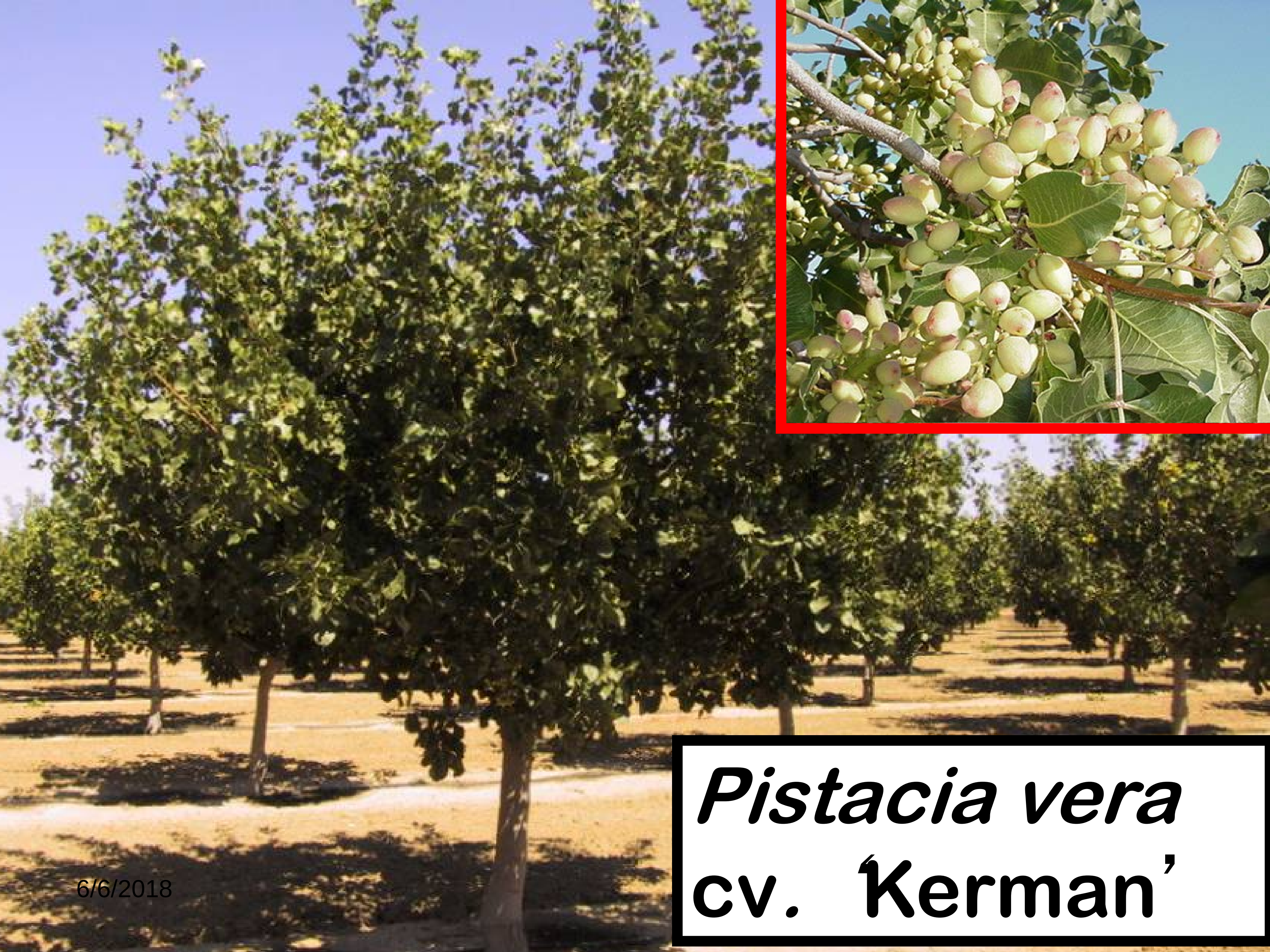
Developing Pistachios Under Saline Conditions: *when applied research is too successful….*

Louise Ferguson and Heraclio Reyes
Plant Sciences Department
Blake Sanden
Kern County Farm Advisor
Steve Grattan
Land Air and Water Resources


Pistacia vera
cv. 'Kerman'

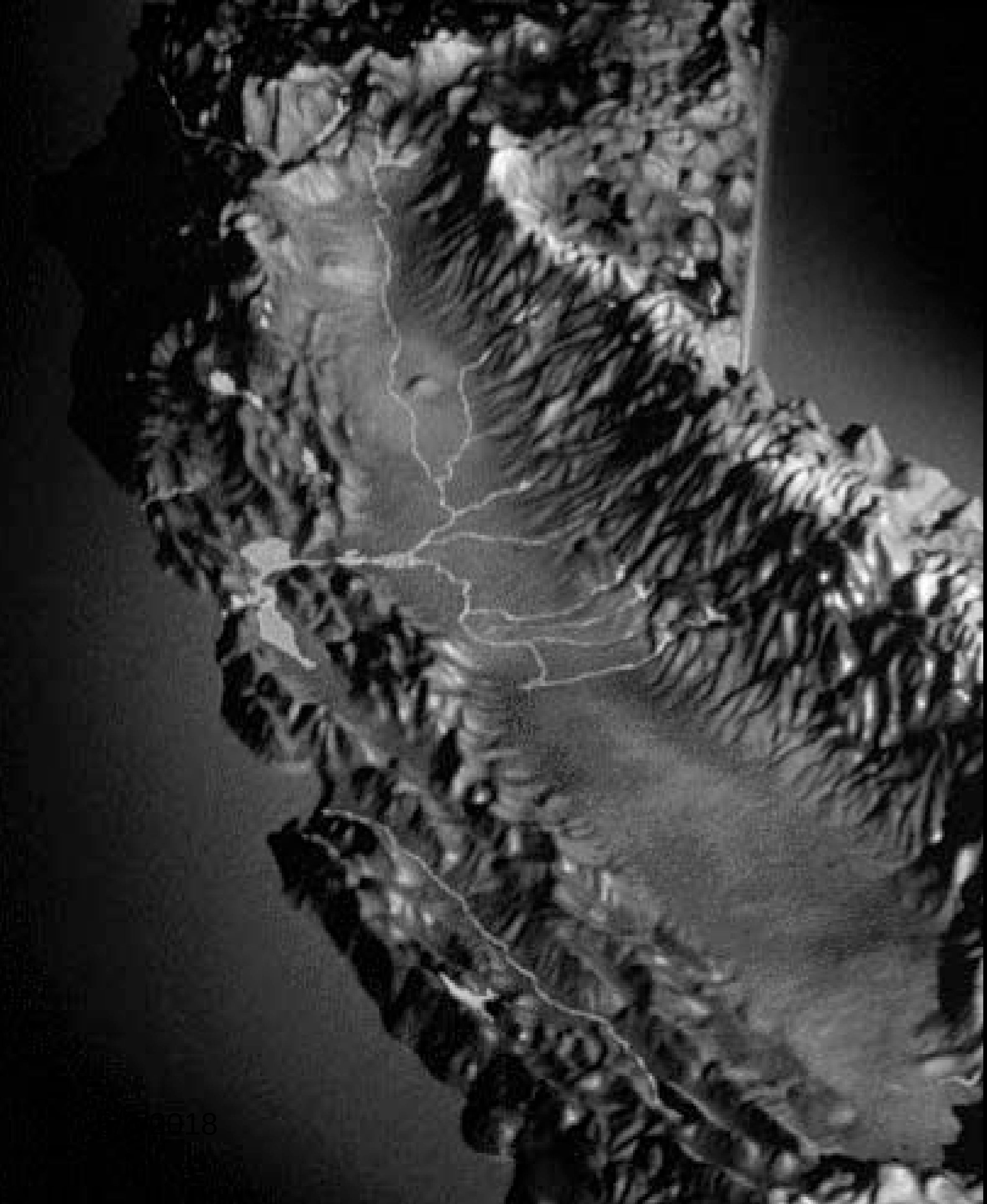
2010:

215,336 ac

3,806 lb/ac
$2.22/lb
$8,449.00/ac

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

James E. Ayars, 2003



Specific Salts

- **<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

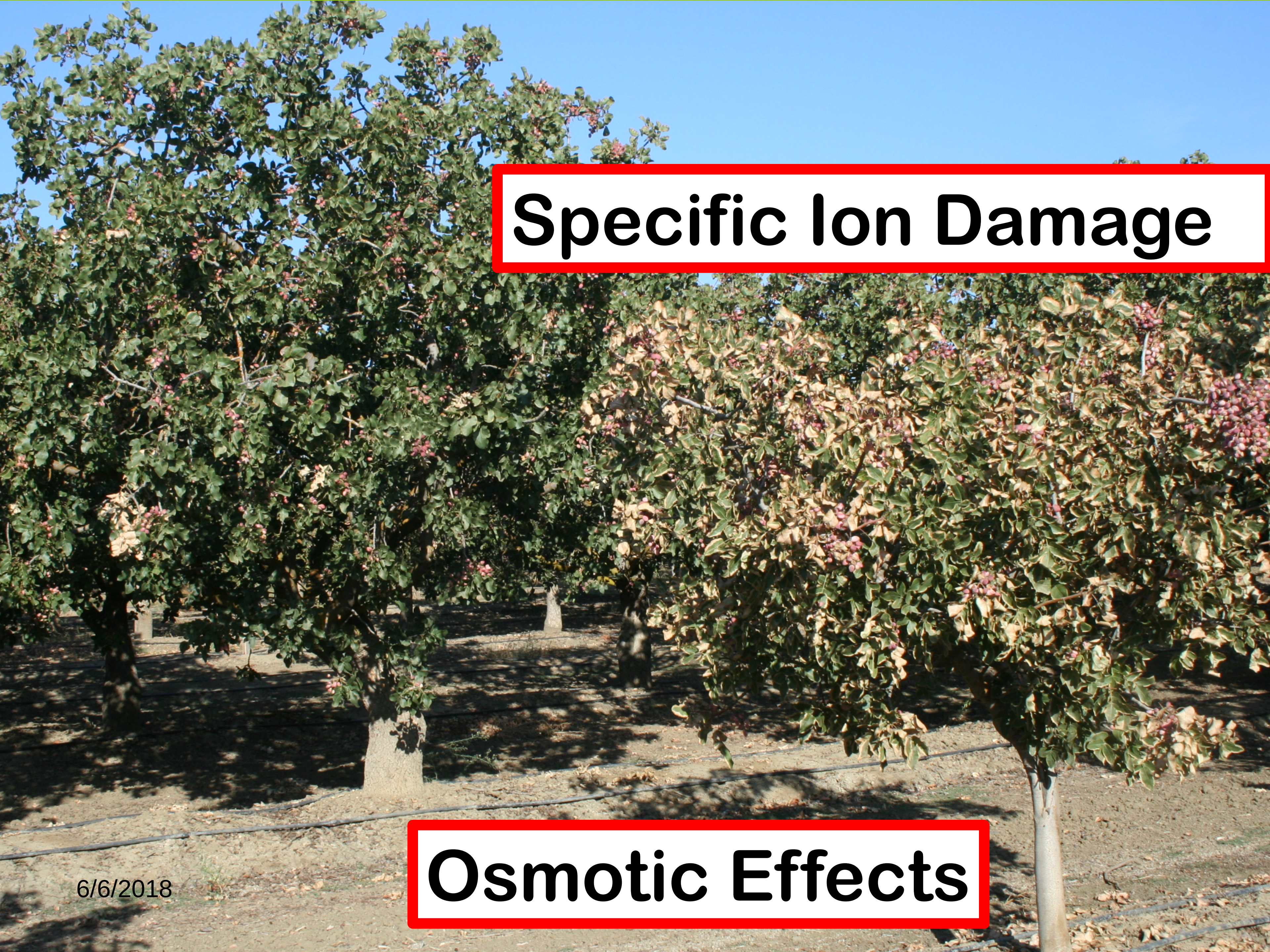
Boron = micronutrient

Salinity:

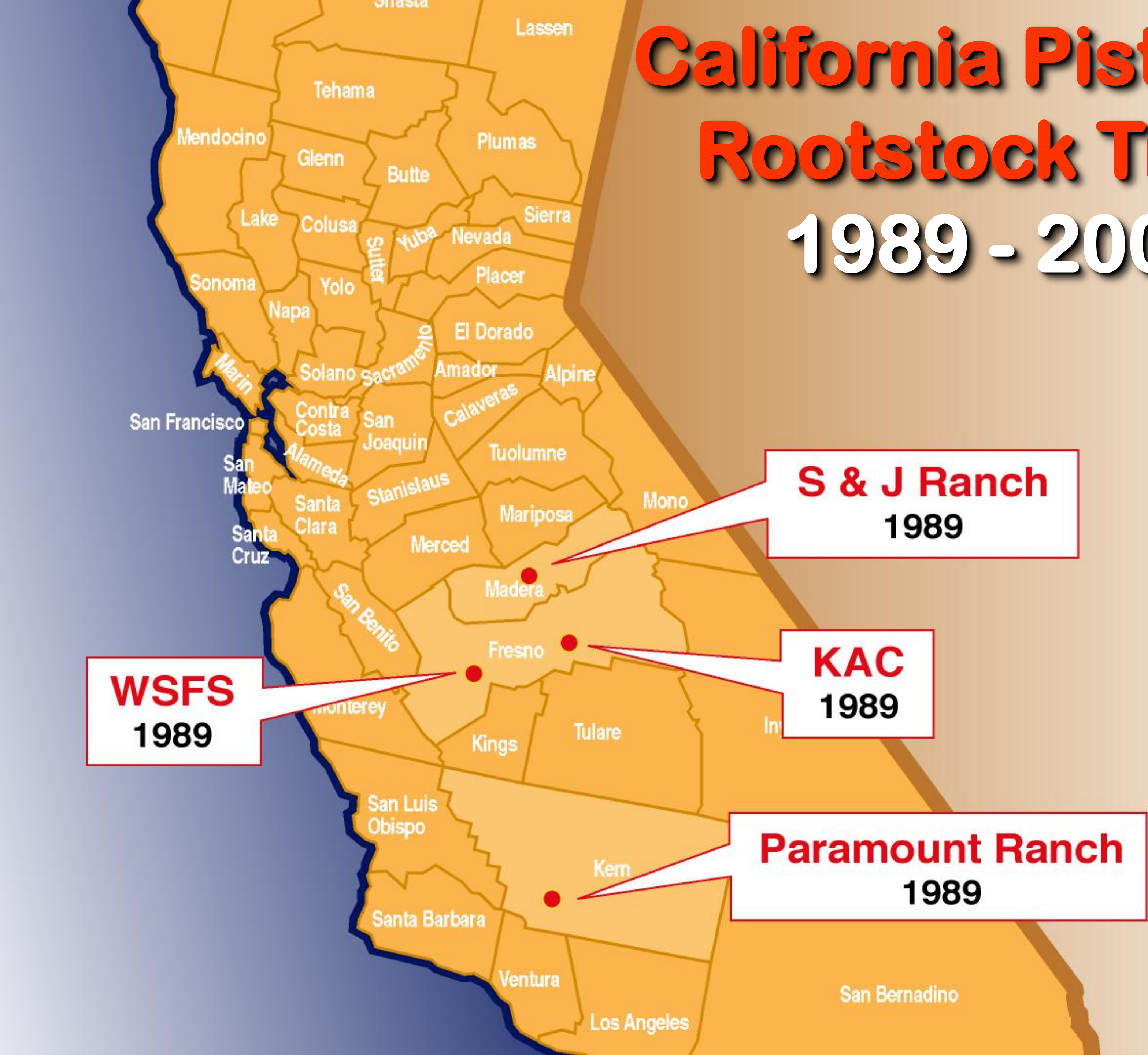
- **Concentration of salts in solution: dS/m**
  - **Irrigation water: ECw**
  - **Soil water: ECe**

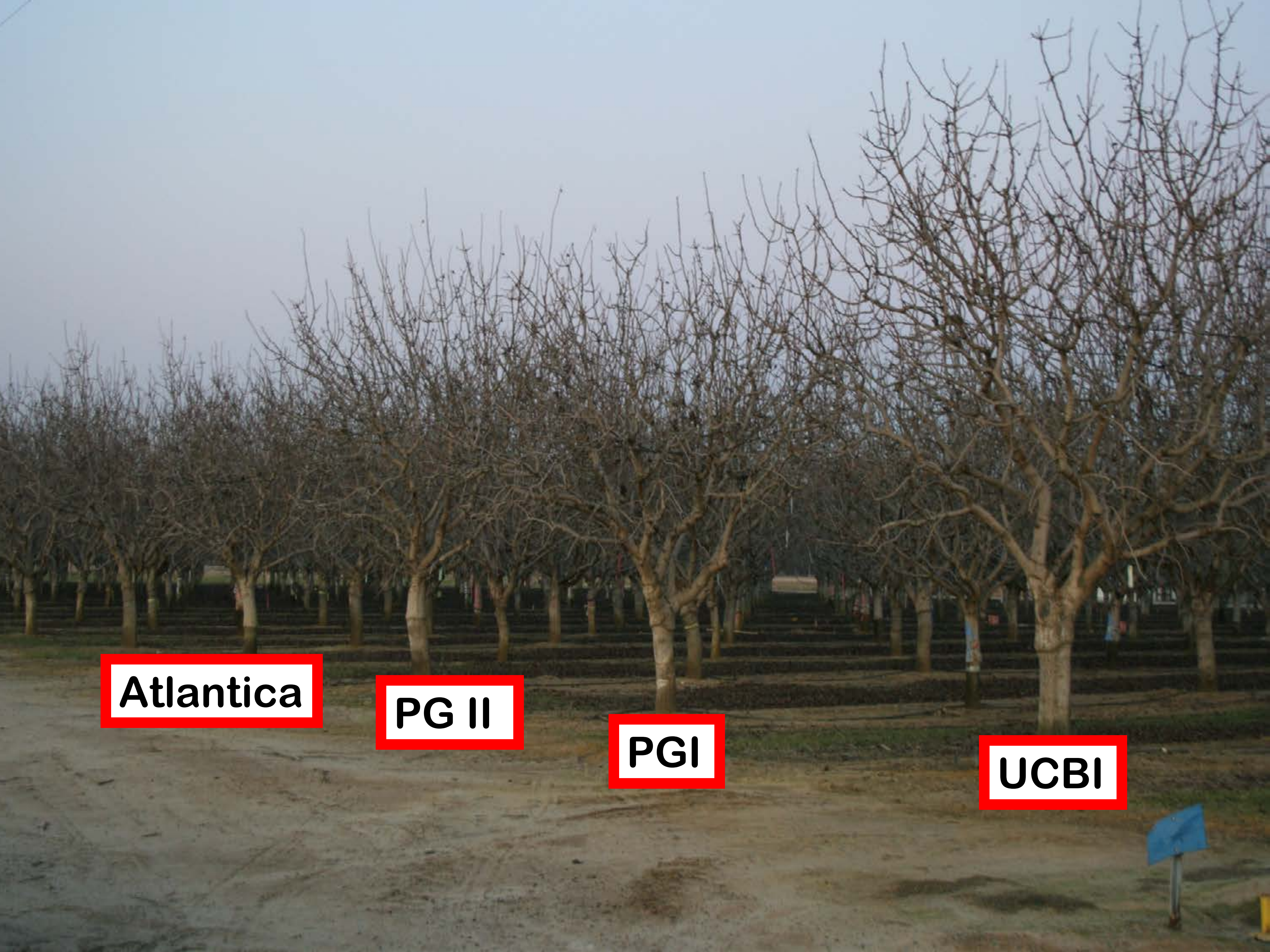
Soil and water salinity cause …

- Salinization:
  - when the concentration of soluble salts in the root zone are high enough to impede optimum growth
    - Osmotic effects
    - Specific ion effects


Specific Ion Damage
Osmotic Effects
6/6/2018

California Pistachio Rootstock Trials
1989 - 2002




Atlantica
PG II
PGI
UCBI

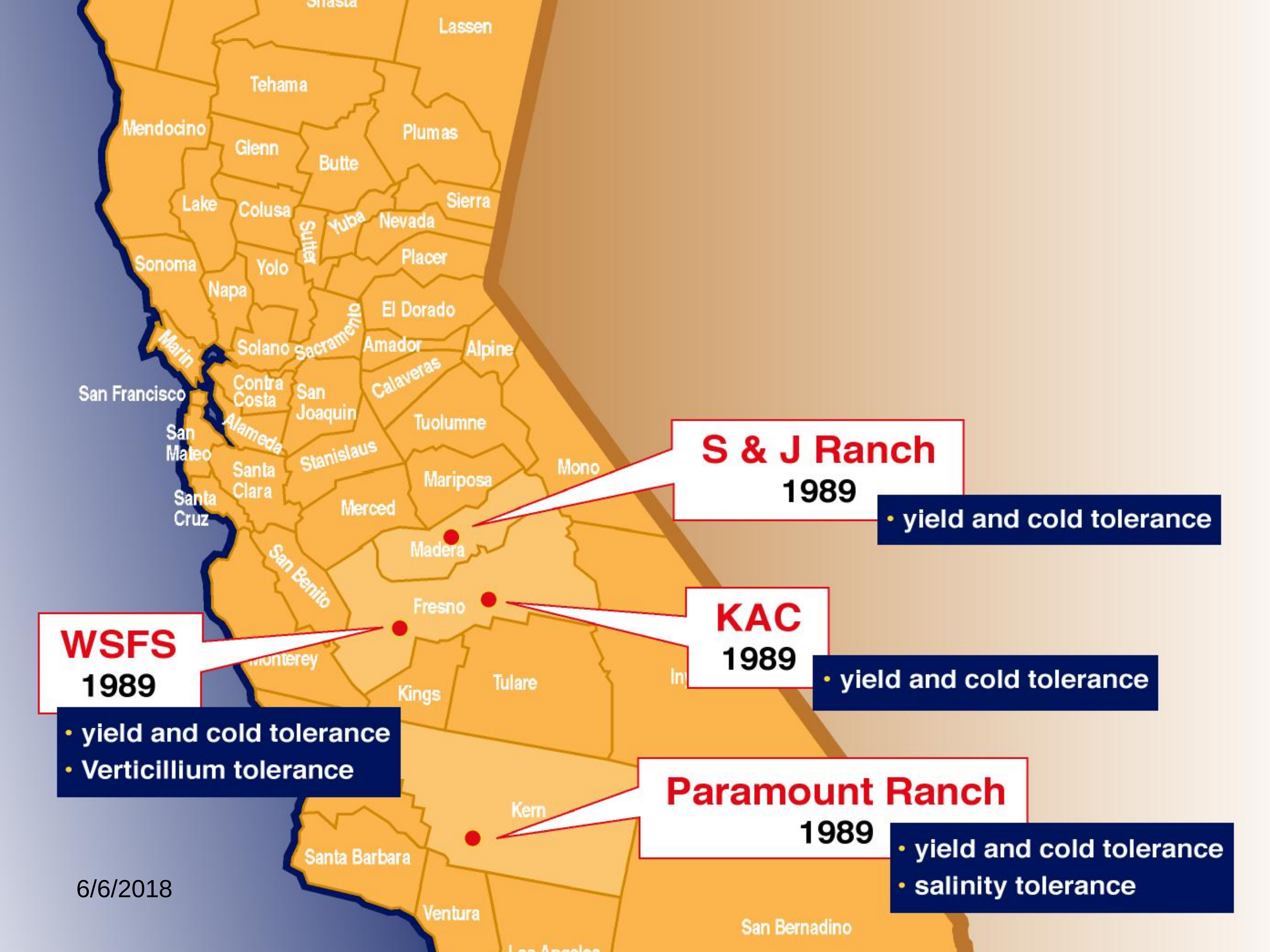
6/6/2018


6/6/2018

Farmer	Eciw (ds/m)	Average Yield 2002 (Tones/ha)	Average ECe (ds/m)	Average Irrigation depth (cm)	Irrigation interval (day)	Applied water (m3/ha)	Soi Textu
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	53	17220	L
Barkhordari	8.11	1	15.5	25.75	46	20600	Si
Shateri	13.57	1	15.12	51.5	51	36000	Si

14.88 acre feet/acre

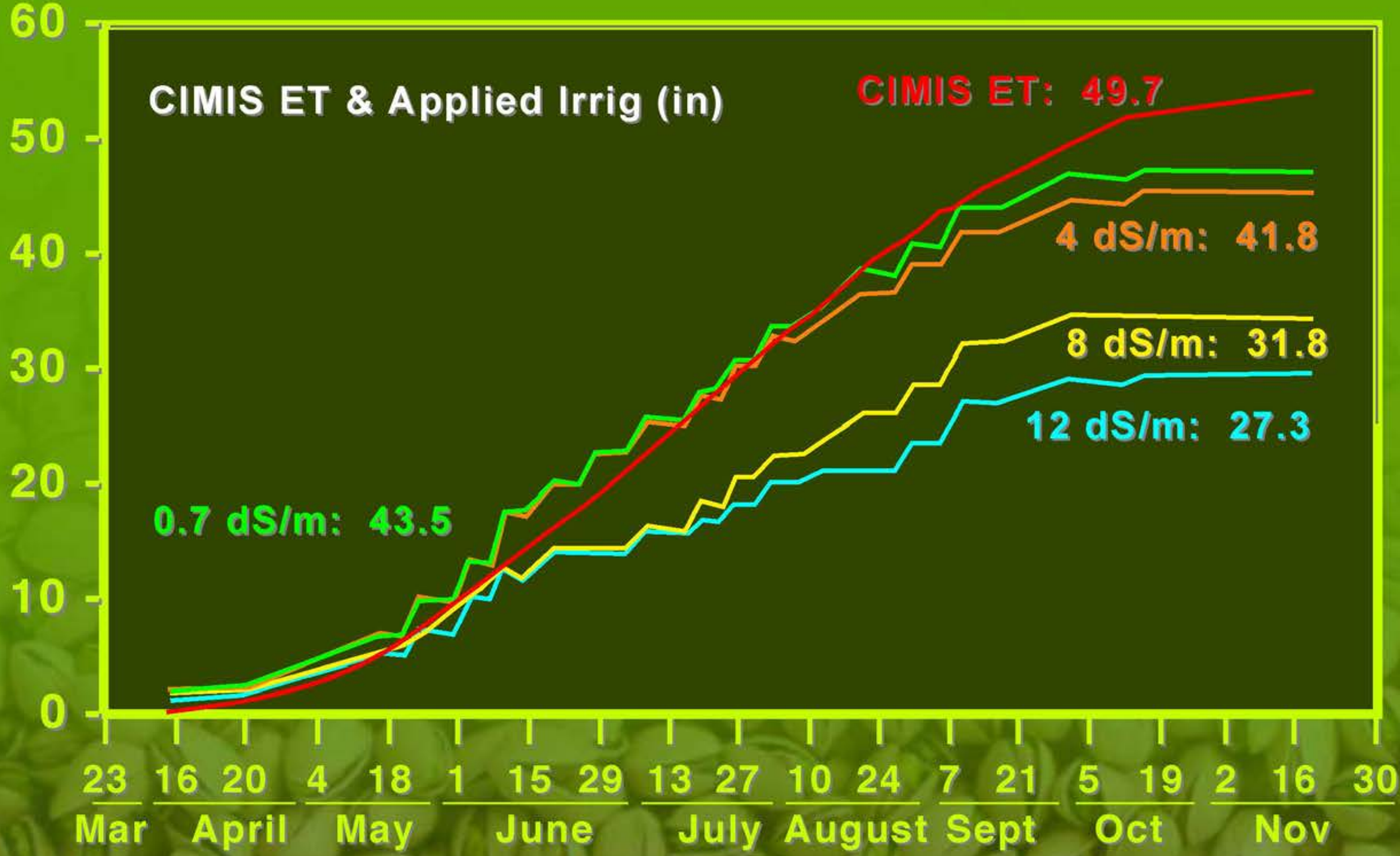
NUTRIENT	CRITICAL VALUES	NORMAL RANGE	GREEN TISSUE	NECROTIC TISSUE
N (%)	2.3	2.5–2.9%	2.3	2.4
P (%)	0.14	0.14–0.17%	0.09	0.09
K (%)	1.0	1.0–2.0%	1.10	0.68
B (ppm)	90	120–250	57	87
Ca (%)	1.3 (?)	1.3–4.0	1.30	1.91
Mg (%)	0.6 (?)	0.6–1.2 (?)	0.59	0.68
Na (ppm)	?	?	6200	12,230
Cl (%)	?	0.1–0.3 ?	1.98	3.43
Mn (ppm)	30	30–80	625,000	60,000
Zn (ppm)	7	10–15	7	6
Cu (ppm)	4	6–10	2.9	2.9



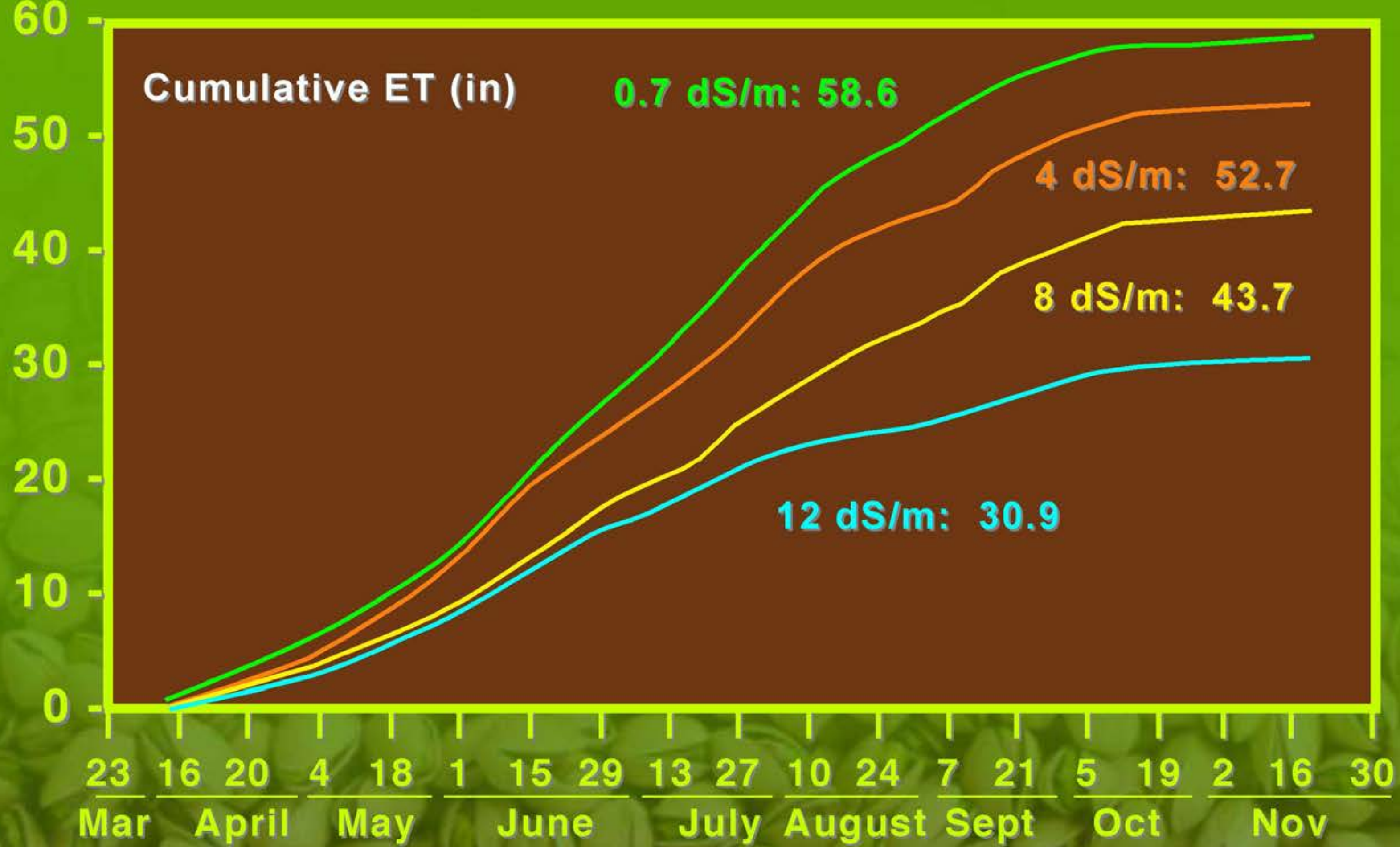
S & J Ranch
1989
• yield and cold tolerance
KAC
1989
• yield and cold tolerance
WSFS
1989
• yield and cold tolerance
• Verticillium tolerance
Paramount Ranch
1989
• yield and cold tolerance
• salinity tolerance
Lassen
Tehama
Mendocino
Glenn
Plumas
Butte
Lake
Colusa
Sierra
Sutter
Yuba
Nevada
Placer
Sonoma
Yolo
Napa
El Dorado
Marin
Solano
Sacramento
Amador
Alpine
San Francisco
Contra Costa
San Joaquin
Calaveras
Tuolumne
San Mateo
Alameda
Stanislaus
Mono
Santa Clara
Mariposa
Santa Cruz
Merced
Madera
San Benito
Fresno
Kings
Tulare
Kern
Santa Barbara
Ventura
San Bernadino


6/6/2018

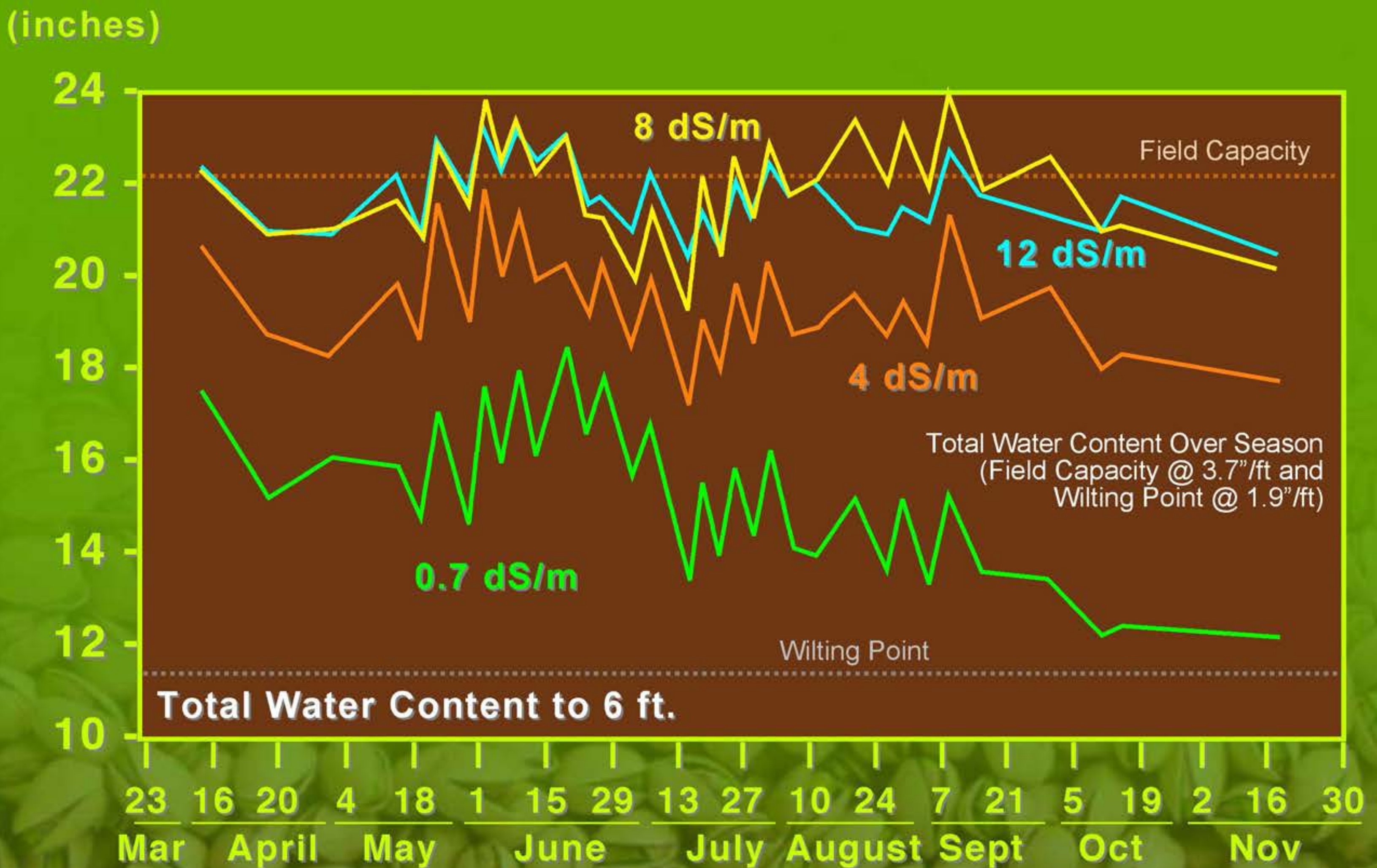
Applied Water: 2002*



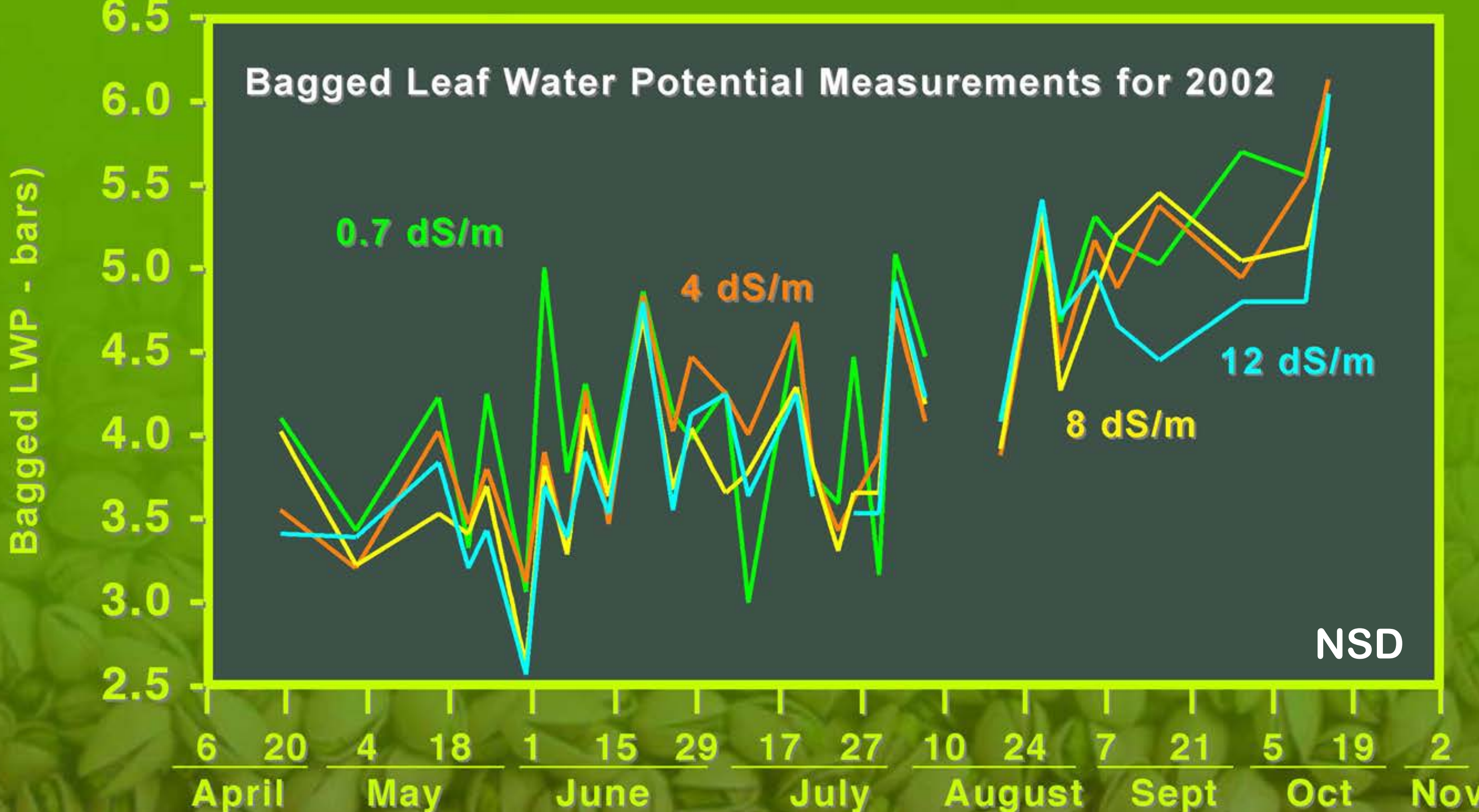
Cumulative ET: 2002*



Soil Total Water Content: 2002*



Tree Water Status: 2002



Effect of Saline Irrigation on Average Annual Individual Tree Yield by Rootstock, 1997 - 2002

6/6/2018

- **No consistent pattern to specific ion damage or boron "toxicity"**

ECw = 0.75 dS/m

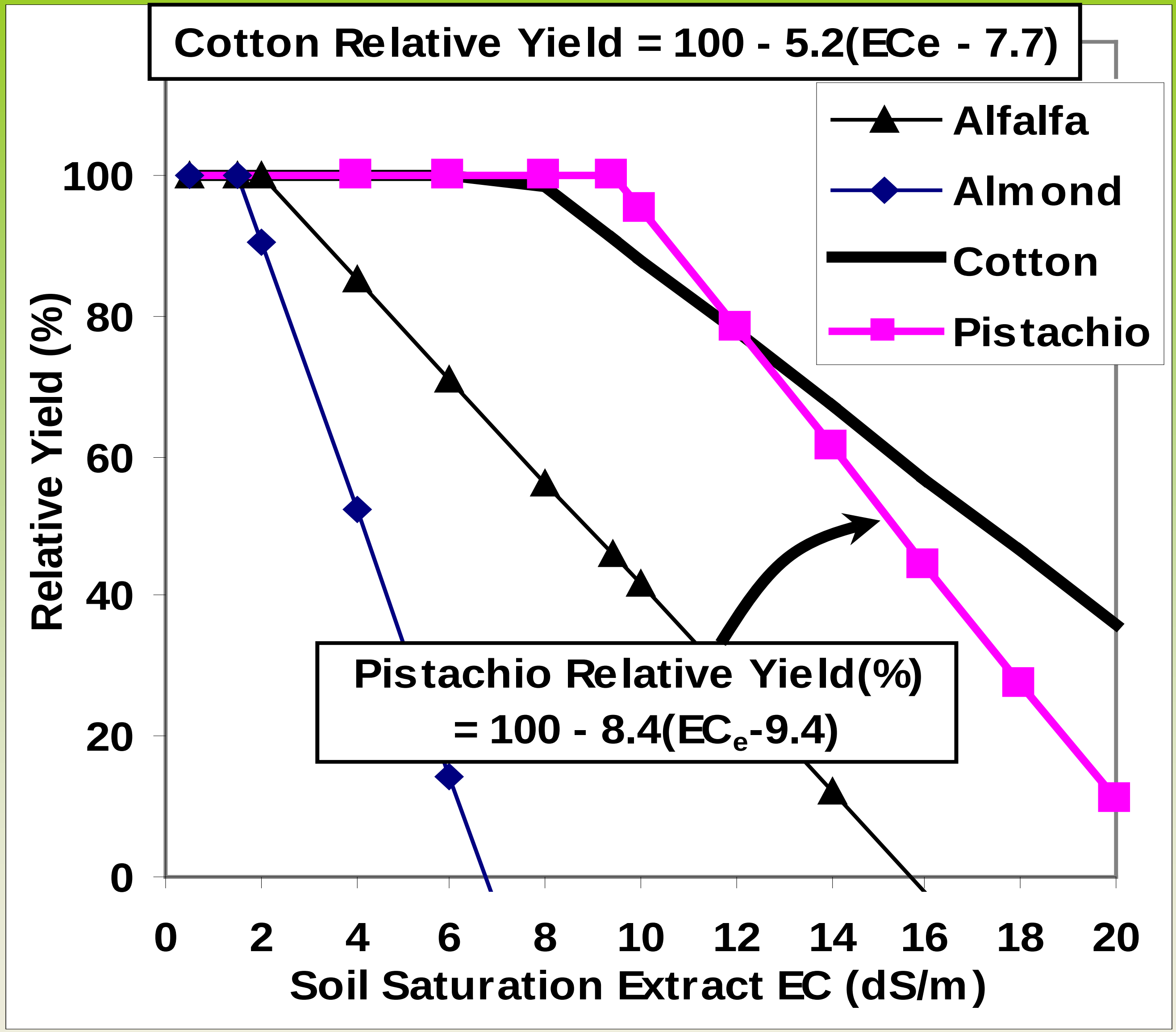
ECw = 0.75 dS/m

1995 – 2002 Field Trial Summary

- **Elevated soil ECe**
- **Decreased Evapotranspiration**
- **Trees on all four rootstocks:**
  - **producing normally > 8.4 dS/m**
  - **insignificant decreases @ 12 dS/m**
  - **no stress**
  - **inconsistent visible specific ion damage**

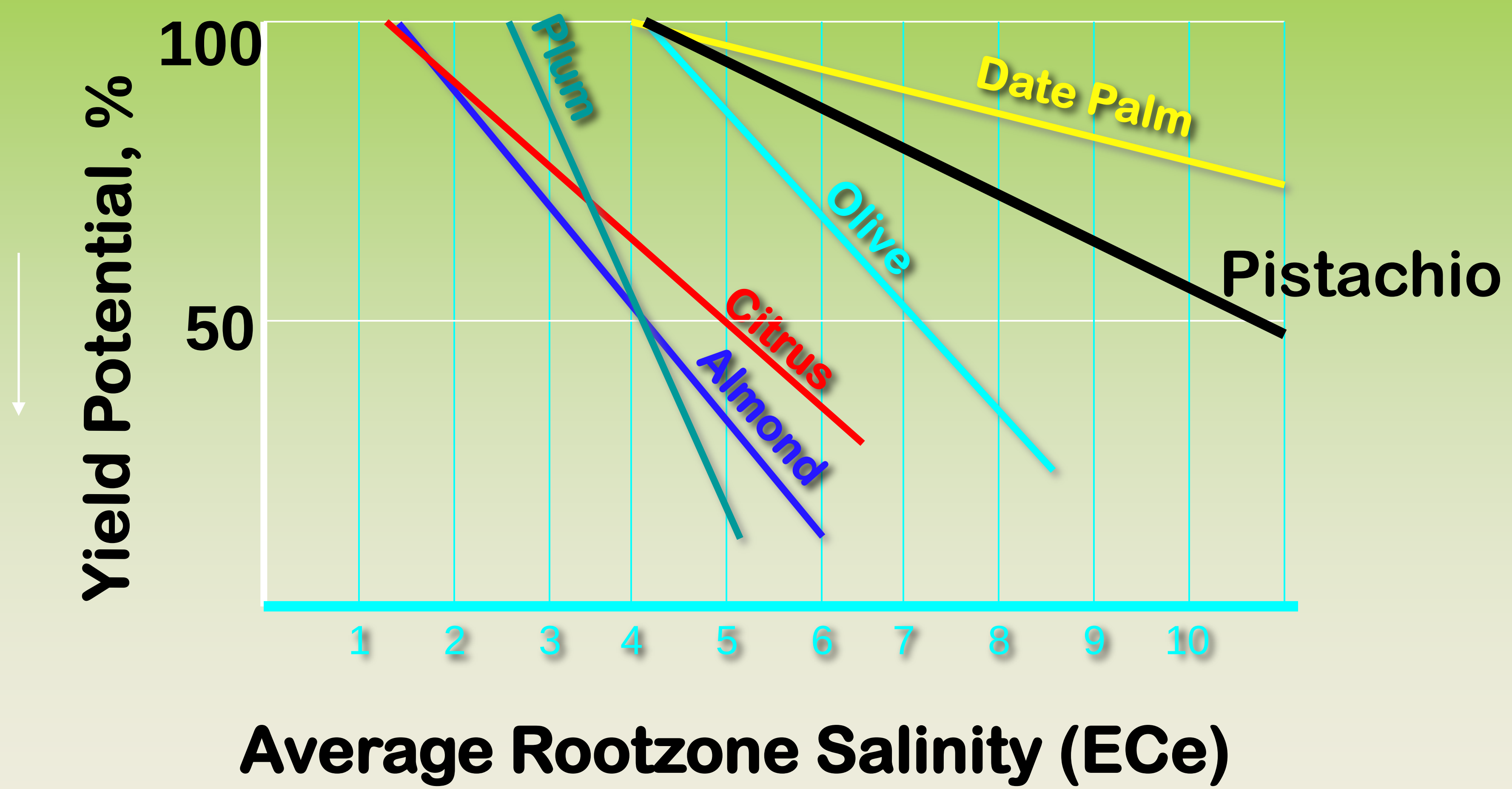
- Normal leaf macronutrient and Na, Cl, B analysis

Relative Yield of as a Function of Soil ECe



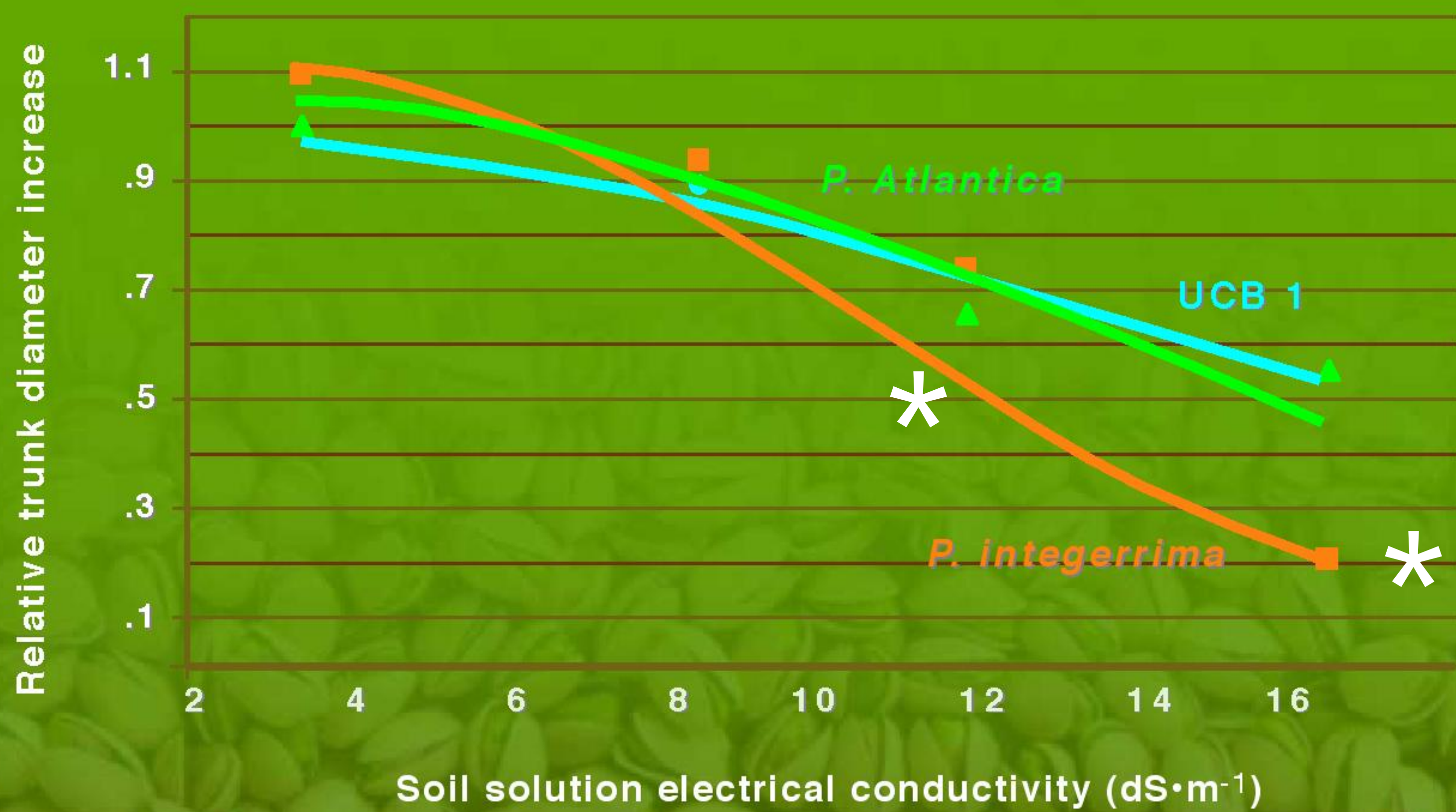
Sanden, B.L., L. Ferguson, H.C. Reyes, and S.C. Grattan. 2004. Effect of salinity on Evapotranspiration and yield of San Joaquin Valley pistachios. Proceedings of the IVth International Symposium on Irrigation of Horticultural Crops, Acta Horticulturae 664:583-

Tree Salt Tolerance

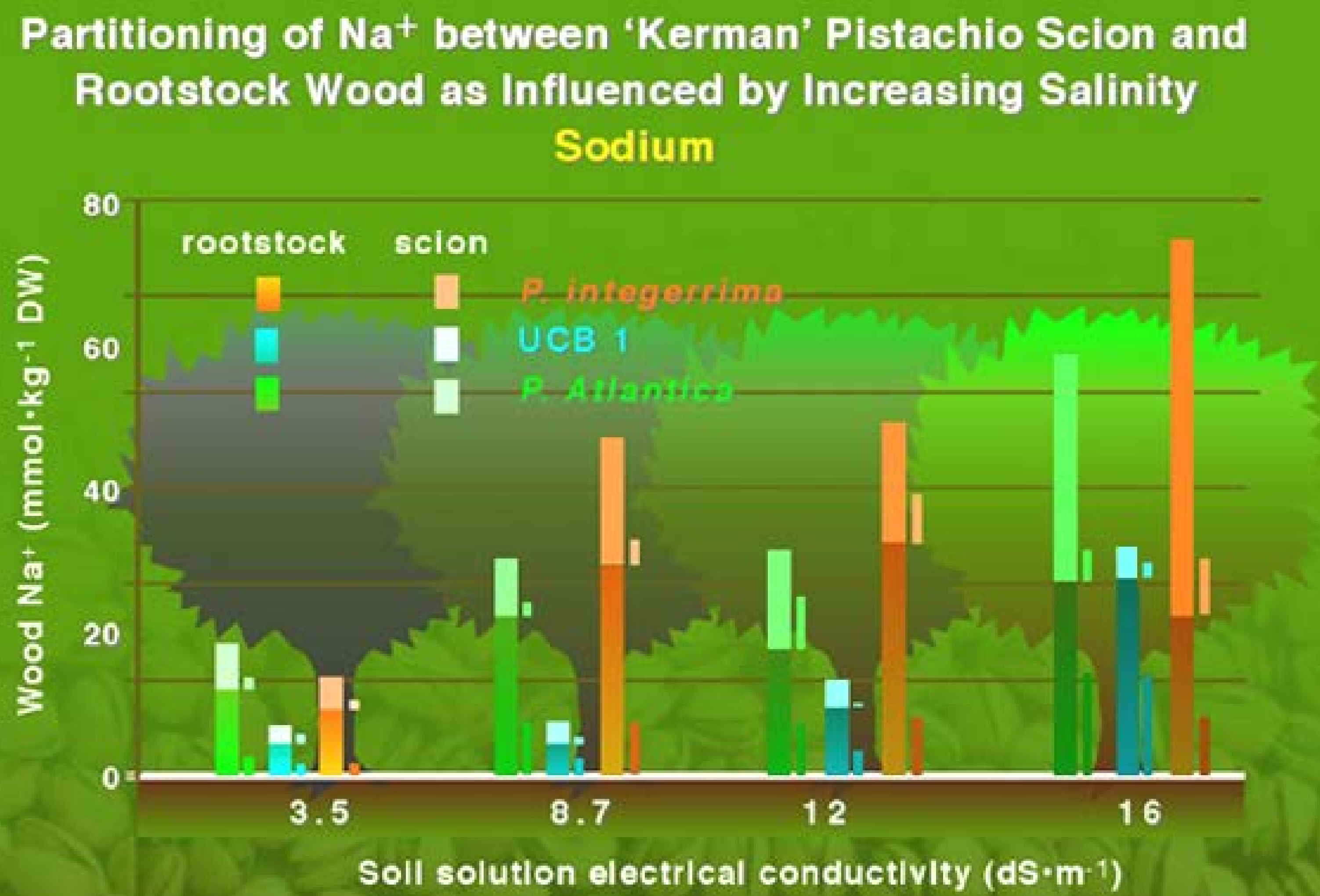


USDA Salinity Laboratory
Riverside CA

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



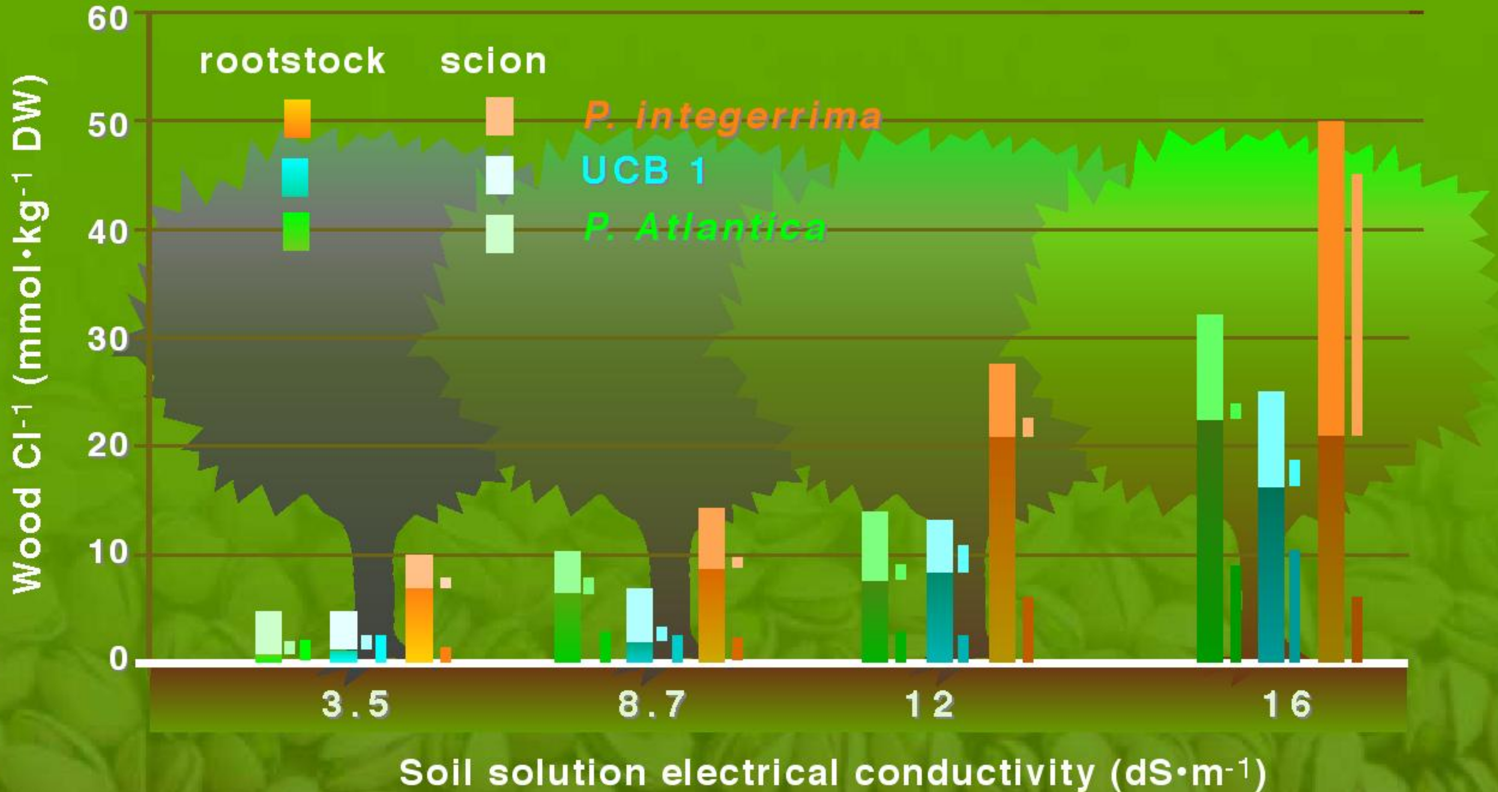
Ferguson, Poss, Grattan, Grieve, Wang, Wilson, Donavan, Chao. 2002 JASHS 127 (2): 194-199



Ferguson, Poss, Grattan, Grieve, Wang, Wilson, Donovan, Chao. JASHS 127 (2) 194-99 2002.

Partitioning of Cl^- Between 'Kerman' Pistachio Scion and Rootstock Wood as Influenced by Increasing Salinity

Chloride



Ferguson, Poss, Grattan, Grieve, Wang, Wilson, Donovan, Chao. JASHS 127 (2) :194-99. 2002

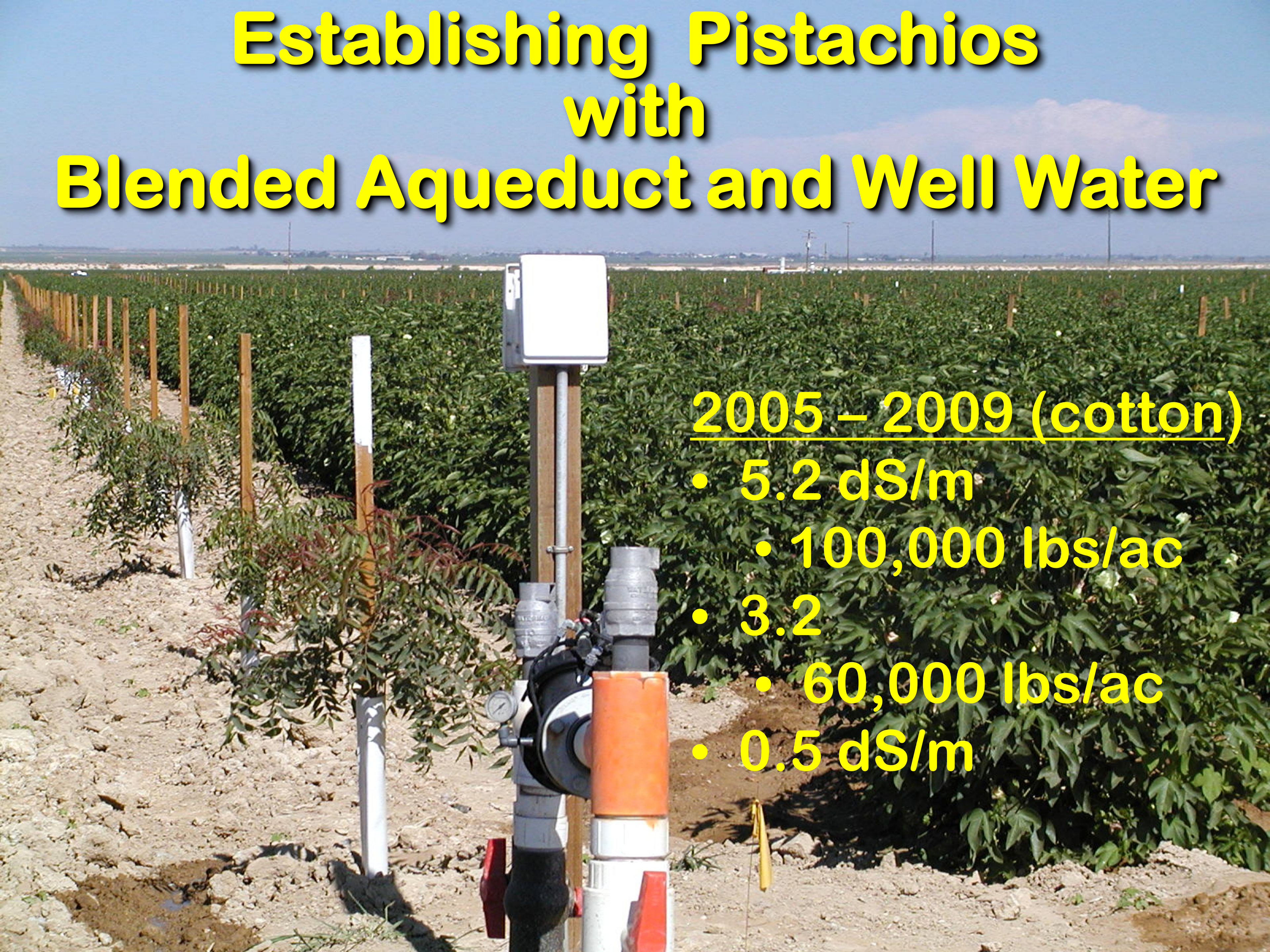

Na CL NA CL Na
B
B

Major Findings……

- **Field Trial:**
  - Established trees can be irrigated with saline water up to 8.4 dS/m
- **Greenhouse Trial:**
  - Osmotic effects > specific ion damage
  - Difference among rootstocks in how they partition Na, CL

Major Question……

- **Can an orchard be established at these salinity levels?**


Establishing Pistachios
with
Blended Aqueduct and Well Water
2005 – 2009 (cotton)
• 5.2 dS/m
• 100,000 lbs/ac
• 3.2
• 60,000 lbs/ac
• 0.5 dS/m

Salinity effect marginal:
- growth
- yield:
  3,000 lb/ac

Kemal Ataturk Dam, Turkey: 1990

Ag Alert, Dec. 2007

"Grower Mark Watte is seeing a major shift from cotton production to permanent crops like pistachios…."

60,000 acres


November, 2009
Na
Saline Sodic Soils

What do we know about salinity tolerance in pistachios…

- Evidence of osmotic adjustment via K^+ ion uptake
- Evidence of osmotic adjustment via synthesis of organic acids
- Differences among rootstocks

What we don’t know about salinity tolerance in pistachios….

- How the salts get taken up
- How the salts are transported
- Where are the salts sequestered
  - cellular level
  - whole plant level
- Specific ion level damages growth/yield

More specifically....

- Do roots do most of the work?
  - Filtering out salts during at cortex during uptake
  - Apoplastic or symplastic flow across cortex
  - Xylem loading and unloading in plant
- Is there phloem loading?
- Are ions sequestered in vacuoles?
  - Delaying onset of specific ion damage

Objective I

- **Investigate the three physiological processes influencing salt transport to the leaves: (in major rootstocks).**
  - **Selectivity of uptake from the soil solution at the root cortex.**
  - **Loading of the xylem.**
  - **Retrieval from the xylem in upper parts of the roots.**

Objective II

– **Determine if control in the shoot occurs by the exclusion of salt from the phloem sap flowing to meristematic regions of the shoot.**

Objective III

– **Determine how the relative growth rate of the Kerman scion on the major different rootstocks affects the salinity status of the scion.**

Objective IV

– **Determine if cellular compartmentalization of salts in the vacuoles of the pistachio scion leaf mesophyll cells is occurring.**

Objective V

- Use this information to direct a plant improvement program.

http://ucanr.org/sites/psalinity

SKIP TO CONTENT SITE MAP Enter Search Terms

University of California Cooperative Extension

Pistachio Salinity Studies

- Overview
- Iranian Pistachio Orchards: Observations
- California Pistachio Orchards: Early Rootstock Trials
- Tank Studies
- Large-Scale Field Trials
- Current Research Direction
- Resources
- Research Team
- Support

EMAIL

Overview

Louise Ferguson & Blake Sanden

What We Know: The Short of It

We know that roots do most of the work in protecting the plant from excessive uptake of salts, and filter out most of the salt in the soil while taking up water. But frankly, the fundamental processes governing the relationship between water and ion flow through roots are complex. Na, Cl and other ions do not move passively with the transpiration stream, neither are their movements entirely independent of it.

In addition to these root processes, we recognize that salt sensitivity is related to mechanisms within

The Terminology of Salinity

Ions

Salinity in based on the presence of charged ions which can have either a positive charge (cations) or a negative charge (anions). These ions can be toxic to plants, depending on the plant and the concentration. Milligrams per liter (mg/L) is the typical unit of measure for ions. Examples of common ions affecting salinity:

cations: calcium (Ca^{++}), sodium (Na^{+}), magnesium (Mg^{++})
anions: chloride (Cl^{-}), bicarbonate (HCO_3)