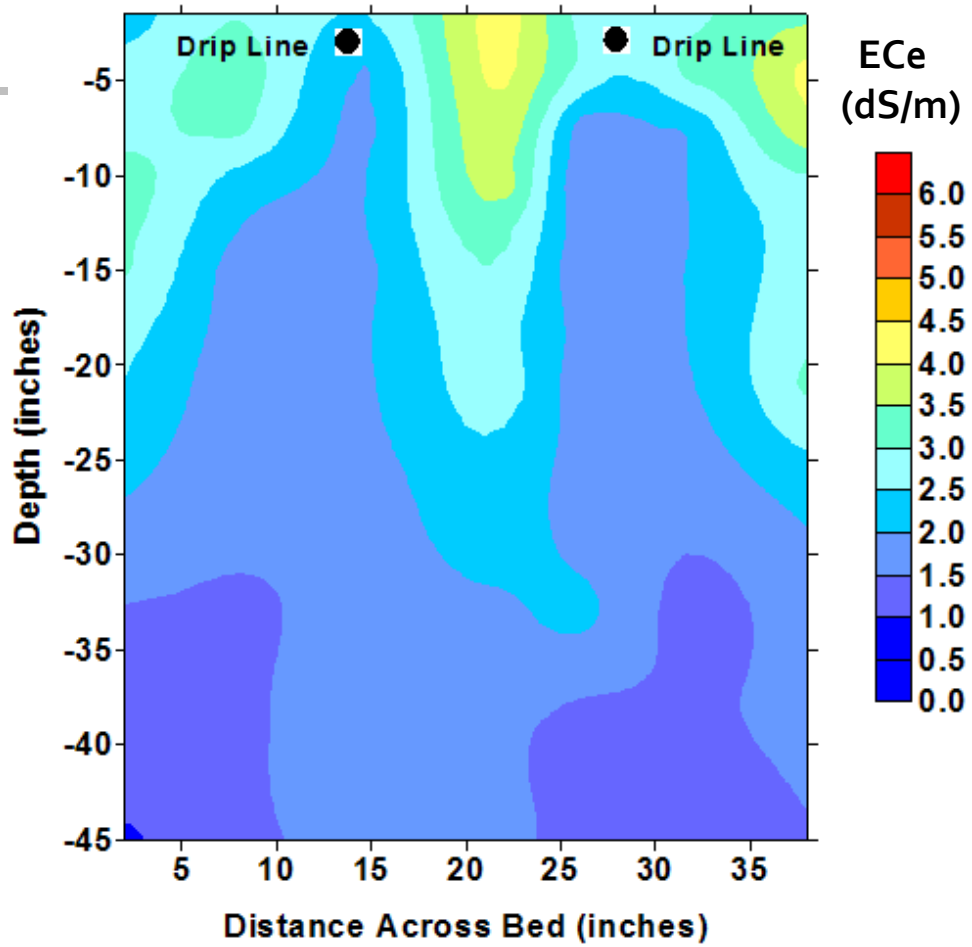
Root density distribution – microsprinkle irrigation – tree crop



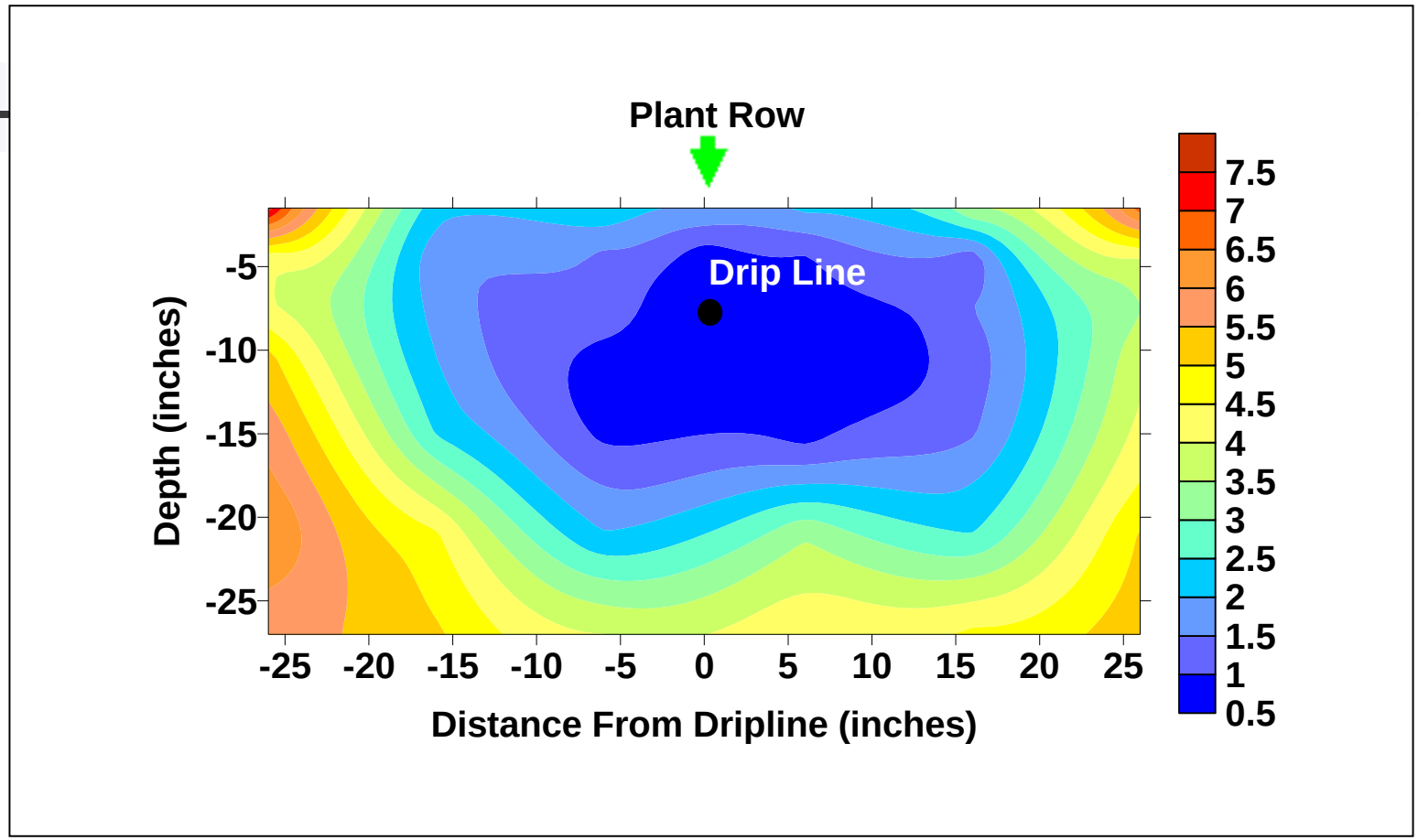
Soil moisture



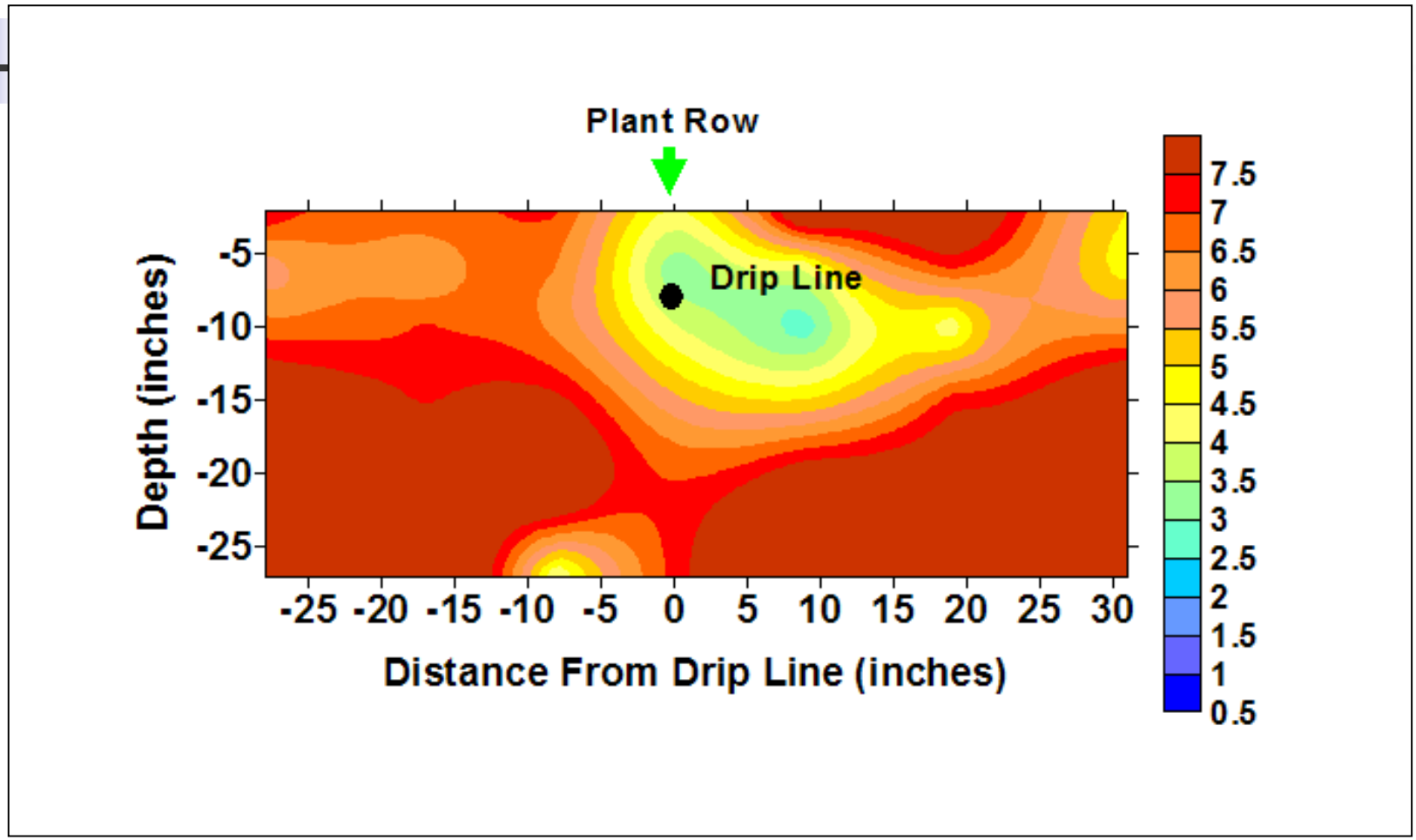
Soil salinity



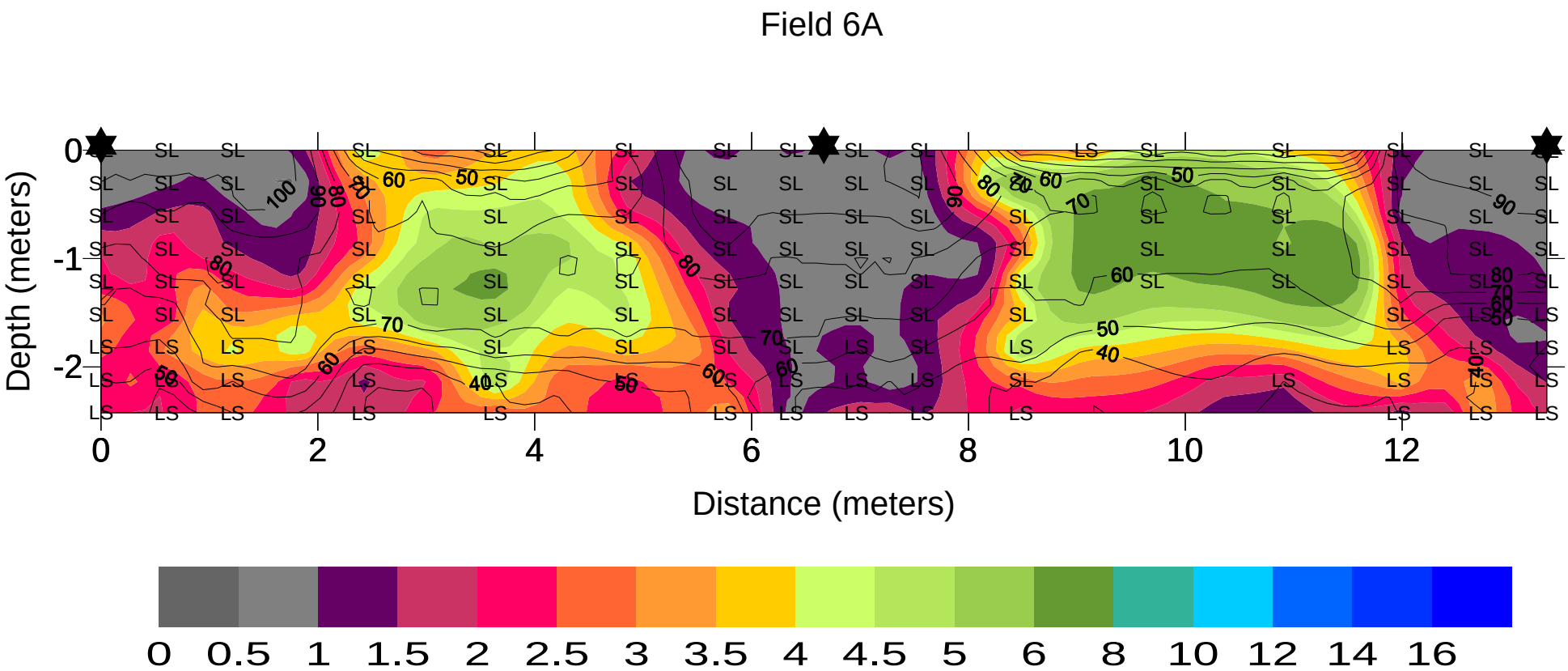
Soil Salinity



Soil Salinity



Soil Salinity



ITRC - Cal Poly

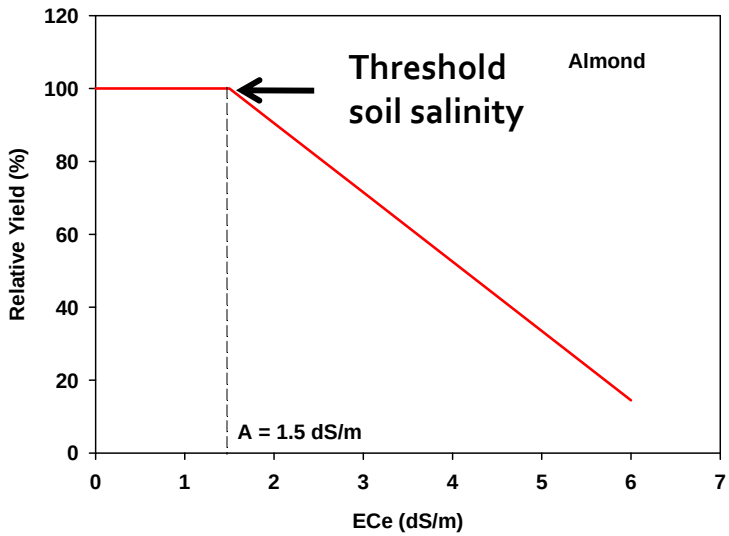
Numbered contour intervals show % field capacity

Summary

- Soil moisture is highest near drip lines and decreases with distance from drip lines
- Soil salinity is the smallest near drip lines and increases with distance
- Salt accumulation occurs above buried drip lines
- Root patterns under drip line depend on the location of plant rows relative to drip lines
  - Drip lines coincide with plant rows – roots are highly concentrated around drip lines
  - Drip lines offset from plant rows – reduced root development near drip lines

Salinity control

- Objective: reduced or maintain soil salinity at values equal to or less than the threshold soil salinity
- Key principle: apply sufficient water to leach salt from the root zone

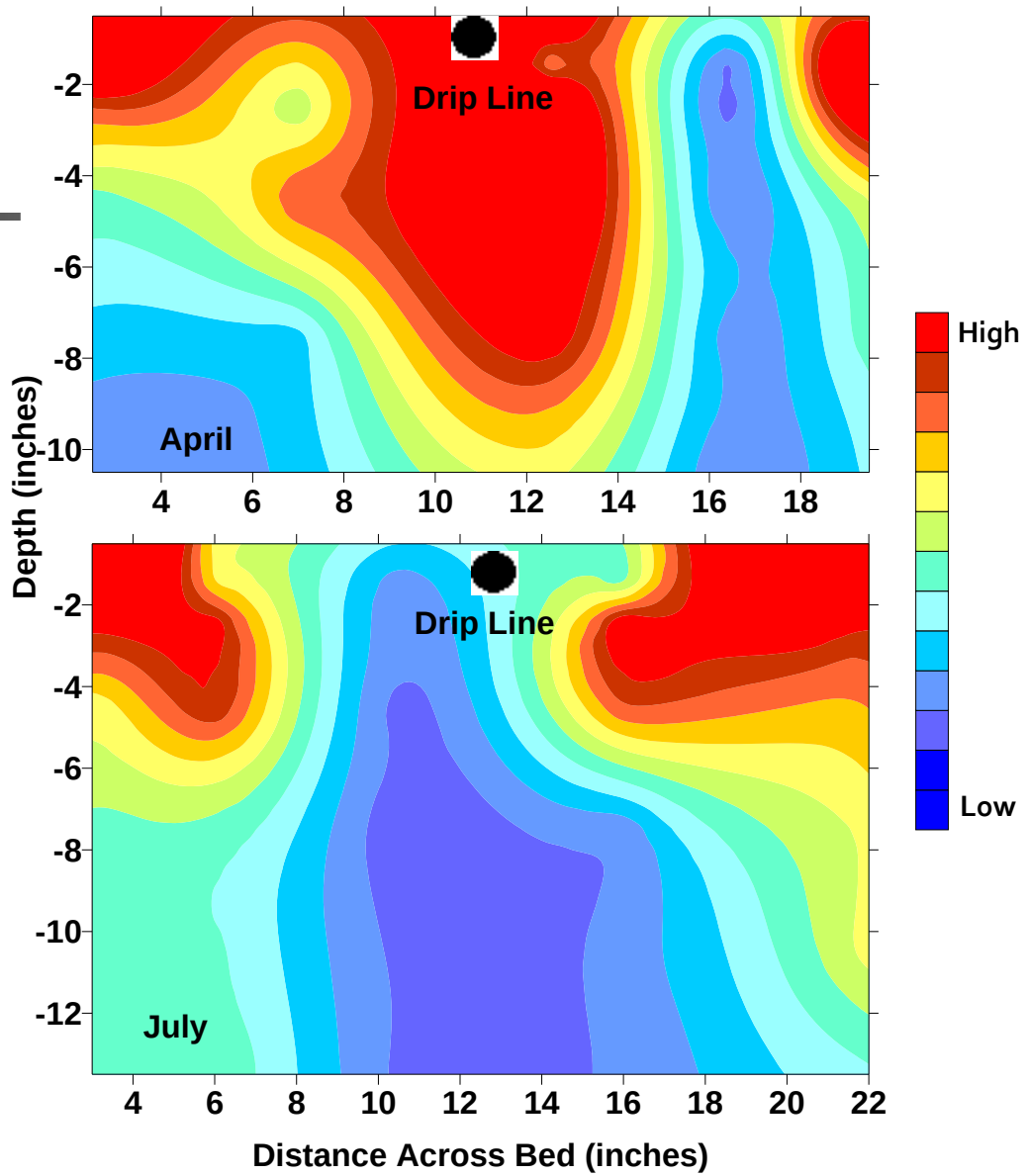


Leaching

- Leaching - process of applying irrigation water in excess of soil moisture depletion to flush salt from the root zone. Excess water percolates below the root zone carrying the salt with it.
- Leaching fraction – actual percentage of the applied or infiltrated water that percolates below the root zone
- Leaching requirement - percentage of applied or infiltrated below the root zone needed to maintain soil salinity at the threshold soil salinity
- Leaching fraction should exceed leaching requirement
- Only recognized and tested method for salinity control

Surface drip irrigation

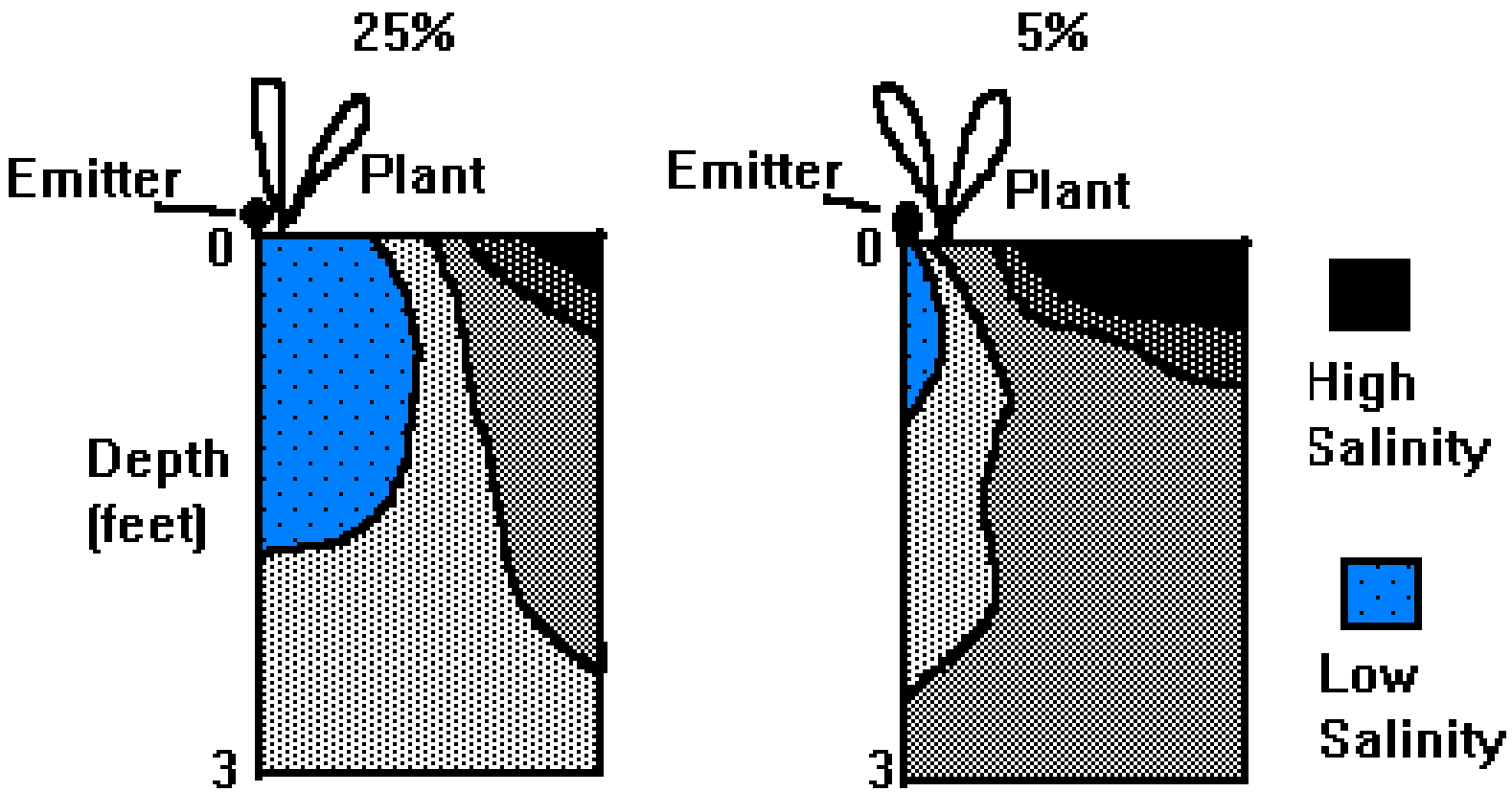
Soil Salinity
(ECe in dS/m)



No leaching under drip irrigation

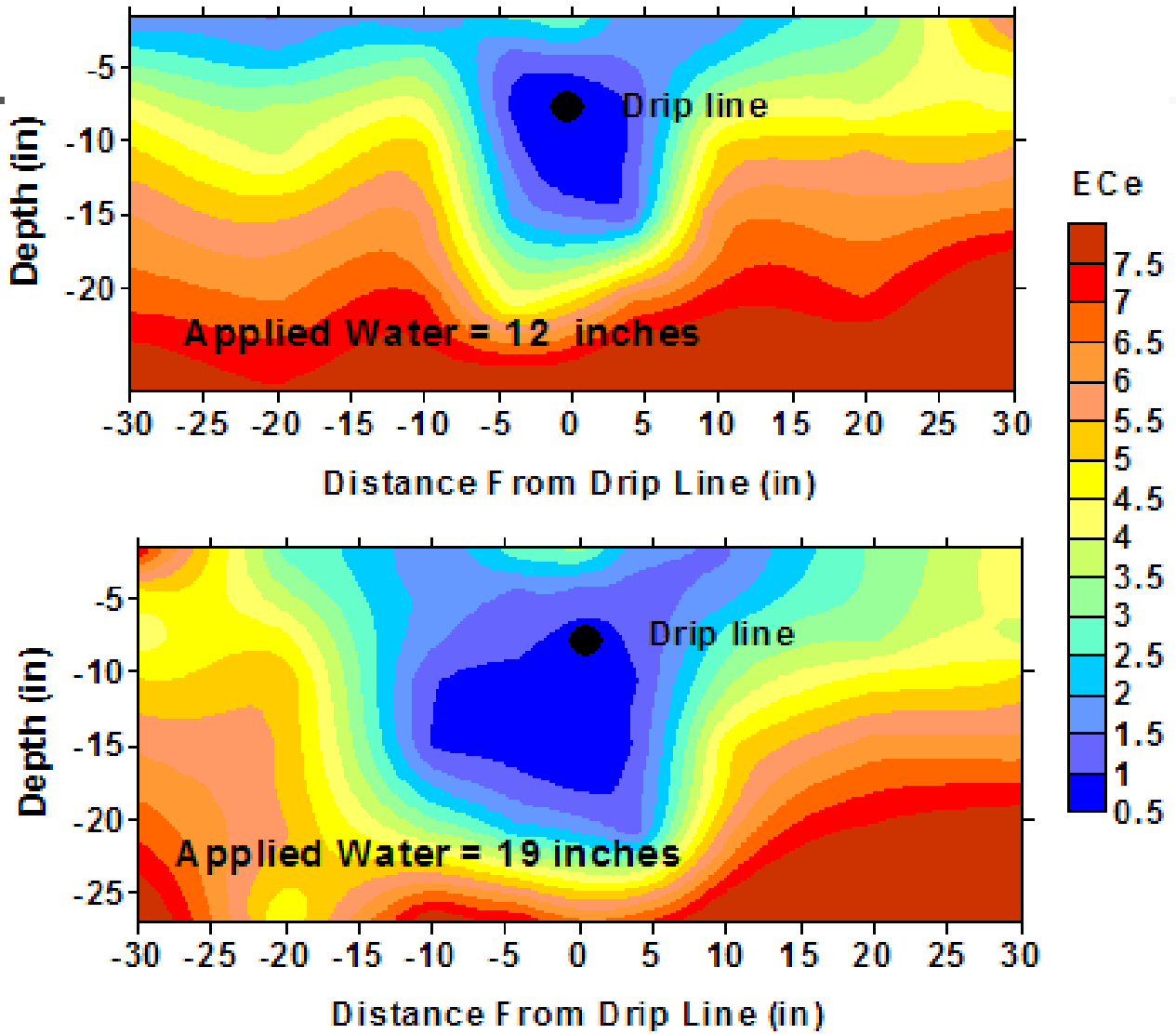
Leaching under drip irrigation

Effect of leaching fraction on volume of relatively low-salt soil



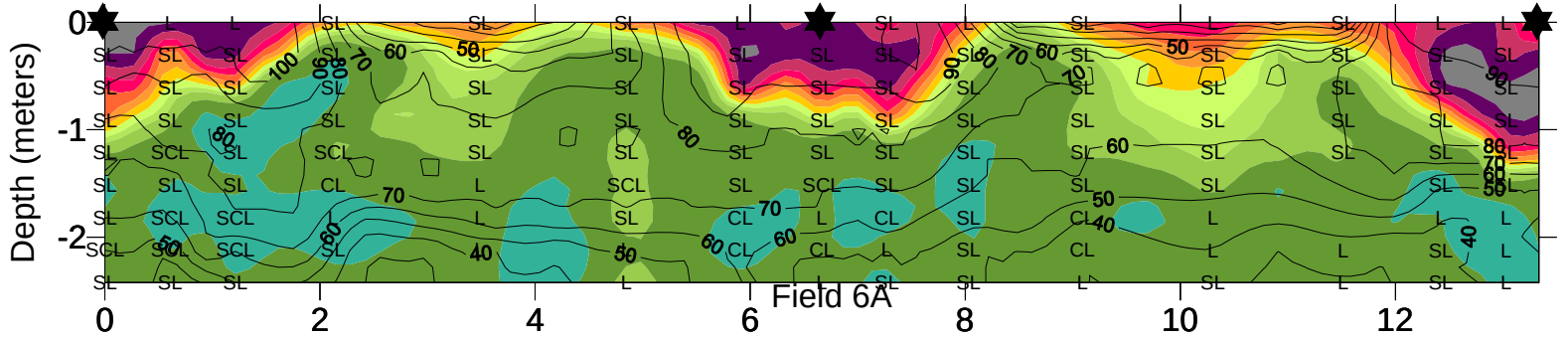
Note: as the leaching fraction increases, the amount of relatively low-salt soil increases.

Effect of amount of applied water of volume of low salt soil under subsurface drip irrigation (saline, shallow ground water)

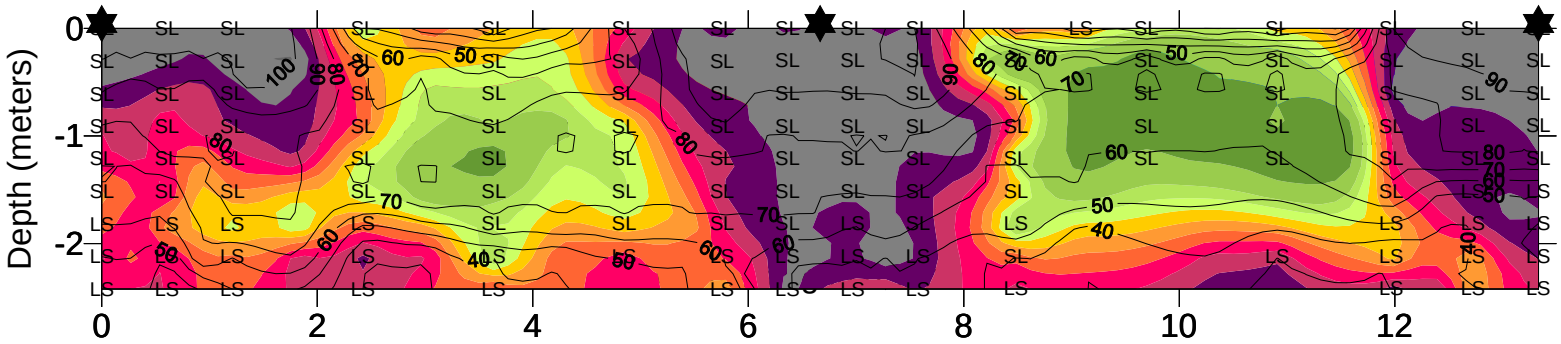


ITRC - Cal Poly

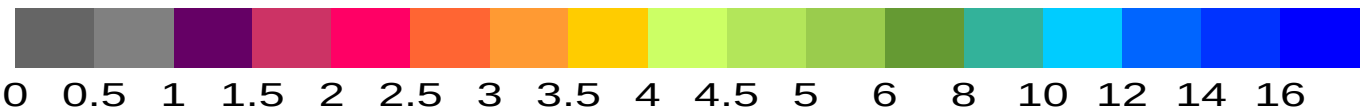
Field 6B



Field 6A



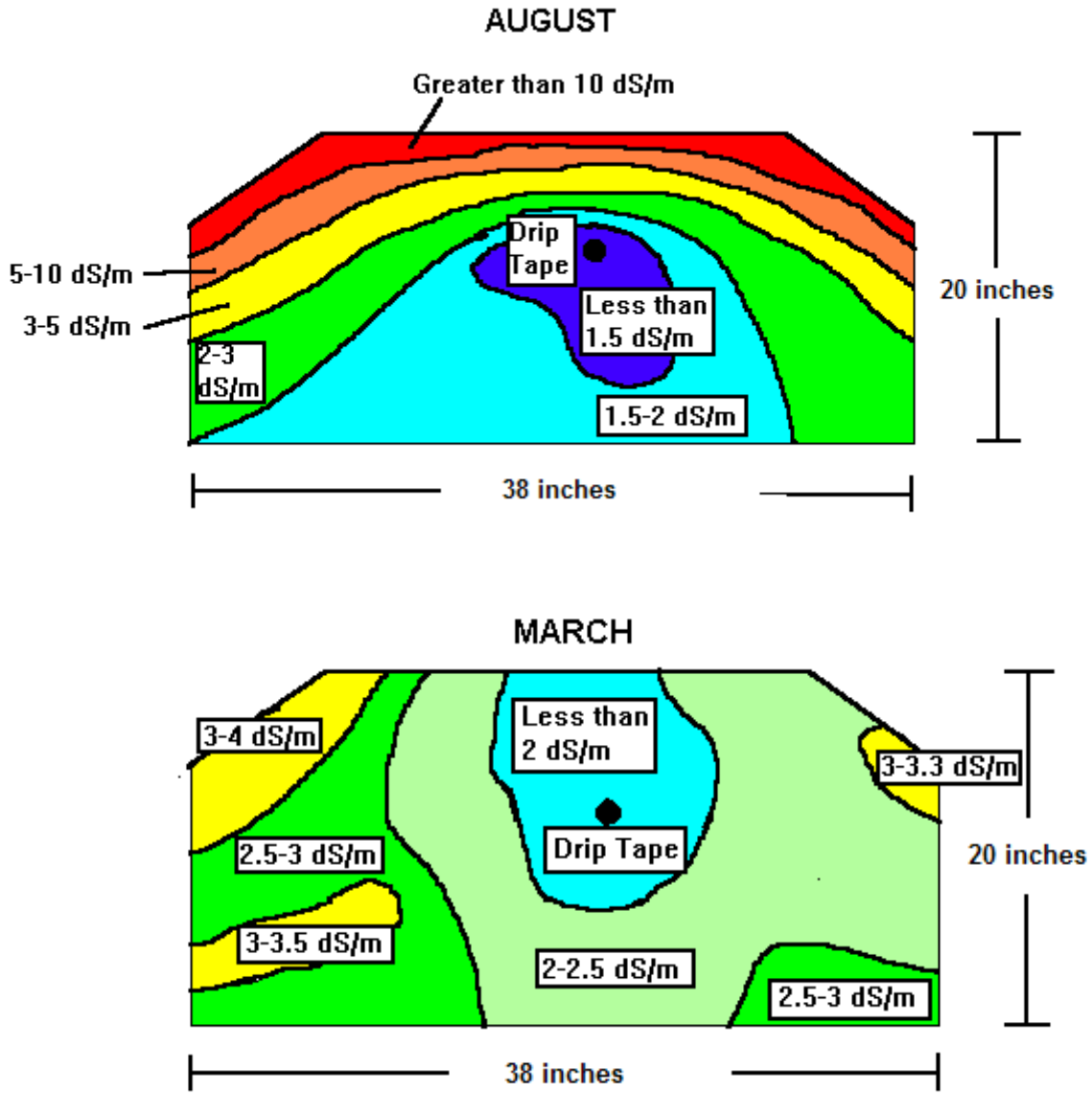
Numbered contour intervals show % field capacity



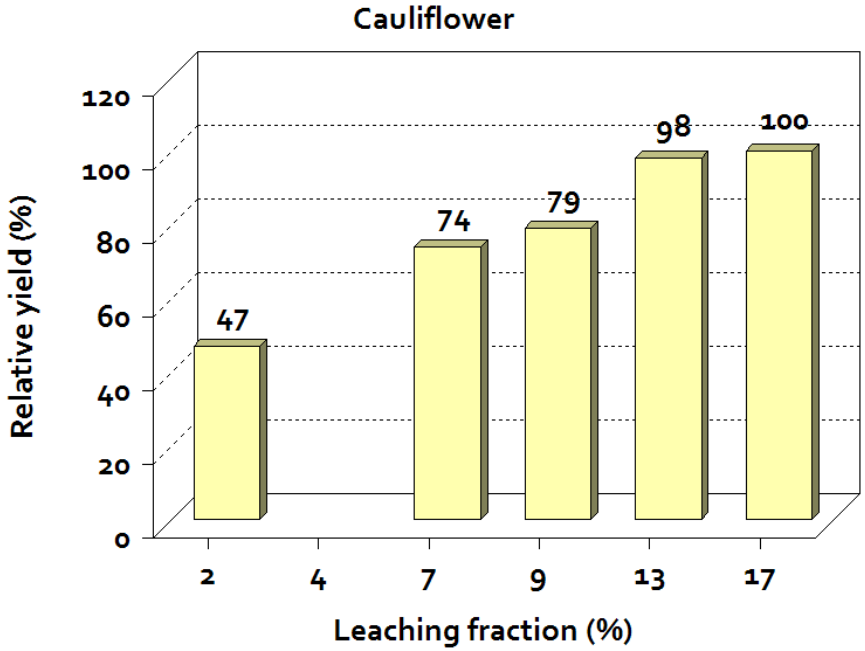
ECe reading in dS/m

Numbered contour intervals show % field capacity

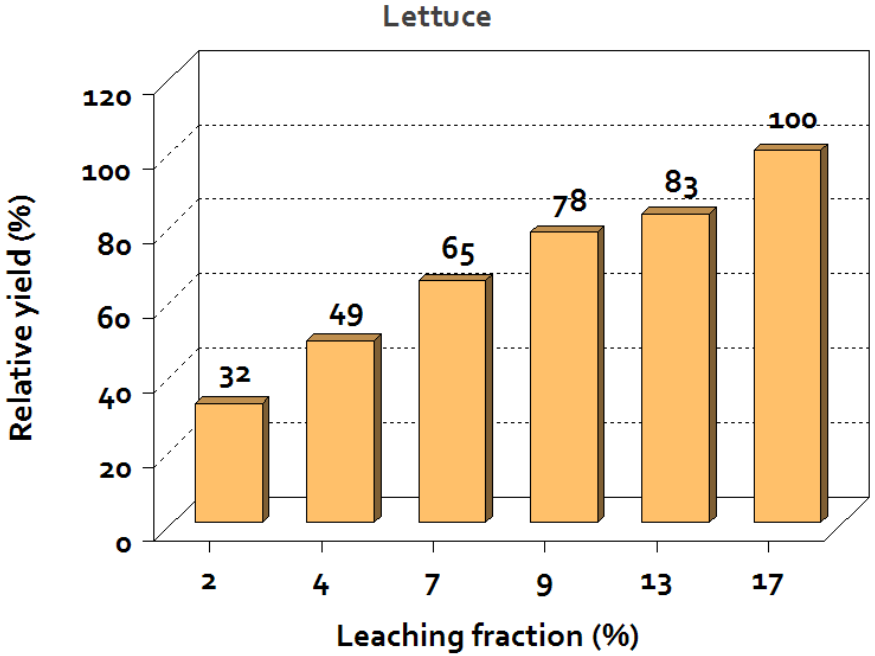
Leaching with pre-plant sprinkle irrigation or rainfall - subsurface drip irrigation

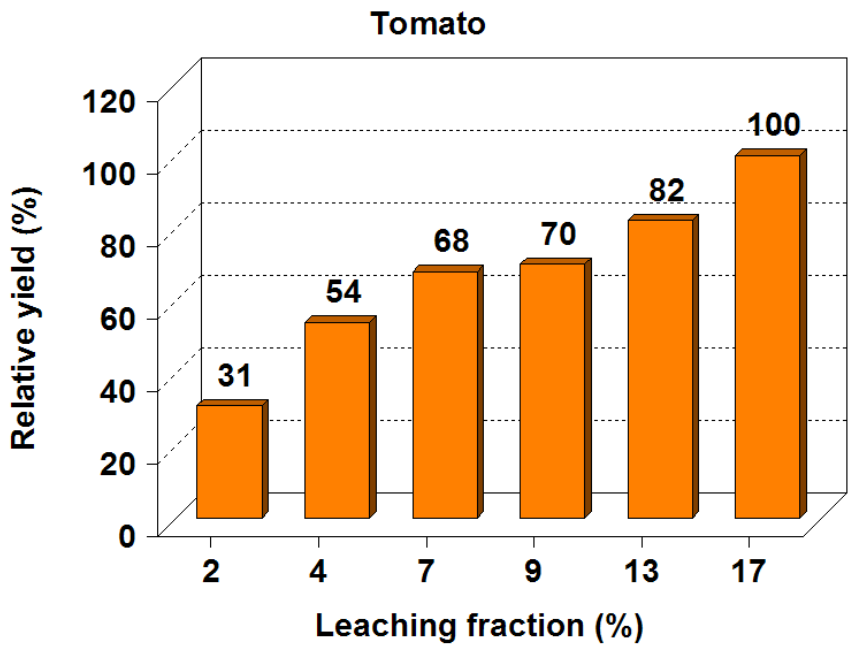


Effect of leaching fraction on yield

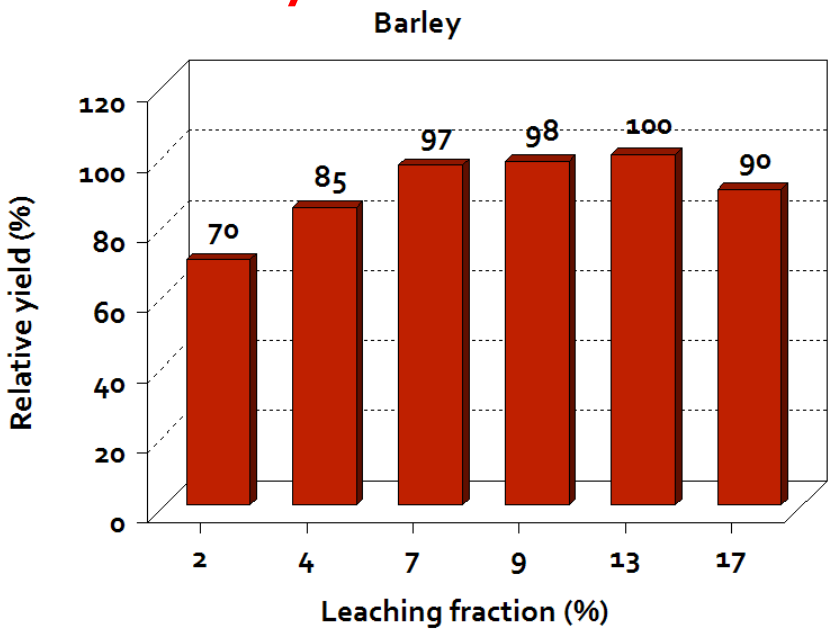


ECi = 2.1 dS/m



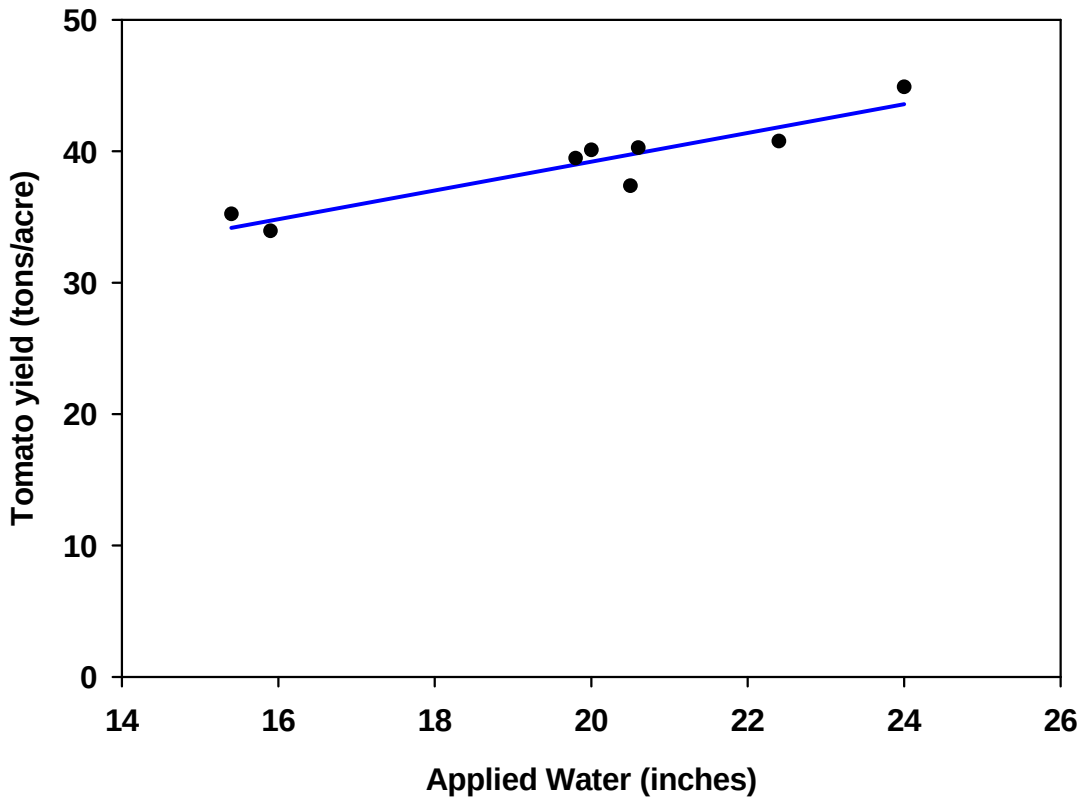


ECi = 2.1 dS/m



ECi = 2.1 dS/m

Effect of applied water on tomato yield under saline conditions



Factors affecting increasing yield with increasing leaching fraction

- Larger amounts of applied water increase leaching fractions
- Larger leaching fractions increase the volume of low salt soil near drip lines
- Larger leaching fractions decrease the soil salinity of the low salt soil
- Larger leaching fractions increase the soil moisture near drip lines

Leaching under drip irrigation

- Highly leached soil occurs near drip lines – relatively large leaching fraction
  - Soil salinity near drip lines reflects the salinity of the irrigation water
  - High levels of soil salinity occur near the edge of the wetted pattern
- Leaching fraction decreases with horizontal distance from drip lines
- Volume of highly leached near drip lines increases with increased applied water
- No leaching occurs above buried drip lines (leaching fraction = 0)
  - Salinity control may require sprinkle irrigation before planting
- Drip lines coincide with plant rows – highly leached root zone
- Drip lines offset from plant rows – little leaching may occur in root zone
- Some amount of leaching cannot be avoided because of the wetting pattern around drip lines unless severe deficit irrigation occurs
- Sufficient water must be applied for leaching (at least an amount equal to the crop water use)

Estimating leaching fractions under drip irrigation

- No satisfactory method exists
- Assumptions used in some methods do not fit field situations

Water balance approach

- Measurements
  - Amount of applied water (AW)
  - Crop evapotranspiration (ET) – CIMIS, other
- Leaching fraction = 100 x (AW – ET) ÷ AW
- Assumes no surface runoff
- May underestimate leaching fractions under drip irrigation
- Field studies results
  - Water balance approach indicated no leaching
  - Soil salinity around drip lines indicated considerable leaching (leaching fraction = 25%)

Soil salinity data

- Measure root zone (ECe)
- Measure irrigation water EC
- Use leaching charts to determine leaching fraction
- Assumptions
  - Root distribution
  - Steady-state leaching
- Assumptions used for leaching charts may not be appropriate for drip irrigation

Is the leaching fraction sufficient?

Measure soil salinity

- Sample soil in the root zone (near drip lines) and measure the ECe
- Compare root zone soil salinity with threshold values for a specific crop
- Monitor soil salinity over time

Agricultural Salinity and Drainage

by

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