Managing Salinity in Vegetable Production

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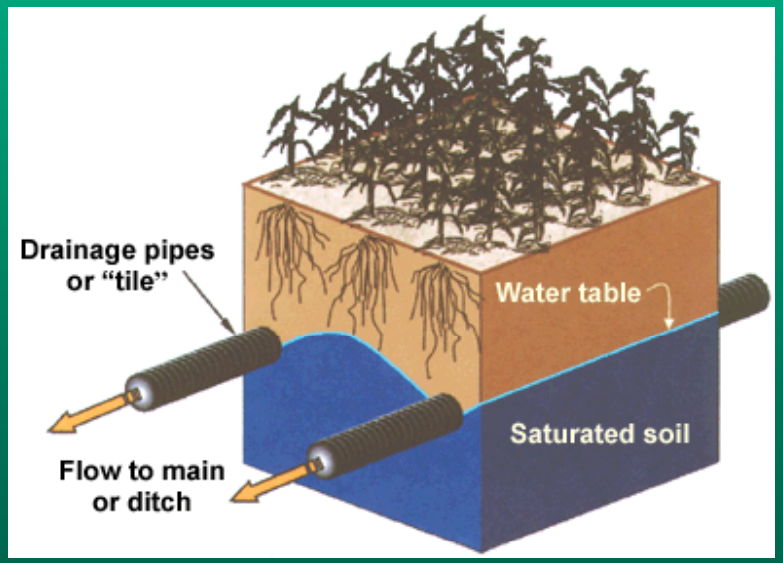
All water contains dissolved mineral salts

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

Main Sources of Salt

- Mineralization of soils (small contribution)
- Shallow saline water table
- Irrigation Water
- Fertilizers
- Manures and composts
  - Poultry manure

Non-conventional waters for irrigation



Common salinizing Constituents

- Sodium (Na^{+})
- Calcium (Ca^{2+})
- Magnesium (umMg^{2+})
- Chloride (Cl^{-})
- Sulfate (SO_4^{2-})
- Bicarbonate (HCO_3^{-})

Cations

Anions

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

Salinity vs Sodicity

- Salinity is a condition where the salt concentration reduces yields or quality (Electrical conductivity, EC)

- Sodicity is a condition where the cations are dominated by sodium (Na+); affects soil structure and water infiltration; affects plant health (sodium induced calcium deficiency; poor aeration) (Sodium Adsorption Ratio, SAR; Exchangeable Sodium Percentage (ESP).

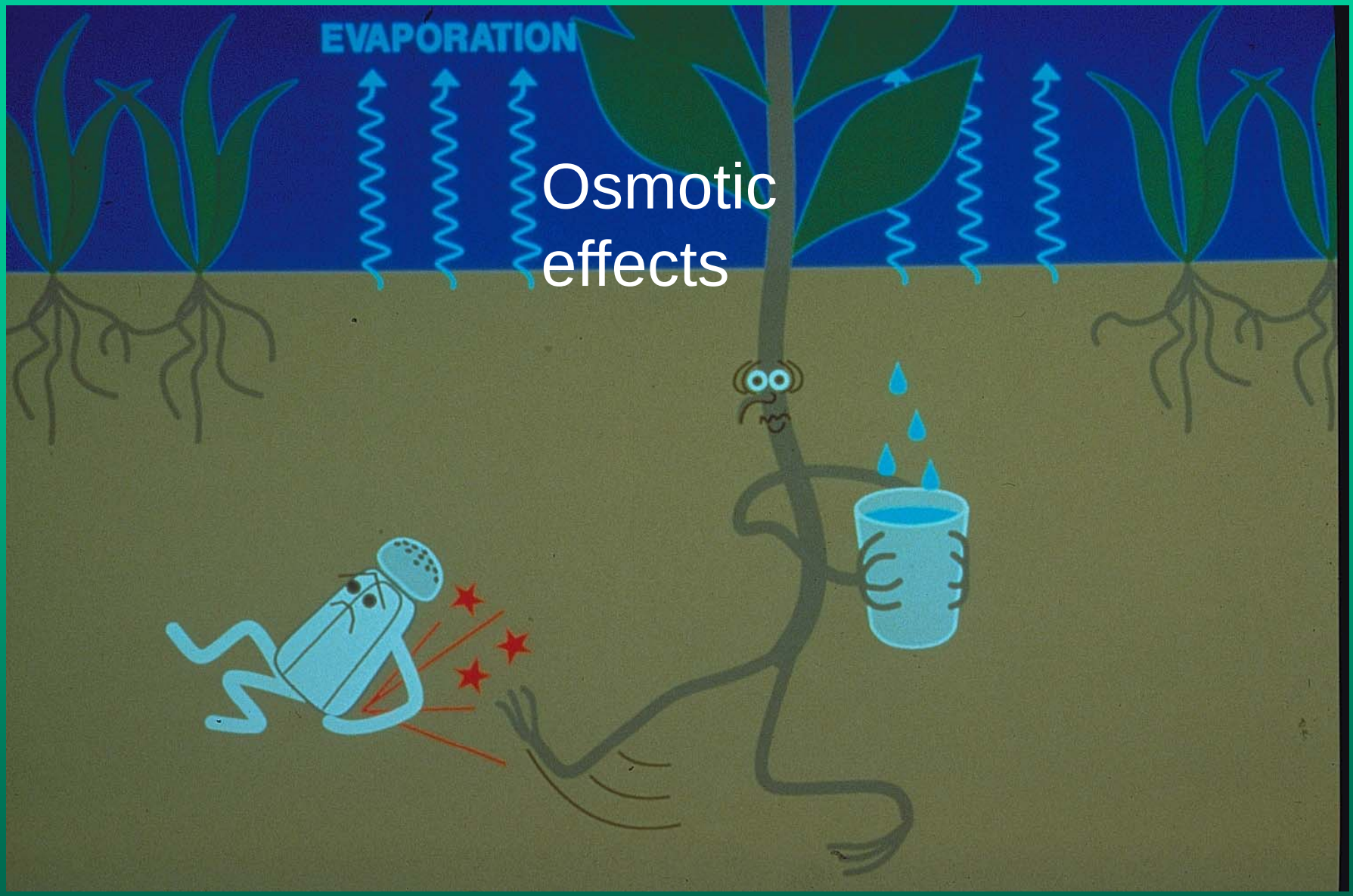
Soft water vs Hard Water

- Soft water:
  - Sodic water (High SAR)
- Hard water:
  - Non-sodic water (Low SAR)

Hard water makes soft soils;
Soft water makes hard soils

Salt affects plant growth and performance several ways:

- Osmotic effects
- Specific ion effects
  - Ion toxicities
  - Nutritional disorders



Agricultural Crops

Increasing Salinity (EC, dS/m) →

Osmotic Effects

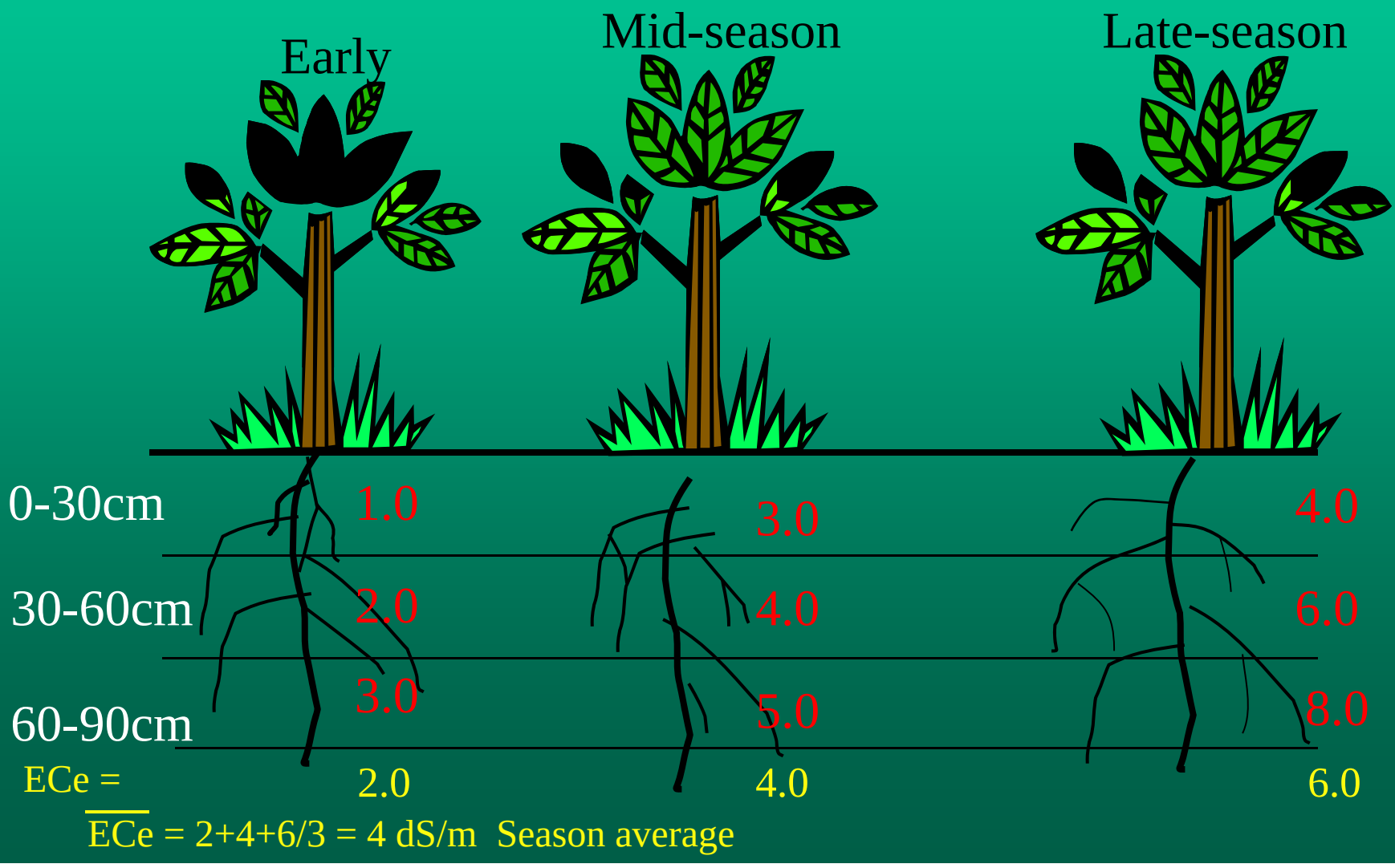
Osmotic effects: Stunting of plant growth

What are the different types of EC?

- ECw = Electrical Conductivity of the Irrigation Water

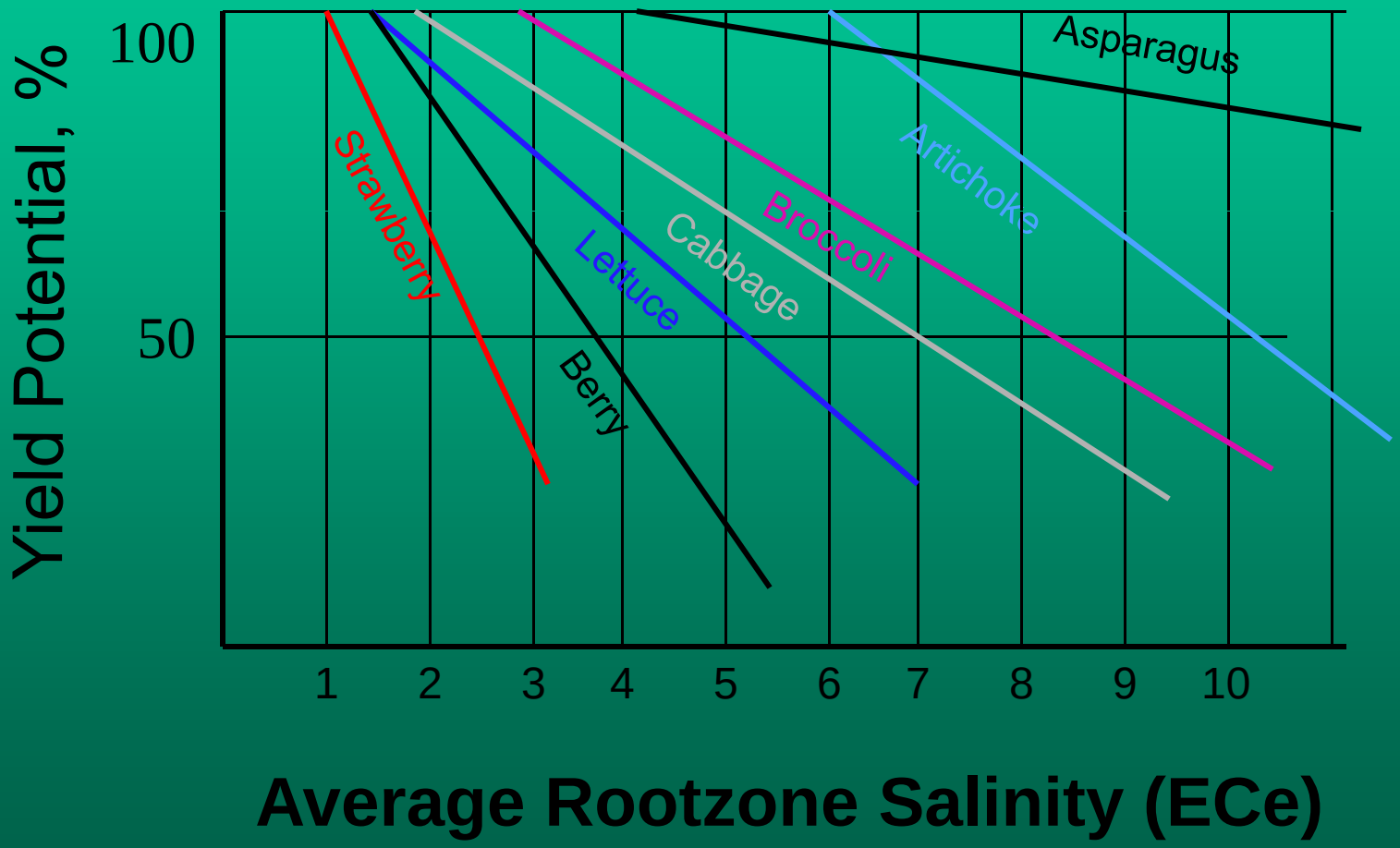
- ECe = Electrical Conductivity of the Saturated Soil Extract

Seasonal Average Rootzone Salinity (ECe)



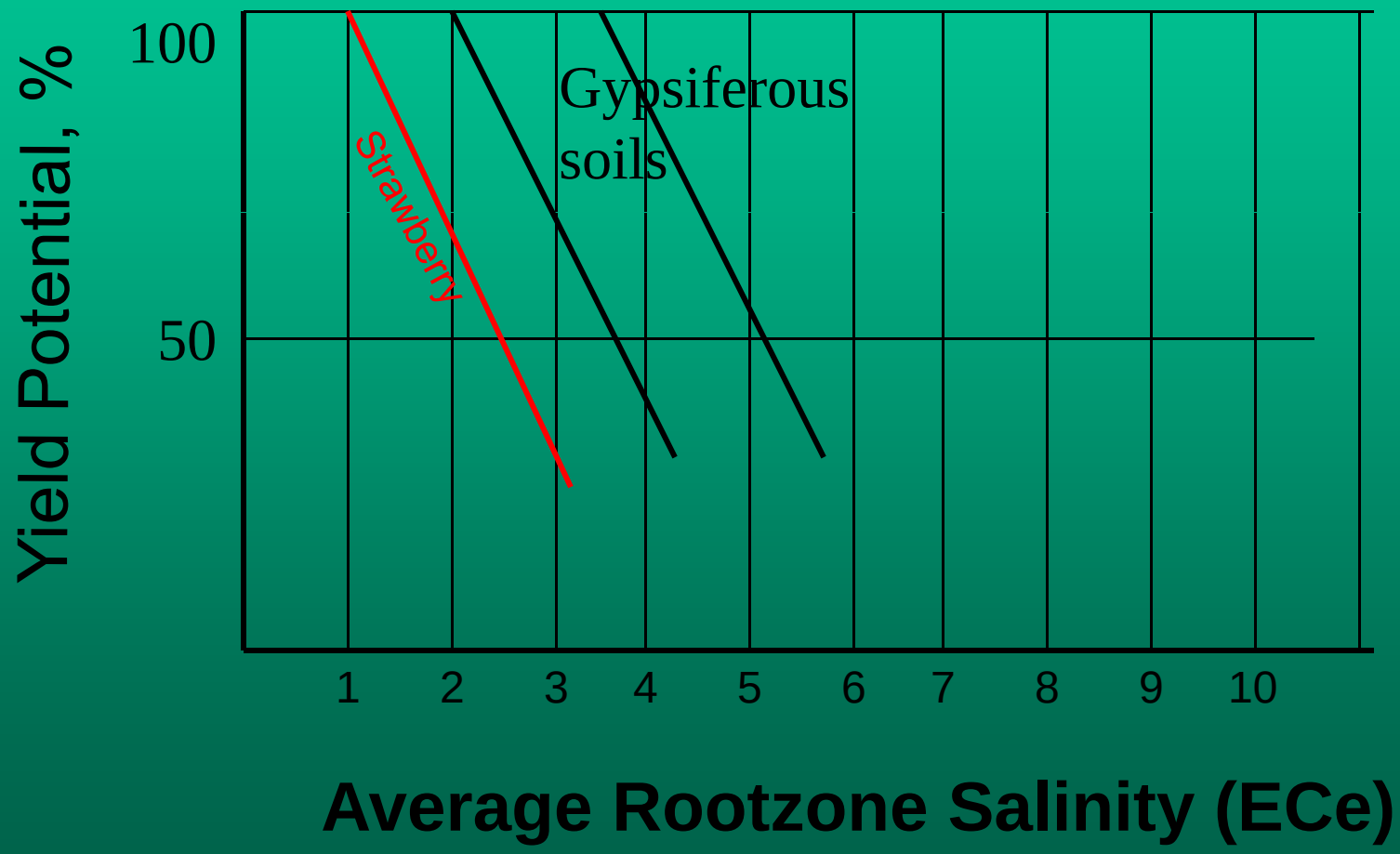
$\overline{ECe}$ = 2+4+6/3 = 4 dS/m Season average

Crop salt tolerance



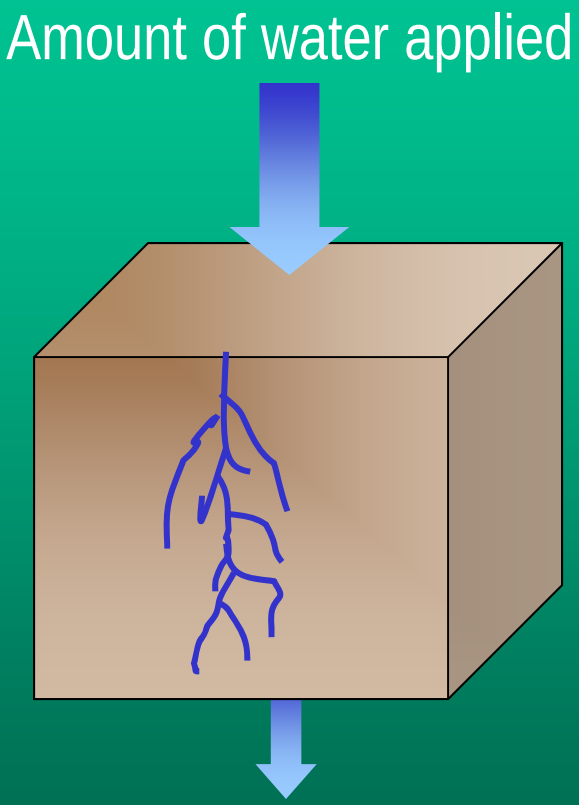
Strawberry salt tolerance

(soil water dominated by gypsum)

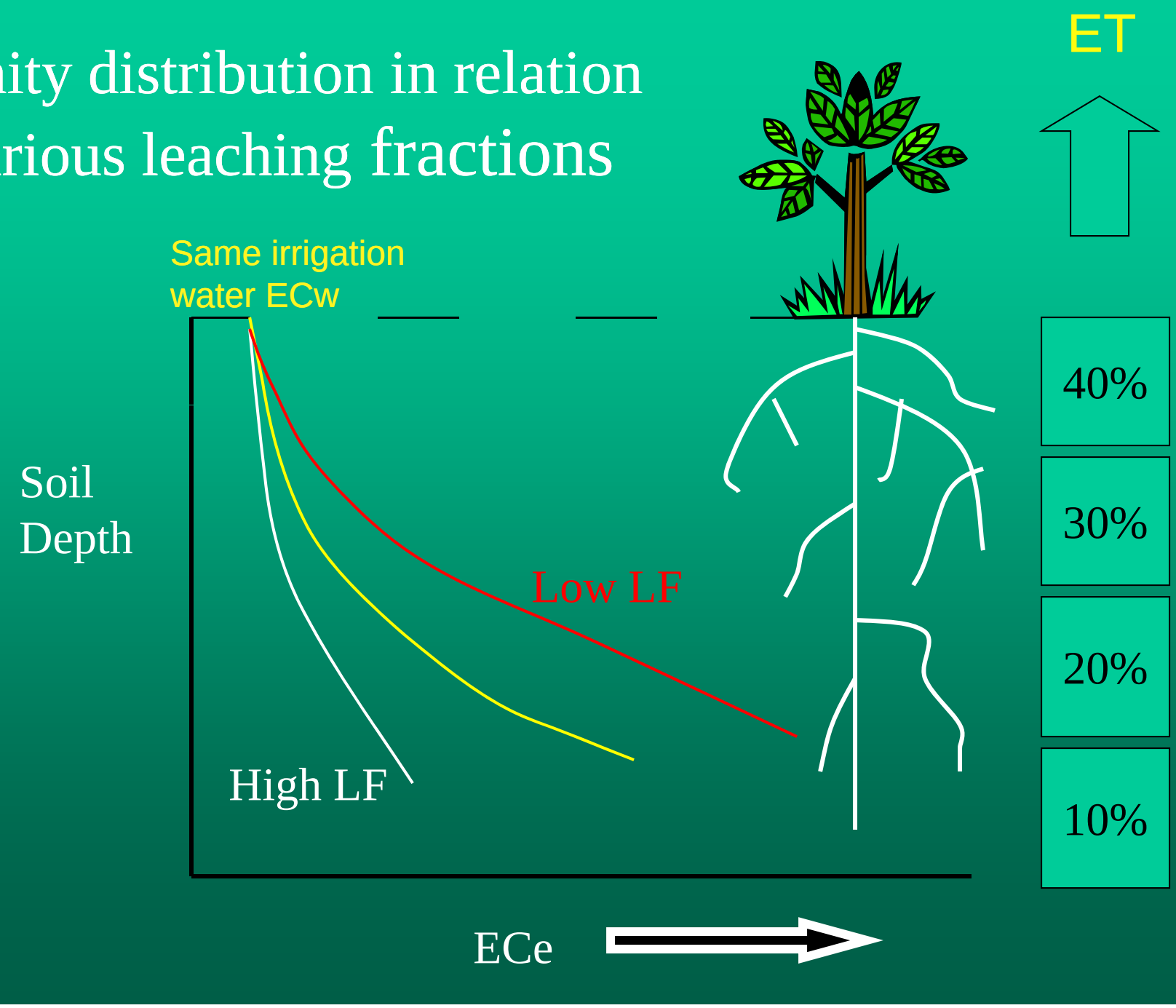


Leaching Fraction (LF)

LF = volume of water that drains below the rootzone / volume of water that infiltrates the ground



Salinity distribution in relation to various leaching fractions



Therefore the same average rootzone ECe can result with different ECw's and different LFs.

ET

ECw = 0.7

ECw = 1.2

Soil Depth

Low LF

High LF

40%

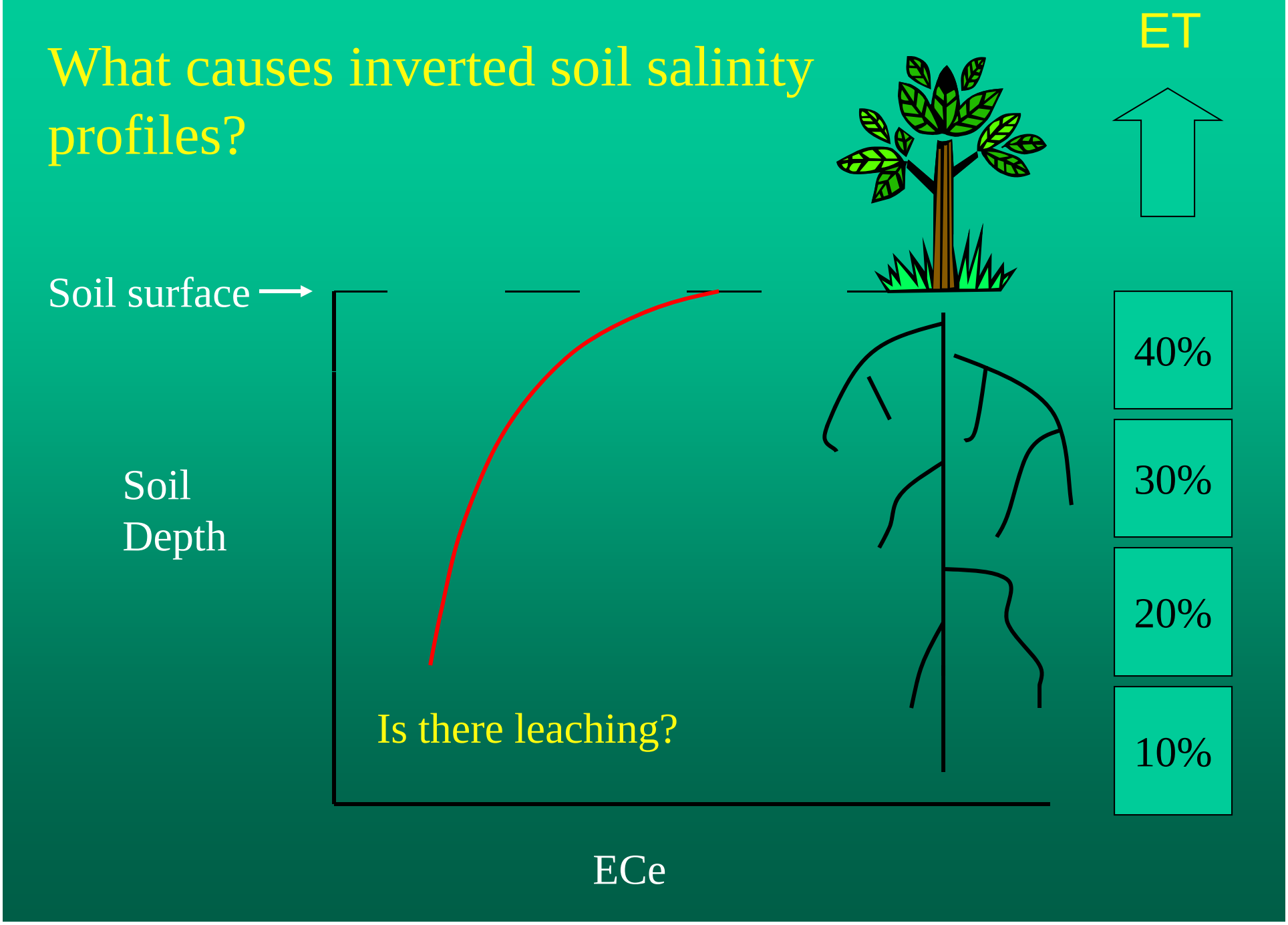
30%

20%

10%

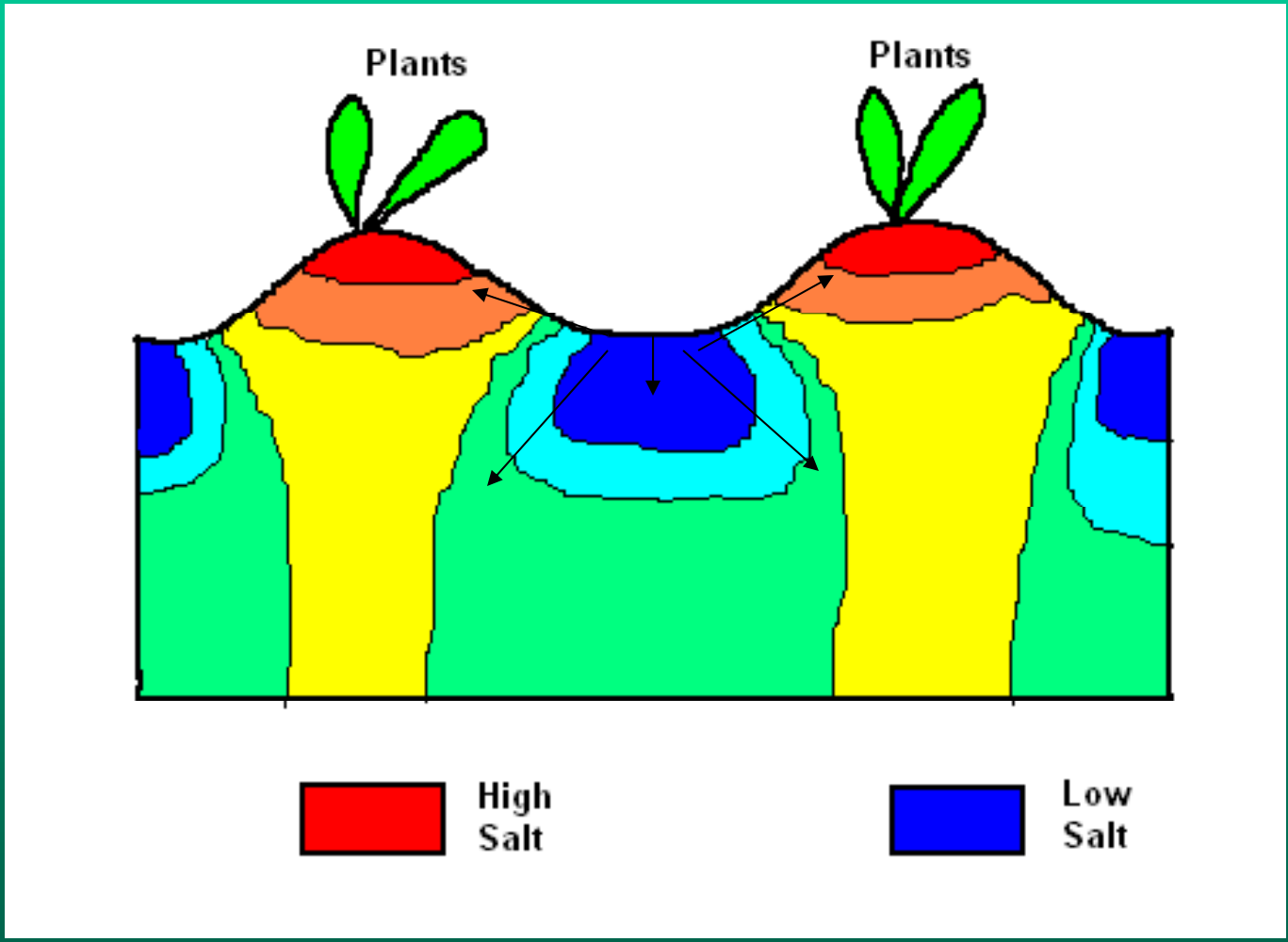
ECe

What causes inverted soil salinity profiles?



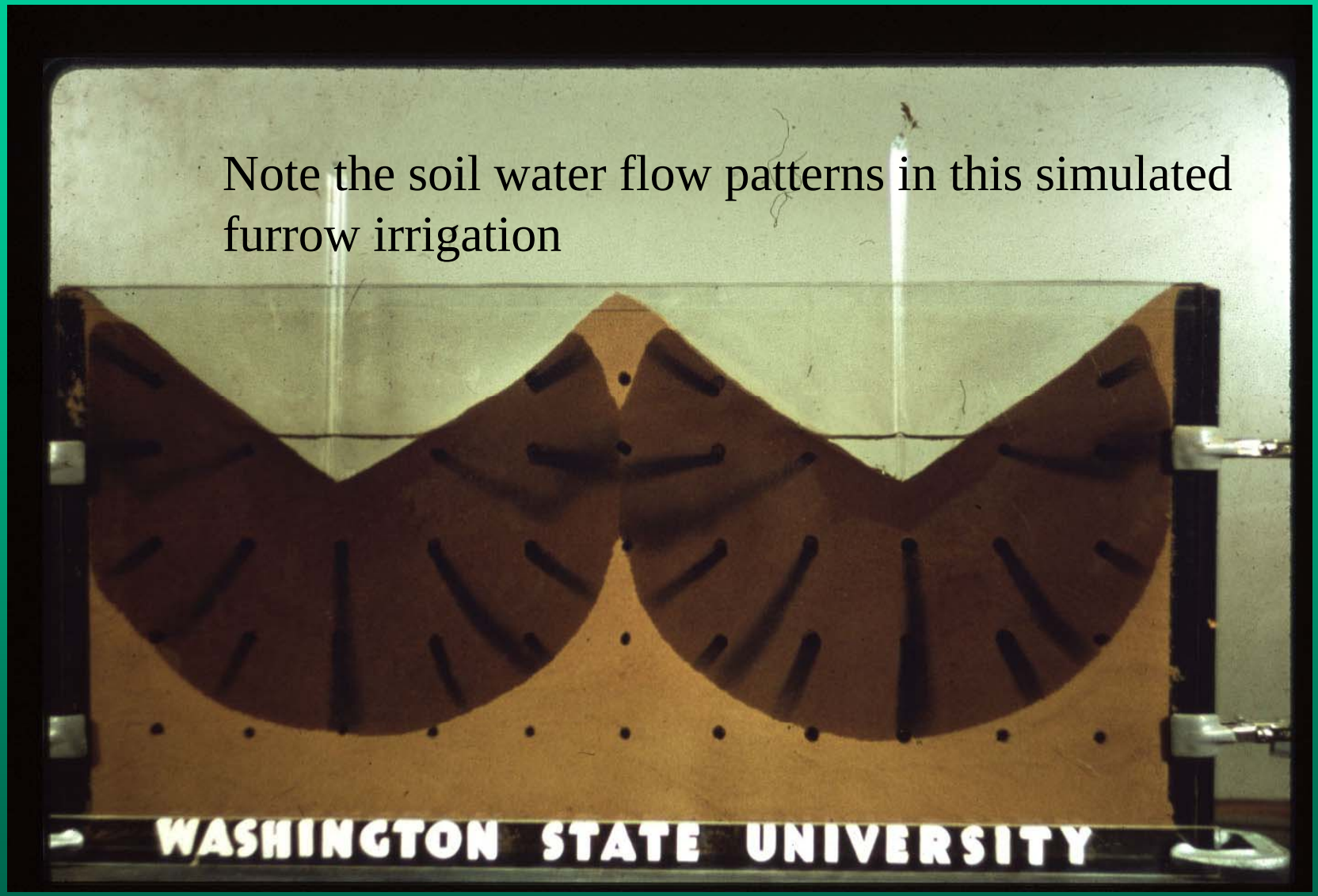
Salt distribution under drip irrigation

Furrow irrigation

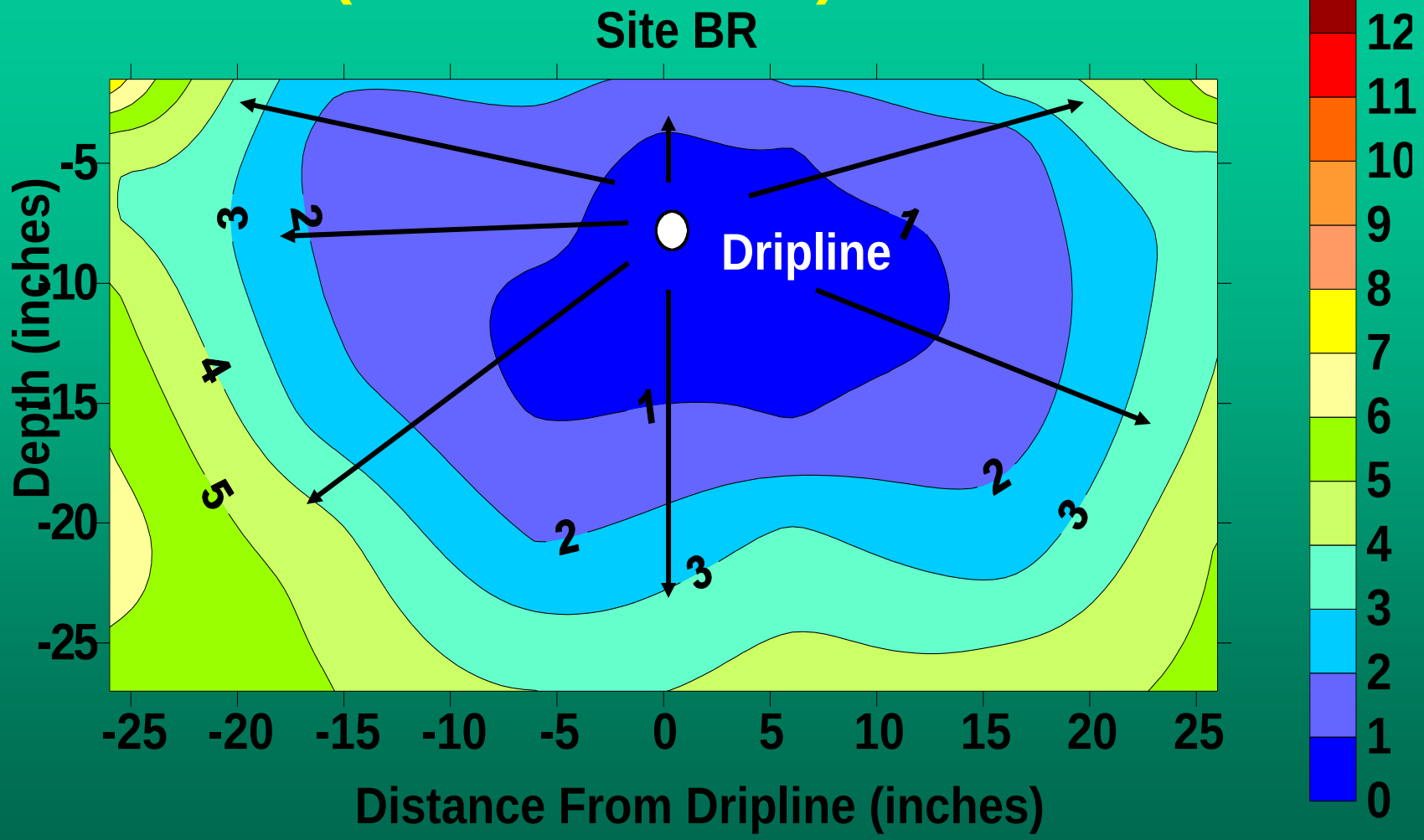


B. Hanson, 2005

Note the soil water flow patterns in this simulated furrow irrigation



Salt pattern under drip irrigation (ECw = 0.3 dS/m)

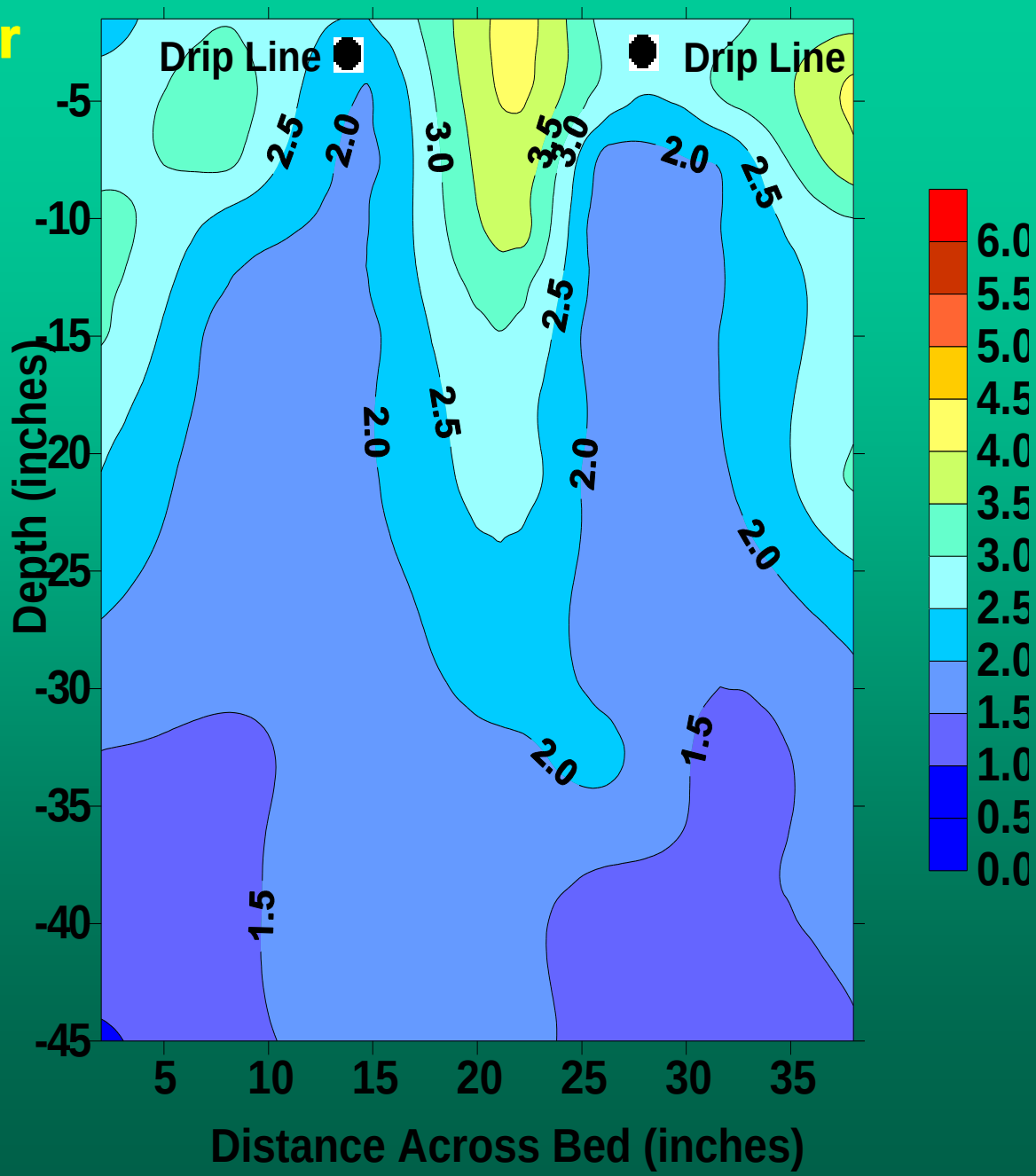


Hanson, 2005

Note: soil salinity is the least near the drip line, an area where the leaching is the greatest. Salt accumulates near the outer part of the wetted pattern.

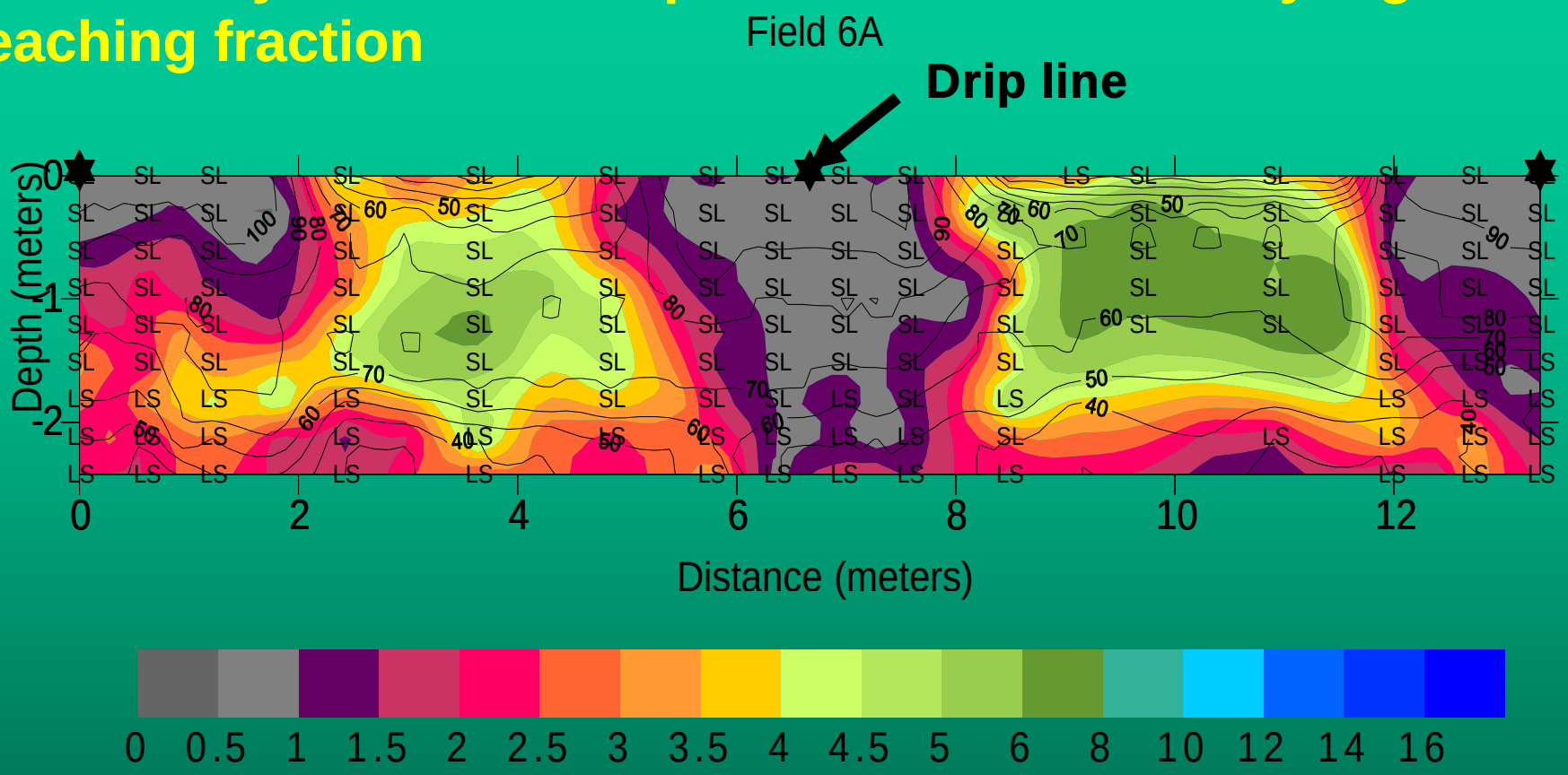
Soil salinity under drip irrigation

Note: soil salinity is lowest under the drip lines and increases as the horizontal distance from the drip lines increases. This behavior indicates that the leaching fraction is the greatest directly below the drip lines. The leaching fraction decreases with horizontal distance from the drip line. Midway between the drip lines, the leaching fraction is zero.

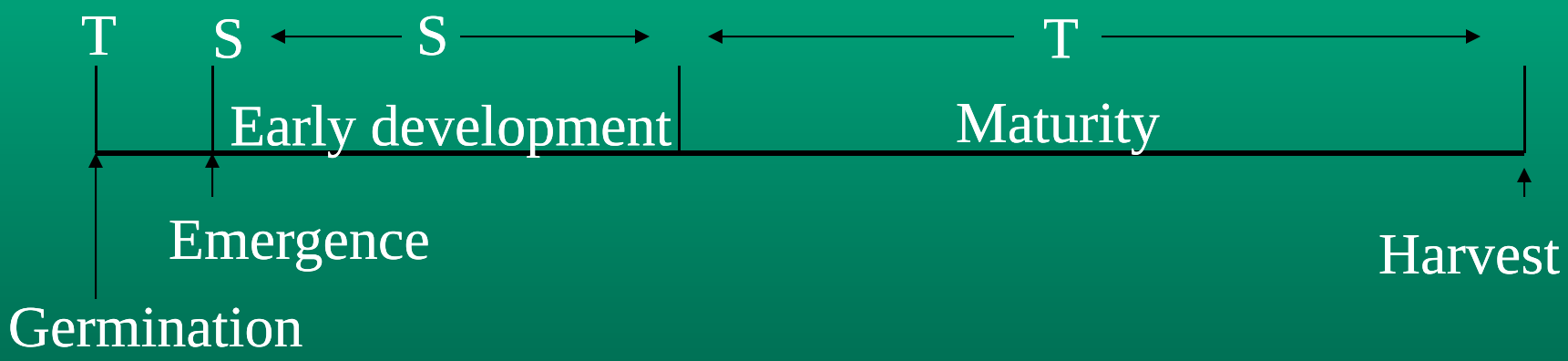


Hanson et al, 2005

Soil salinity under microsprinklers for a relatively high leaching fraction



Crop Sensitivity to Salinity in Relation to Stage of Growth

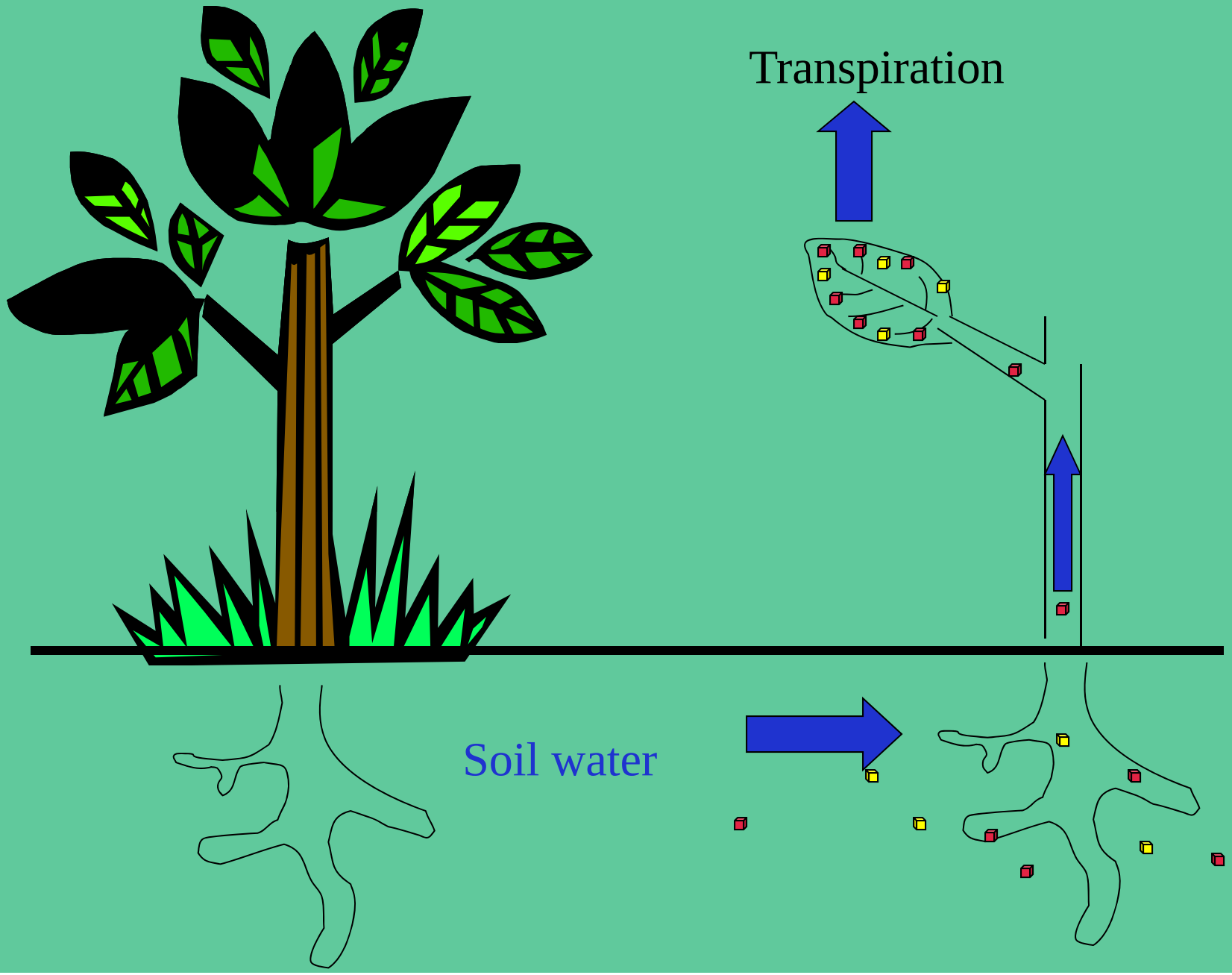


After Maas and Grattan, 1999

Ion toxicity

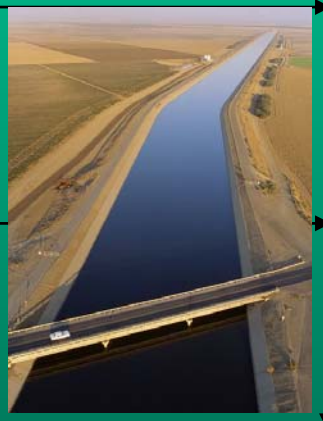
Chloride, sodium and boron

Soidum and Chloride Accumulation



Chloride tolerance of various *Strawberry**

Variety	Chloride in soil extract (mg/L)	Chloride in irrigation water(mg/l)
Lassen	265	180
Shasta	175	120



* Assumes a 15-20 % Leaching Fraction

Amendments

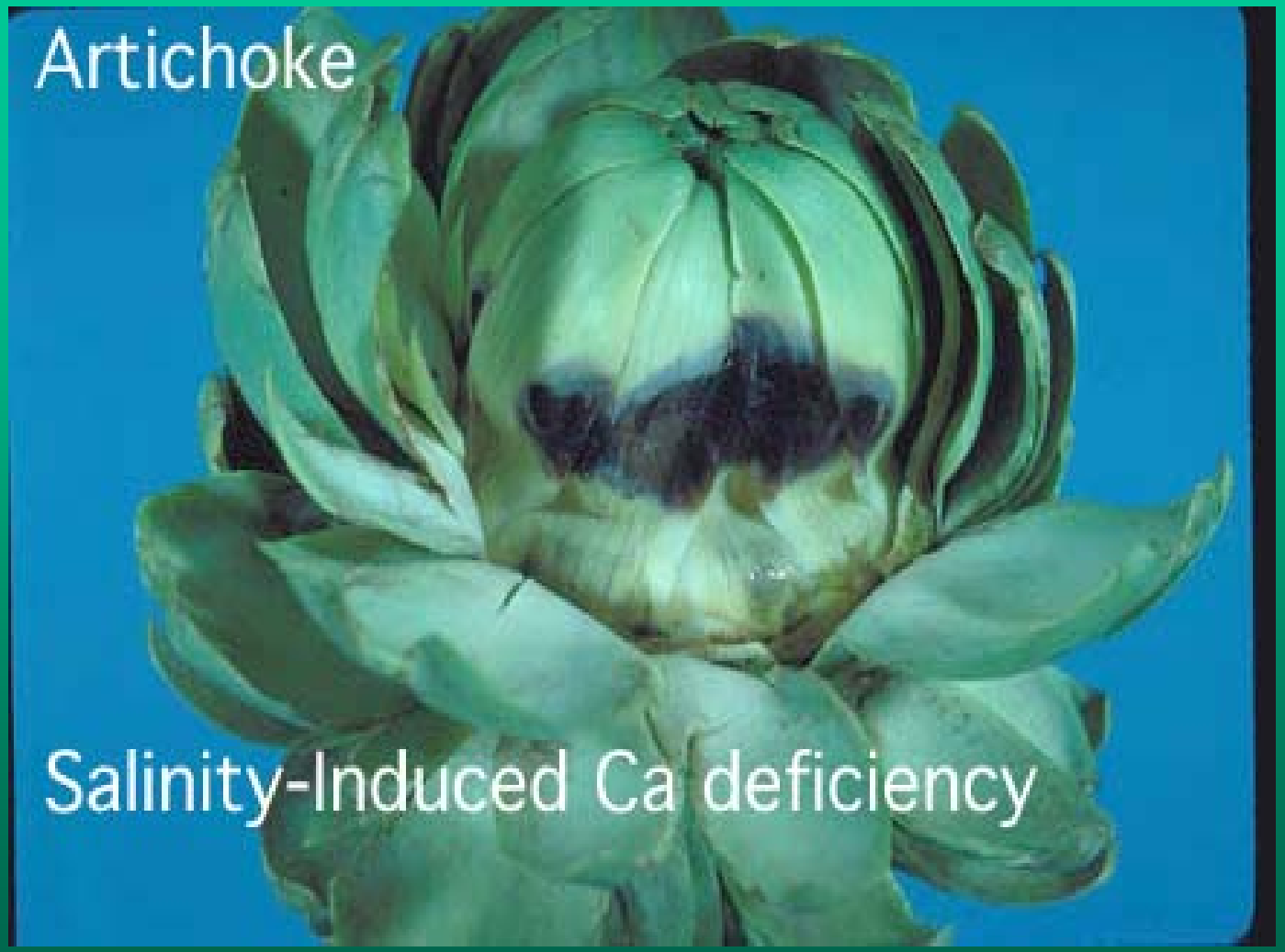
- Gypsum ($CaSO_4$)
- Sulfuric Acid (H_2SO_4)

Do they reduce salinity damage?

Importance of adequate Calcium (Ca) nutrition

- Early scientists were not fully aware of the need for adequate Ca supplies to reduce Na's toxic effect
- Ca stabilizes root membranes and makes them more selective for ion transport
- Na sensitivity to crops is more likely related to the Na/Ca ratio than the Na concentration
- Na is generally not a problem if the Sodium Adsorption Ratio (SAR) is < 3

Salinity induced nutritional disorders



Salinity mangement

- Species vary in salt tolerance
- Asparagus>Artichoke>Broccoli>Cabbage >Lettuce>Berries
- Strawberries are sensitive to Cl but depends on variety
- Soils with an ECe > 1 dS/m will reduce strawberry yield potentials
- In gypsiferous soils, plants can tolerate about 1 to 3 dS/m more

Salinity Management

- Make sure to take samples of water, soil and leaf tissue at several times during season.
- Amendments to free calcium (Ca^{2+}) are effective when free calcium is limiting.
- Leaching in drip irrigation occurs under the drip line, but salts accumulate between drip lines and between emitters where no leaching occurs.
- Leach profile in winter and when salinity increases to critical levels.