Understanding the Effects of Salinity on Pistachios

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Salinity:

- Amount of salts dissolved in water
- Concentration of salts in solution
  - Irrigation water
  - Soil water

Origin of Salinity in Soil and Water

- Chemical weathering of earth minerals
  - rocks and soils
  - sedimentary marine geological formations
- Dissolved over the millennia
- Transported by water
  - terminates in oceans or closed basins
  - concentrated by evaporation
  - percolates into ground

Specific Salts in Irrigation Water

- **<u>Cations = +</u>**
- Na^{+} = Sodium
- Ca^{2+} = Calcium
- Mg^{2+} = Magnesium
- K^{+} = Potassium

- **<u>Anions = -</u>**
- Cl^{-} = Chloride
- SO_4^{-} = Sulfate
- HCO_3^{-} = Bicarbonate
- CO_3^{2-} = Carbonate
  - » pH > 8

Boron = micronutrient

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Salinity Units of Concentration

- Weight Basis
- 1 ppm
- 1 mg/l
- 1 mg/kg
- 1% = 10,000 ppm

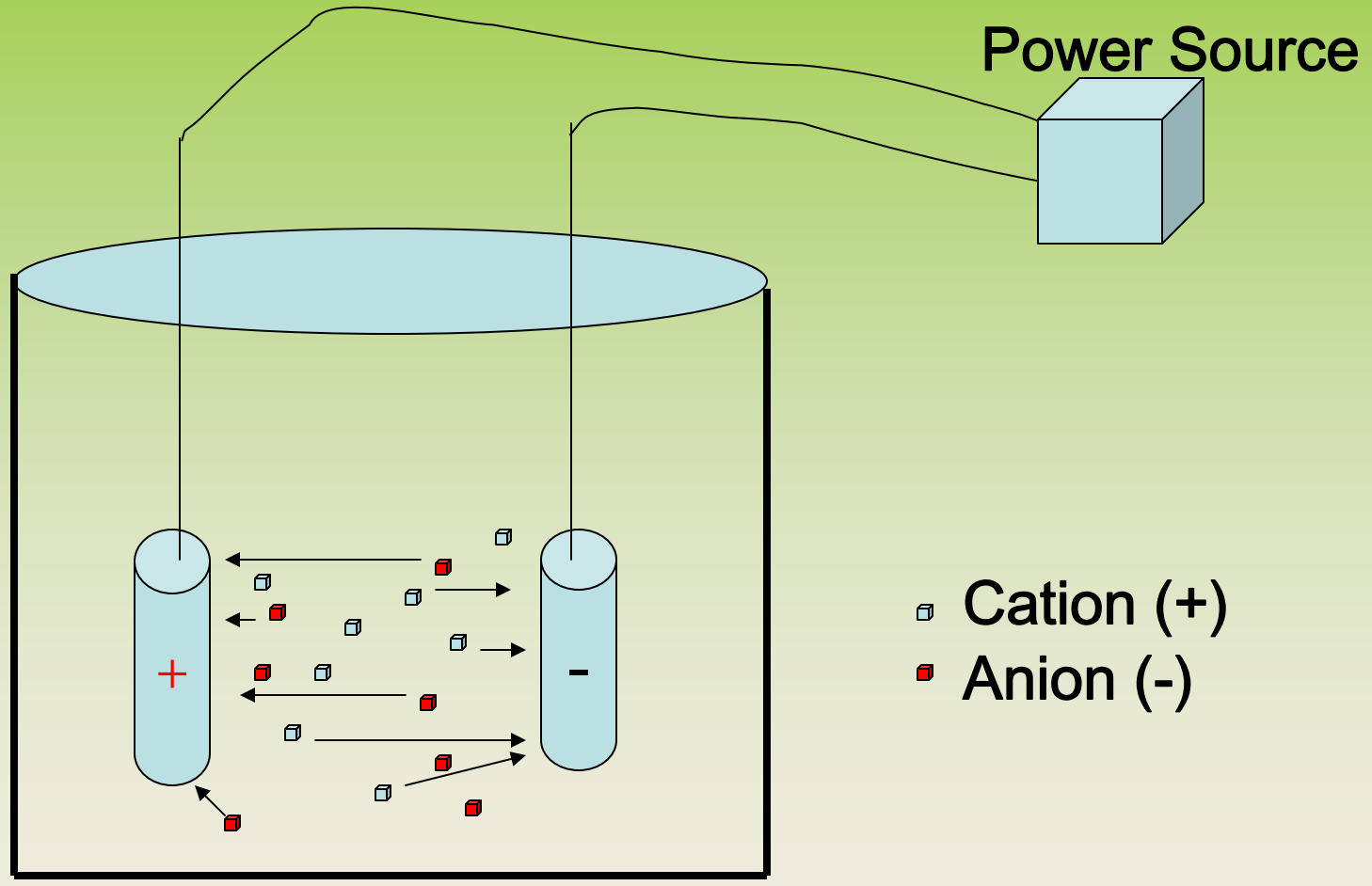
- Volume Basis
- mg/l
- meq/l
- $1 mmol_c$ /l = 1 meq/l
  - Systeme International d'Unites (SI)

Total dissolved solids (TDS) in irrigation and soil water

Measuring TDS

- Electrical conductivity (EC)
- Salts dissolve in water (+ or -)
- Charged electrode in water
  - Anions and cations migrate = electricity
- Water conducts electricity
- Electrical conductivity meter measures it

Electrical Conductivity



Units for Measuring TDS

- **ECw (water) or ECe (soil water extract)**
  - **mmhos/cm = dS/m**
  - **dS/m x (conversion factor) = TDS**
    - **Ion, concentration, temperature (25^{o}C)**
    - **Soil – distilled dilution water –> underestimate**


WTW
LF 318
25,6°C
ms/cm
µS/cm
AUS
OFF
Conductivity Meter

Soil and water salinity cause ……

- Salinization:
  - when the concentration of soluble salts in the root zone are high enough to impede optimum growth.

“Salinity in soil and water is irrevocably associated with irrigated agriculture throughout the world.”

James E. Ayars, 2003

Where is Salinization a Problem ?

- Arid and semi arid regions
- Evapotranspiration > precipitation
- Irrigation is necessary
- World: 12% irrigated land
- USA: 28% of irrigated land
  - sharply increased from 1950 - 2010

Where in California……

- Imperial and San Joaquin Valleys
  - Westside
    - Naturally saline soils
      - weathering of marine sediment coastal range origin
    - Lack of a subsurface drainage outlet
      - SJV Drainage program
    - Over irrigation
    - Drainage water
    - Saline irrigation water
    - Fertilization

How does salinity harm plants ?

- Salinization is progressive:
  - Irrigation, fertilization, possible soil saturation
- Osmotic effects
  - more common
- Specific ion toxicities
  - visible

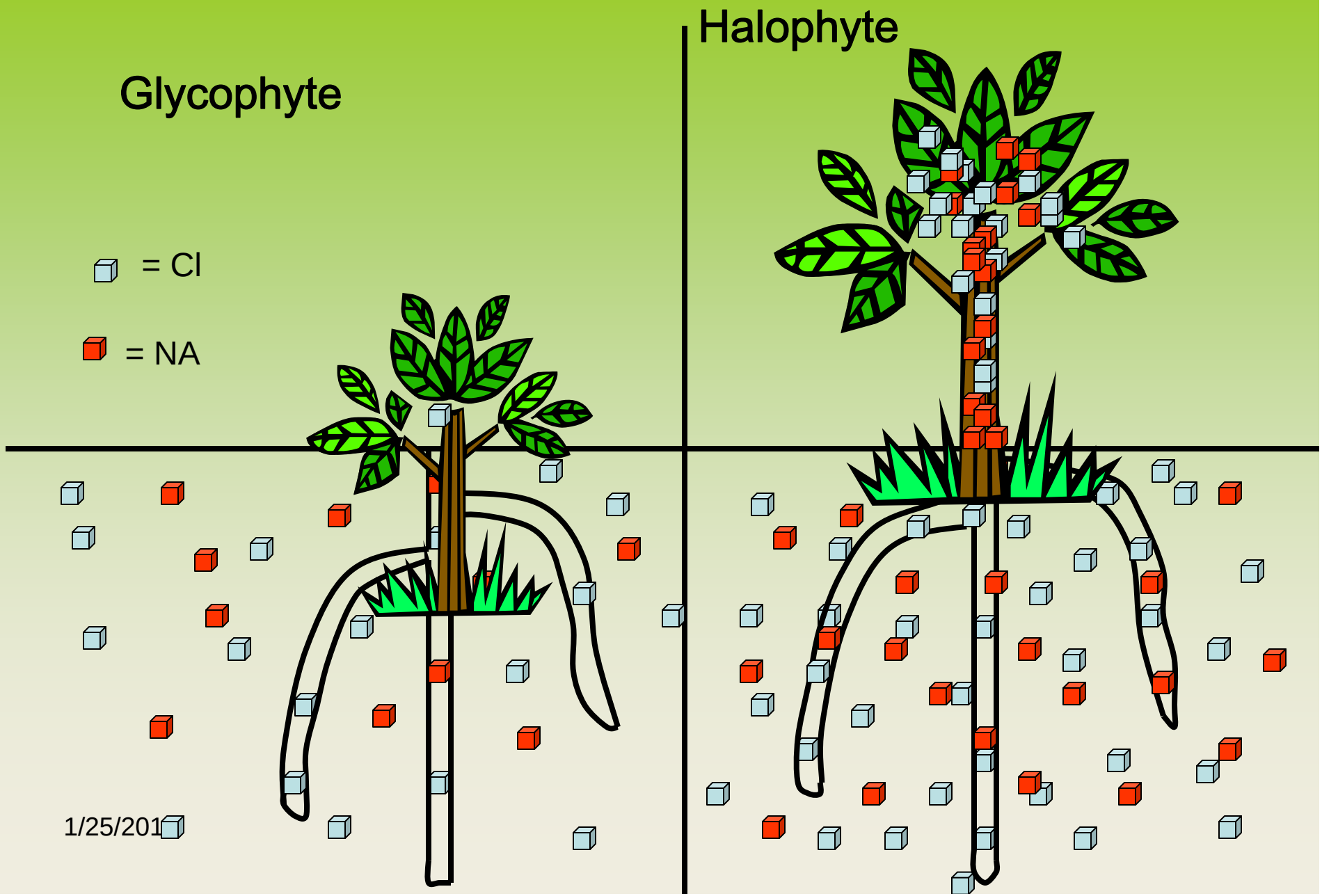
Osmotic Effects of Salinity

- [root cell solute] > soil water ECw
  - water moves freely into root
- As soil ECw increases > [root cell solute]
  - Roots must compete for water

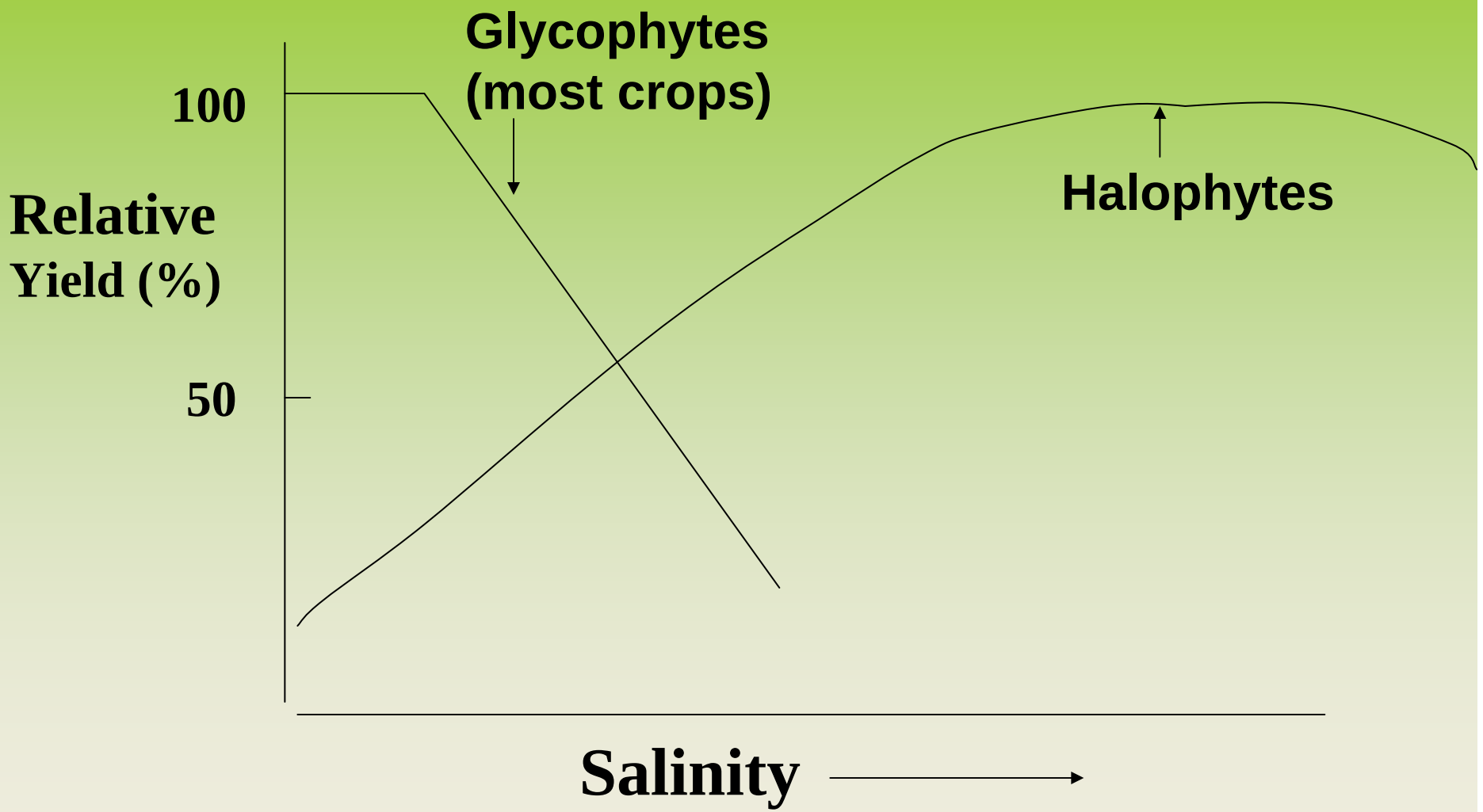
Osmotic Effects of Salinity

- To restore ability to extract soil water
  - plants adjust osmotically:
    - Glycophytes – “sweet” water loving plants
      - synthesize sugars, organic acids to adjust osmotically
      - Uses plants reserves
      - Less reserves available for growth, cropping
      - A smaller plant with less crop
    - Halophytes – salt loving plants
      - accumulate salts to adjust osmotically

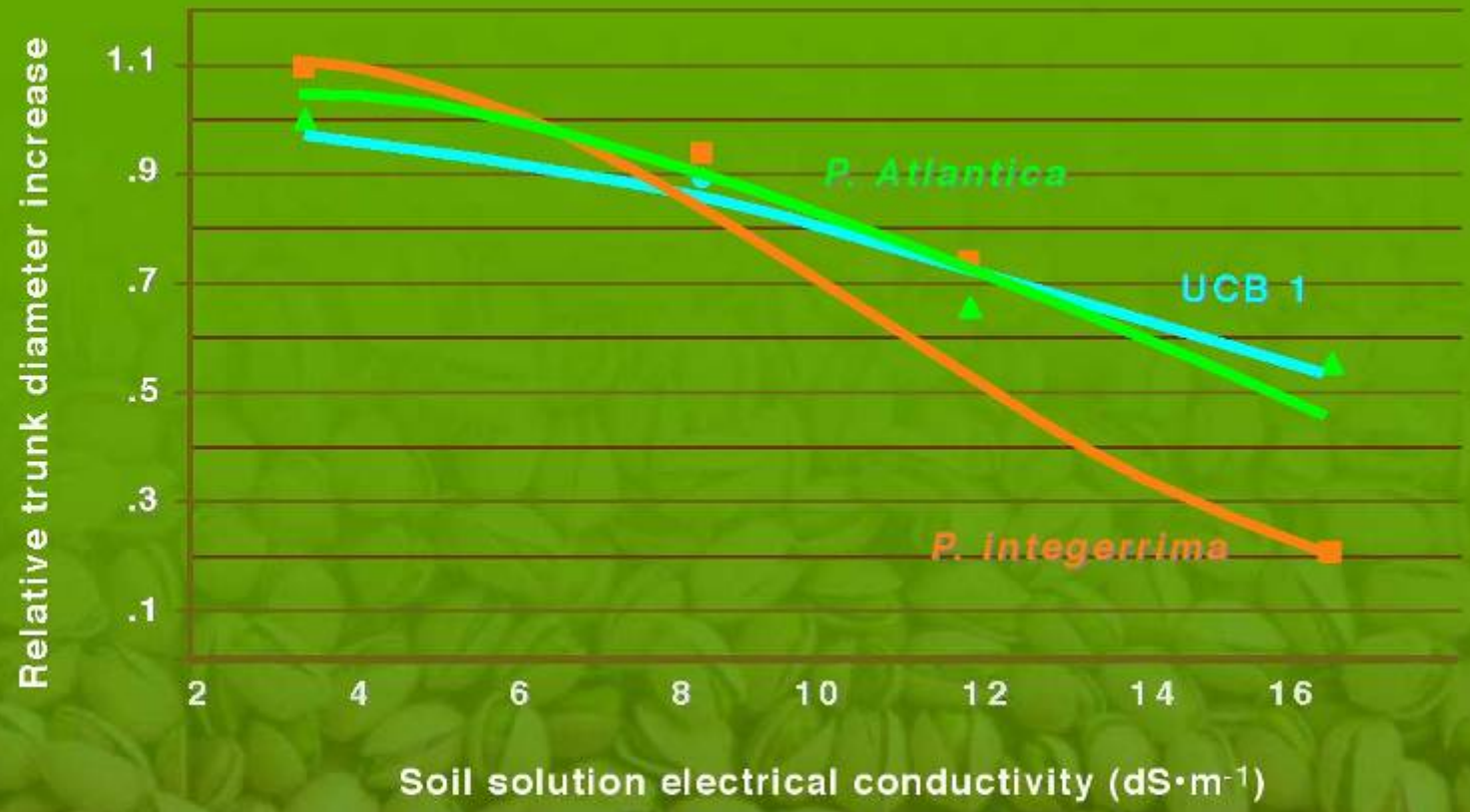
Differences in Osmotic Adjustment



Glycophytes and Halophytes



Trunk Diameter Increase of 'Kerman' Pistachio as a Function of Increasing Salinity

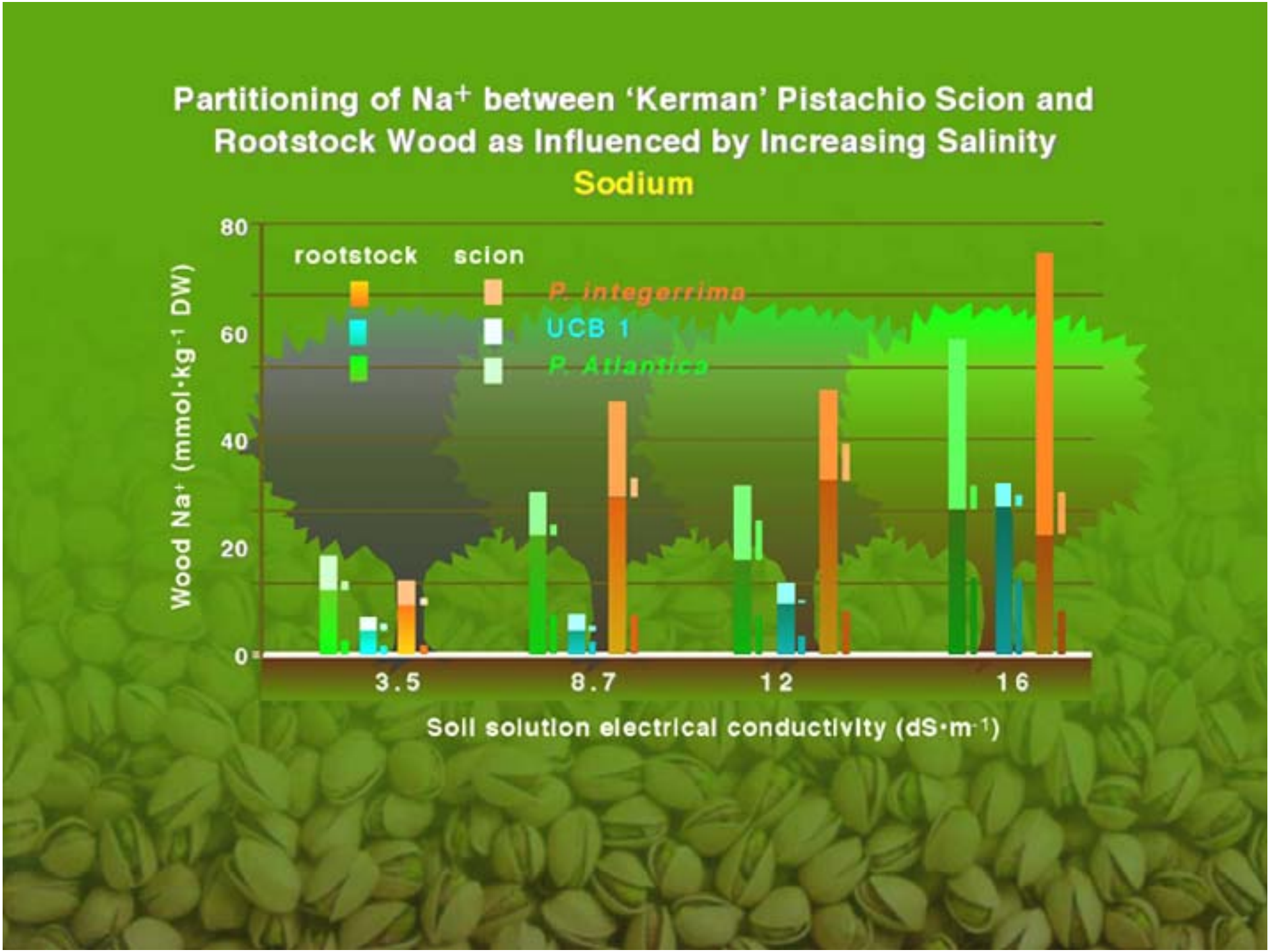


Farmer	Eciw (ds/m)	Average Yield 2002 (Tones/ha)	Average ECe (ds/m)	Average Irrigation depth (cm)	Irrigation interval (day)	Applied water (m3/ha)	Soil Texture
Vakili	14.5	1.5	13.14	31.7	50	22190	Si.L
Masoomi	22	0	11.51	43	45	34400	L
Mohammadi	24	3.7	10.38	56.7	45	45360	L
Shakeri	11.9	2.2	12.8	24.6	55	17220	L
Barkhordari	8.11	1	15.5	25.75	46	20600	Si.L
Ghateri	13.57	1	15.12	51.5	51	36000	Si.L

Specific Ion Effects of Salinity

- Cl and Na
  - absorbed by roots
  - accumulate in leaves
  - produce “burn”

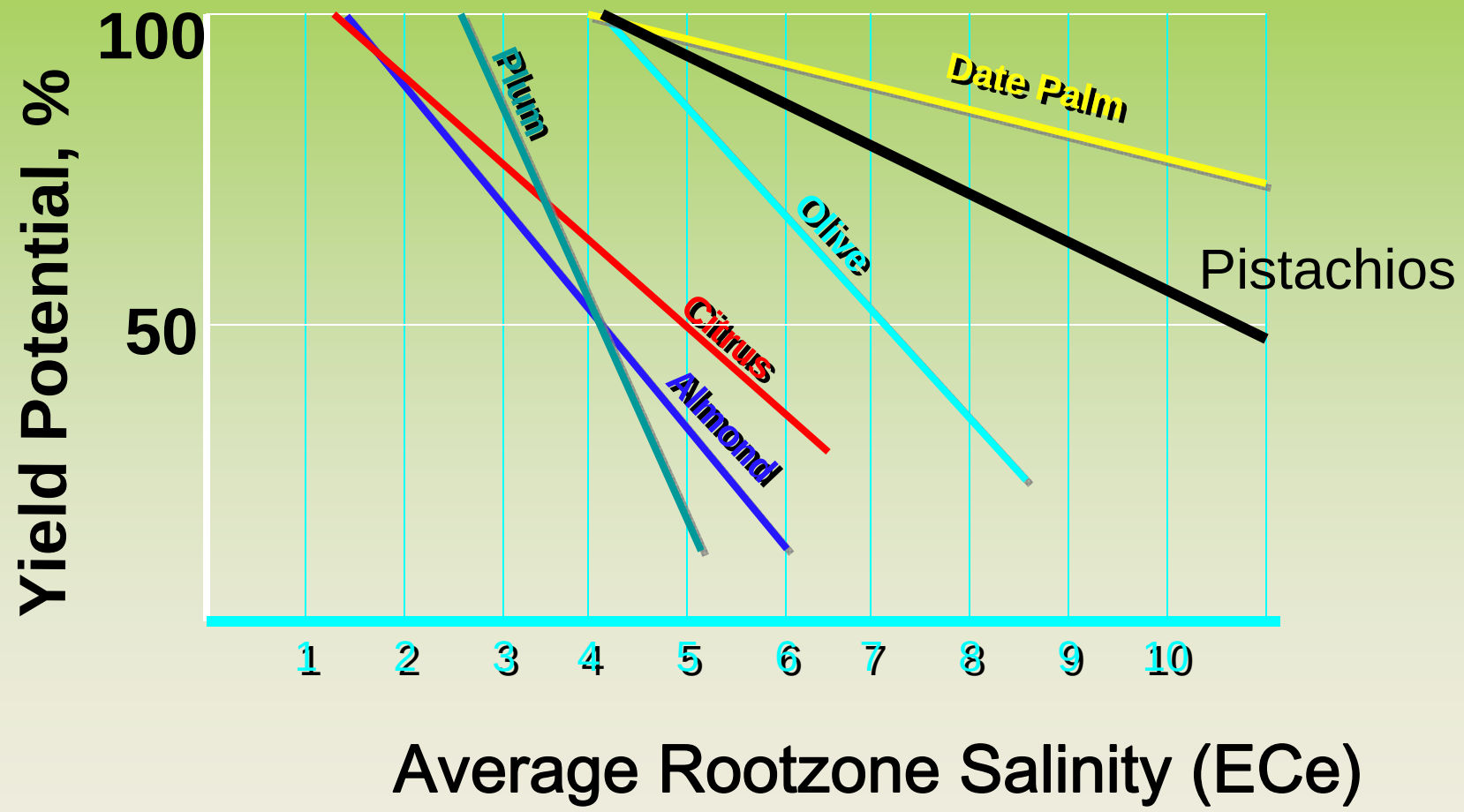
NUTRIENT	CRITICAL VALUES	NORMAL RANGE	GREEN TISSUE	NECROTIC TISSUE
N	2.3	2.5–2.9%	2.33	2.44
P	0.14	0.14–0.17%	0.09	0.09
K	1.0	1.0–2.0%	1.10	0.68
B	90 ppm	120–250 ppm	57 ppm	87 ppm
Ca	1.3% (?)	1.3–4.0%	1.30 %	1.91%
Mg	0.6% (?)	0.6–1.2 (?)	0.59%	0.68%
Na	?	?	6200 ppm	12230 ppm
Cl	?	0.1–0.3 ?	1.98 %	3.43%
Mn	30 ppm	30–80 ppm	625000	60000
Zn	7 ppm	10–15 ppm	7 ppm	6 ppm
Cu	4 ppm	6–10 ppm	2.9 ppm	2.9 ppm


Partitioning of Na+ between 'Kerman' Pistachio Scion and Rootstock Wood as Influenced by Increasing Salinity
Sodium
Wood Na+ (mmol·kg-1 DW)
80
60
40
20
0
rootstock
scion
P. integerrima
UCB 1
P. Atlantica
3.5
8.7
12
16
Soil solution electrical conductivity (dS·m-1)

What do we know about mechanism salinity tolerance pistachios…

- Tolerant to ECe 8.4 dS/m
- Evidence of osmotic adjustment via ion uptake
- Evidence of osmotic adjustment via synthesis of new compounds
- Rootstock differences
- Is salt sensitivity different at different seasonal growth stages?
  - More sensitive early vegetative growth
  - More tolerant later in the season

Tree salt tolerance



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How to avoid salinity problems

- Row crop and wheat examples: Ayers, 2003
  - Previously leached and drained
- Tried fallowing, rotation, more salt tolerant crops, and better irrigation systems with more control
  - Stopgap solutions
- Now manage root zone salinity
    - Need good quality water
    - Need good drainage
    - Drainage water can be used partially if not toxic

Pistachio Salinity Management Now

- UCB I rootstock
- Monitor soil and keep EC_e < 8.4 dS/m
- Budget irrigate using evapotranspiration and pistachio K_c
- Calculate leaching fraction
- Avoid soil saturation
- Use good water during early vegetative growth, possibly nut fill

Calculating Leaching Fractions

- If want soil EC_e = dS/m of irrigation water
  - 33% leaching fraction
- EC_e = 2 X (dS/m of Irrigation water)
  - 10% leaching fraction
- EC_e = 3 X (dS/m of Irrigation water)
  - 5% leaching fraction

Industry Plan for Salinity Management

- Investigate the mechanism
  - Dr. Eduardo Blumwald
- Obtain and evaluate accessions
  - International contacts
- Aim toward a plant improvement program

2010 annual STATEWIDE Pistachio DAY

UC CE University of California Cooperative Extension

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http://fruitsandnuts.ucdavis.edu/