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

0/6/2018







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>

0/6/2018

- Na⁺ = Sodium
- Ca²⁺ = Calcium
- Mg²⁺ = Magnesium
- K⁺ = Potassium

• <u>Anions = -</u>

- CI^{-} = Chloride
- SO_4^- = Sulfate
- $HCO_3^- = Bicarbonate$

•
$$CO_3^{2-}$$
 = Carbonate

» pH > 8

Boron = micronutrient

Specific Salts in Irrigation Water



- $\frac{\text{Anions} = -}{\text{Cl}^2} = \text{Chloride}$

Boron = micronutrient



Salinity Units of Concentration

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

- Volume Basis
- mg/l
- meq/l
- $1 \text{mmol}_{c} / \text{I} = 1 \text{meq/I}$
 - 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





Units for Measuring TDS

- ECw (water) or ECe (soil water extract)
 mmhos/cm = <u>dS/m</u>
 - <u>dS/m</u> x (conversion factor) = TDS
 - Ion, concentration, temperature (25°C)





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
 - Naturally saline soils
 - weathering of marine sediment coastal range origin
 - Lack of a subsurface drainage outlet
 - Over irrigation
 - Drainage water
 - Saline irrigation water
 - Fertilization



Marine origin Closed basin + no drainage Evaporation > transpiration Irrigation + 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 Halophyte **Glycophyte** 🗇 = CI = NAA R A P ſ 7 A A 6/6/2018 R R A

Glycophytes and Halophytes



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



Soil solution electrical conductivity (dS·m⁻¹)

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	du : ha	12.0	24.0	33	17220	L
Barkhordari	8.11	1	15.5	25.75	46	20600	Si.L
Shateri	13.57	1	15.12	51.5	51	36000	Si.L



Specific Ion Effects of Salinity



- CI and Na
 - absorbed by roots
 - accumulate in leaves
 - produce "burn"

NUTRIENT	CRITICAL VALUES	NORMAL RANGE	GREEN TISSUE	NECROTIC TISSUE
Ν	2.3	2.5–2.9%	2.33	2.44
Р	0.14	0.14–0.17%	0.09	0.09
K	1.0	1.0–2.0%	1.10	0.68
В	90 ppm	120–250	57 ppm	87 ppm
		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
CI	?	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
6/6/2018	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



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



Average Rootzone Salinity (ECe)

Pistachio Salinity Management

- UCB I rootstock
- Monitor soil and keep $EC_e < 8.4 \text{ dS/m}$
- Budget irrigate using evapotranspiration and pistachio $\rm K_{\rm c}$
- 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 - <u>33% leaching fraction</u>
- EC_e = 2 X (dS/m of Irrigation water)
 <u>10% leaching fraction</u>
- EC_e = 3 X (dS/m of Irrigation water)
 <u>5% leaching fraction</u>



Kemal Ataturk Dam, Turkey: 1990

OroBlanco

Ag Alert, Dec. 2007

"Grower Mark Watte is seeing a major shift from cotton production to permanent crops like pistachios...." 6/6/2018 24,896 ha





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

Industry Plan for Salinity Management

- Investigate the mechanism of salinity tolerance in pistachios
- Obtain and evaluate accessions
 - International contacts
- Aim toward a plant improvement program



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Muchas Gracias

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