Understanding and Managing Salinity for Walnuts

David Doll
Farm Advisor
UCCE Merced
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Agriculture and Natural Resources

Salinity Tolerance of Walnuts

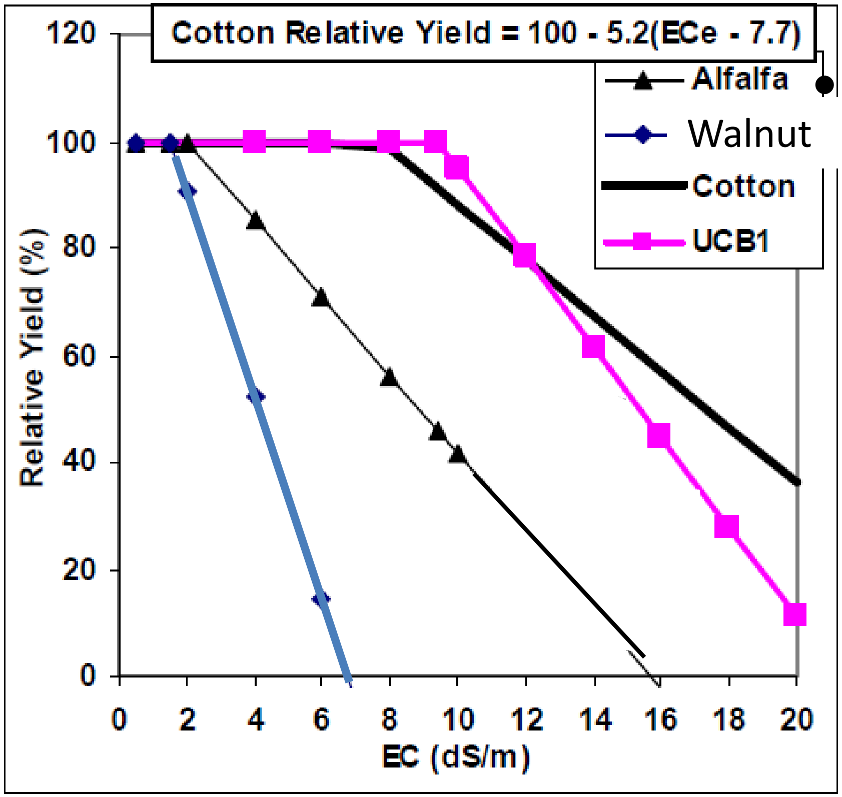

Fig. 2. Relative yield (RY) of various crops as a function of soil EC_e (Sanden, et al., 2004).

How Tough are Walnuts?

- Sensitive to Na, B, and Cl
- Unknown, but think every dS/m above 1.5 = 18-21 % growth rate decrease

Salinity of:	Unit	None	Increasing	Severe
	Degree of Growth/Yield Reduction			
Avg. root zone[1]	dS/m	< 1.5	1.5 – 4.8	> 4.8
Irrigation water[1]	dS/m	< 1.1	1.1 – 3.2	> 3.2

* Source: Adapted from E.V. Maas (1990), p. 280. Guidelines assume

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Salinity Tolerance of Walnut

Sources of Salts in CA ag:

Present in soils

Fertilizer and composts

Irrigation water

- Surface – tends to be cleaner
- Well – variable quality

Water analysis needs to be conducted to know the quality of water!

Well Water Analysis: Interpretation

Sample	pH	Ecw (dS/m)	Ca (meq/L)	Mg	Na	HCO3 (meq/L)	SO4	Cl	SAR	SARadj	B (ppm)
High	7.79	2.88	10.10	14.4	12.0	4.71	26.8	4.55	3.43	8.13	0.77
UC	<7.0	<1.1			SAR			<4.0	<3.0		<0.5

Water is not ideal!

	Degree of Growth/Yield Reduction			
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Well Water Analysis: Interpretation

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UC	<7.0	<1.1			SAR			<4.0	<[illegible]0		<0.5

Water is not ideal!

	Degree of Restriction None	 Increasing	 Severe
SAR	<3.0	3-9	>9.0
Chloride (meq/l)	<5	5-15	>15

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

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Acidifying water will drop adjusted SAR closer to reported SAR

pH dependent: Indicates that Ca2+ or Mg2+ will not remain free in soil solution

Water is too hot!

Well Water Analysis: Interpretation

Sample	pH	Ecw (dS/m)	Ca (meq/L)	Mg	Na	HCO3 (meq/L)	SO4	Cl	SAR	SARadj	B (ppm)
High	7.79	2.88	10.10	14.4	12.0	4.71	26.8	4.55	3.43	8.13	0.77
OK	7.89	1.20	4.33	3.5	6.42	1.77	10.1	0.99	3.25	5.44	0.46
UC	<7.0	<1.1			SAR			<4.0	<3.0		<0.5

Not the best water, but workable:

Adjust pH to free up calcium

Additional gypsum (~500 lbs/acre foot = 2 meq Ca increase)

Well Water Analysis: Interpretation

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OK	7.89	1.20	4.33	3.5	6.42	1.77	10.1	0.99	3.25	5.44	0.46
???	7.66	0.86	1.91	2.9	4.48	6.3	0.36	1.69	2.91	6.74	2.6
UC	<7.0	<1.1			SAR			<4.0	<3.0		<0.5

	Degree of Restriction		
	None	Increasing	Severe
Boron (mg/L)	<0.5	0.5-3.0	>3.0

Well Water Analysis: Interpretation

Water Infiltration Reduction Potential

Sample	pH	Ecw (dS/m)	Ca (meq/L)	Mg	Na	HCO3 (meq/L)	SO4	Cl	SAR	SARadj	B (ppm)
High	7.79	2.88	10.10	14.4	12.0	4.71	26.80	4.55	3.43	8.13	0.77
OK	7.89	1.20	4.33	3.5	6.42	1.77	10.1	0.99	3.25	5.44	0.46

Interpretive Guidelines – Slow Water Infiltration

Ratio	Potential to Develop Slow Water Intake Rates		
	None	Increasing	Severe
SAR/EC_w	< 5.0	5 - 10	> 10.0

Too *clean* of water reduces infiltration

Anecdotal Interpretive Guidelines – Ca:Mg ratio

Ratio	Potential to Develop Slow Water Intake Rates		
	None	Increasing	Severe
Ca:Mg	> 2.0	2.0 – 1.0	< 1.0

Too *little calcium reduces* infiltration

Well Water Analysis: Interpretation

Salinity Impacts:

- $EC_w > 1.5$ dS/m – growth can be impacted
- SAR > 3
- Chlorides > 5 meq/L
- Boron > 0.5 ppm

Infiltration Issues:

- SAR/ $EC_w < 5.0$
- Ca:Mg >2.0

Plugging (not covered)

- Total salts, bicarbonate and carbonate load, manganese, and iron

Lowering pH of Irrigation Water

Titration for water must be performed to determine amounts needed.

Send water plus acid of choice to a local lab.

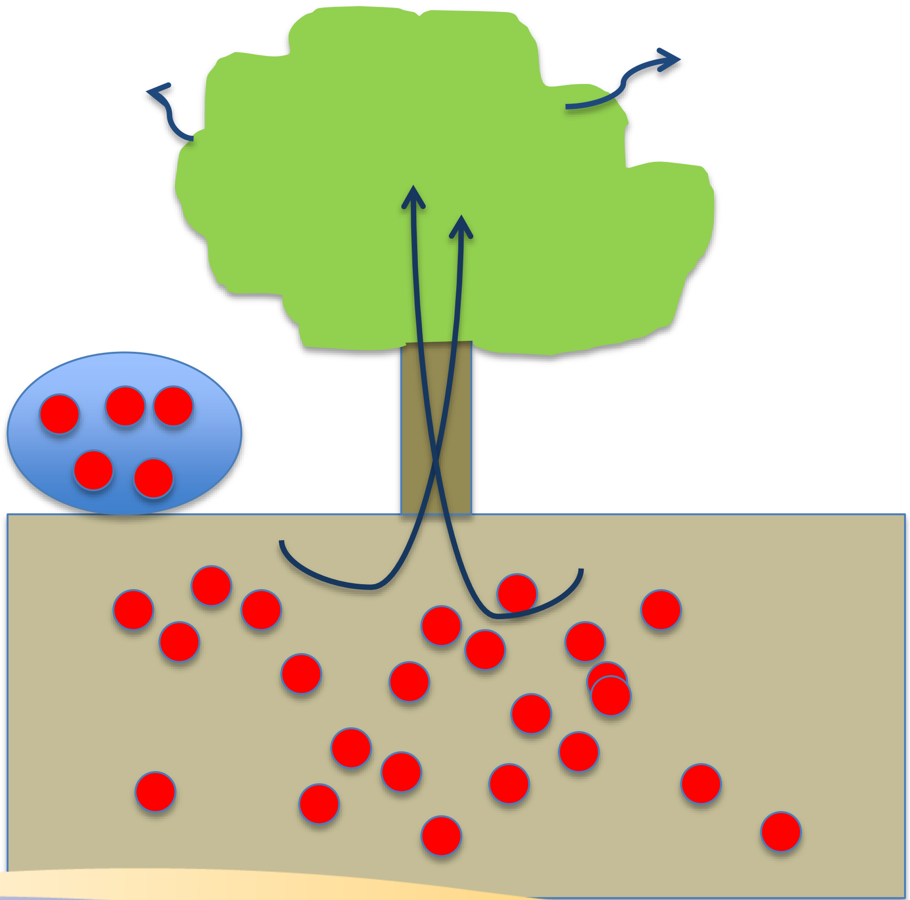
Adding Calcium to Irrigation Water

Salt	Formulation	Solubility (distilled water @20°C, at ph=7)		Soil Rxn and effect on pH
		(g/100 mls)	General rating	
Calcium nitrate	$Ca(NO_3)_2$	121	Highly soluble	Gradual, Neutral
Calcium chloride dihydrate	$CaCl_2 \cdot 2H_2O$	98	Highly soluble	Gradual, Neutral
Calcium chloride	$CaCl_2$	74	Highly soluble	Gradual, Neutral
Calcium acetate	$C_4H_6CaO_4$	34.7	Highly soluble	Increase pH of acid soils
Gypsum	$CaSO_4 \cdot 2H_2O$	0.26	Moderately soluble	Gradual, Neutral
Dolomite	$CaMg(CO_3)_2$	0.03 (depends on soil ph)	Low solubility	Increase pH of acid soils
Lime	$CaCO_3$	0.005 (depends on soil ph)	Very low solubility	Increase pH of acid soils
By-product ash	CaO or $Ca(OH)_2$	Variable (depends on soil pH)	Very low solubility	Increase pH of acid soils
Source: CRC Handbook of Chemistry and Physics, 56th Edition				

Adding Calcium to Irrigation Water

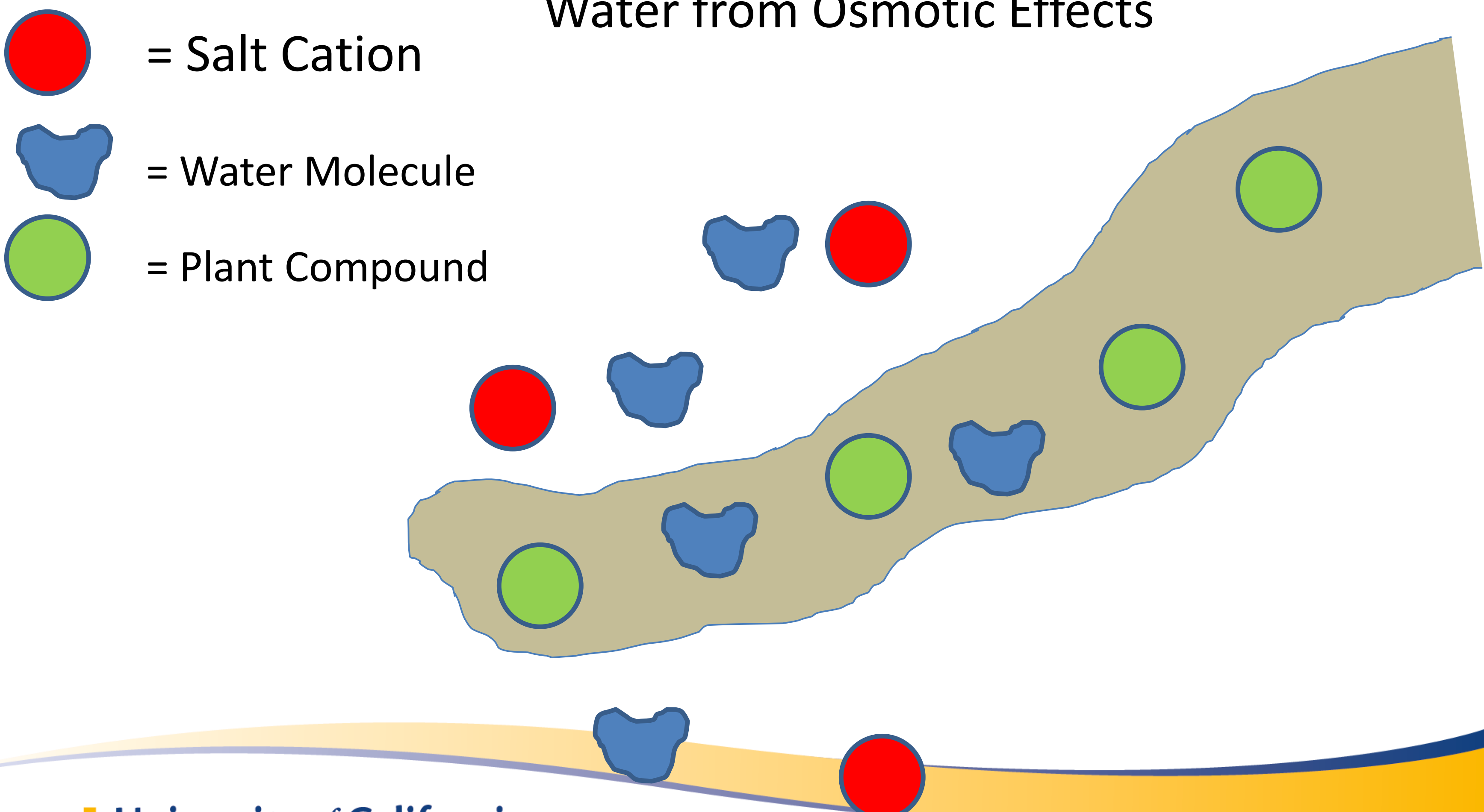
- In solution: ~ 250 lbs of gypsum/acre ft to increase one meq/l of calcium
- Land grade applications made monthly


Walnut Salinity Issues: Salt Accumulation



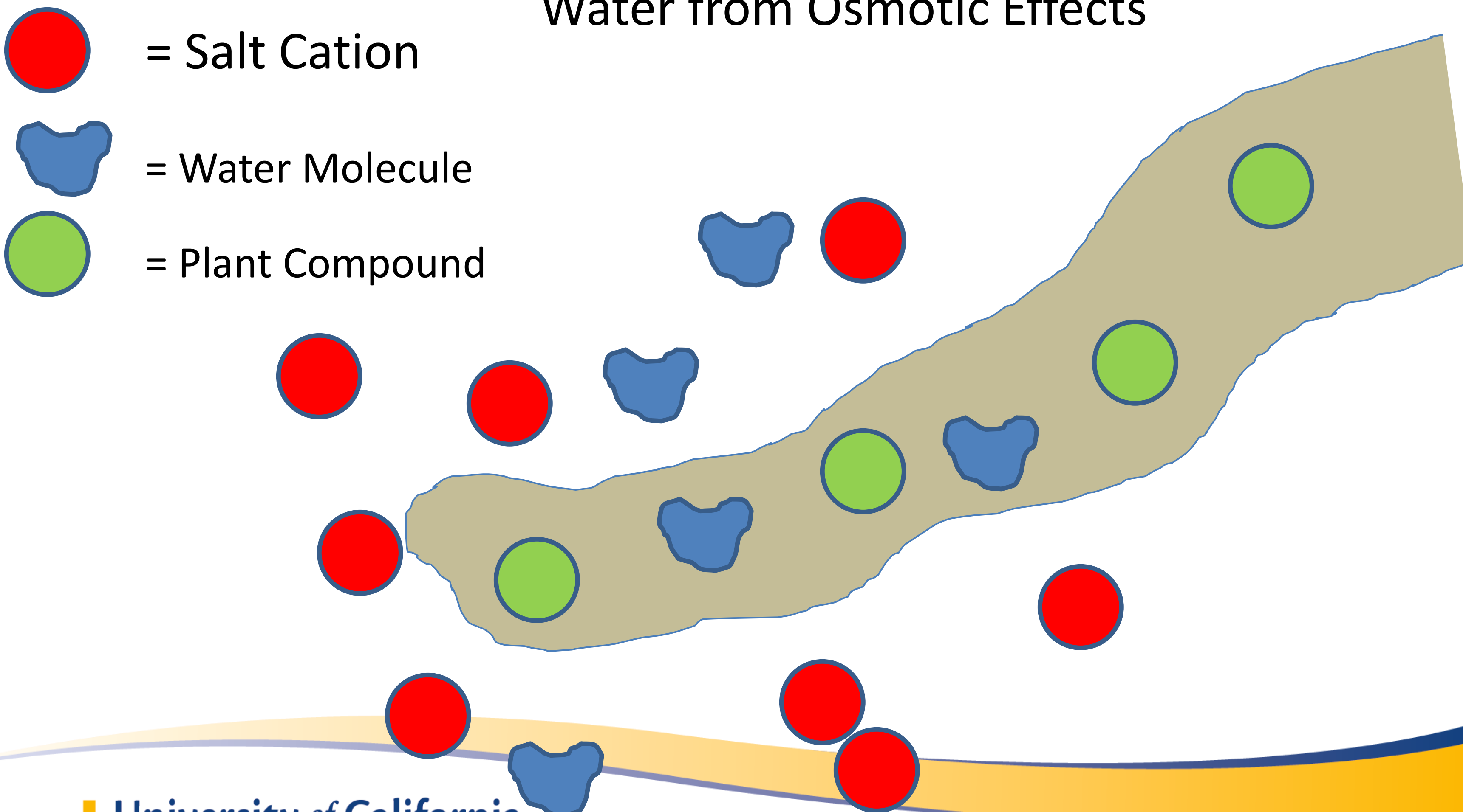
Walnut Salinity Issues: Osmotic Effect

Low Salinity: Movement of Water from Osmotic Effects



Walnut Salinity Issues: Osmotic Effect

High Salinity: Movement of Water from Osmotic Effects



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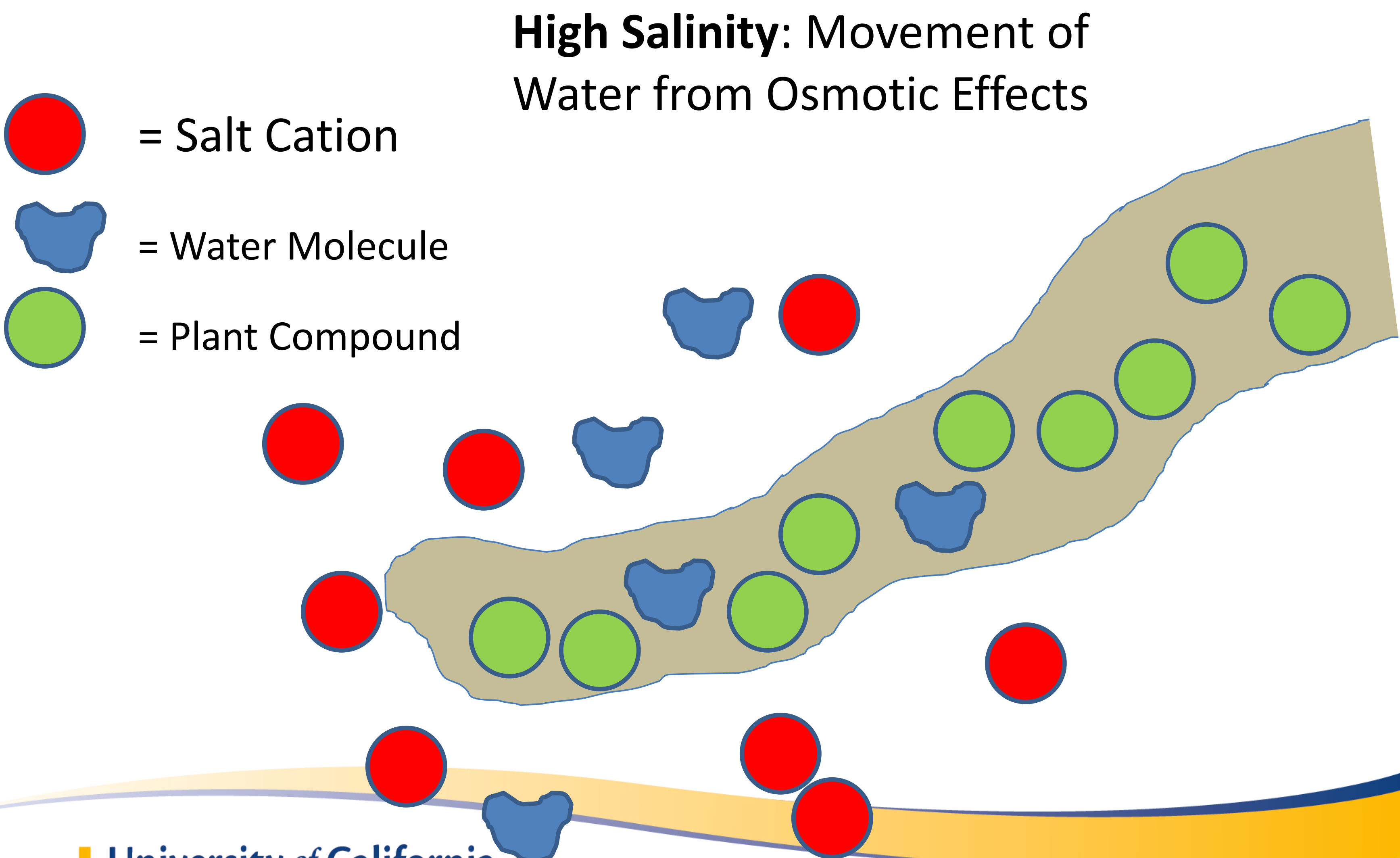
Walnut Salinity Issues: Osmotic Effect



Walnut Salinity Issues: Osmotic Effect

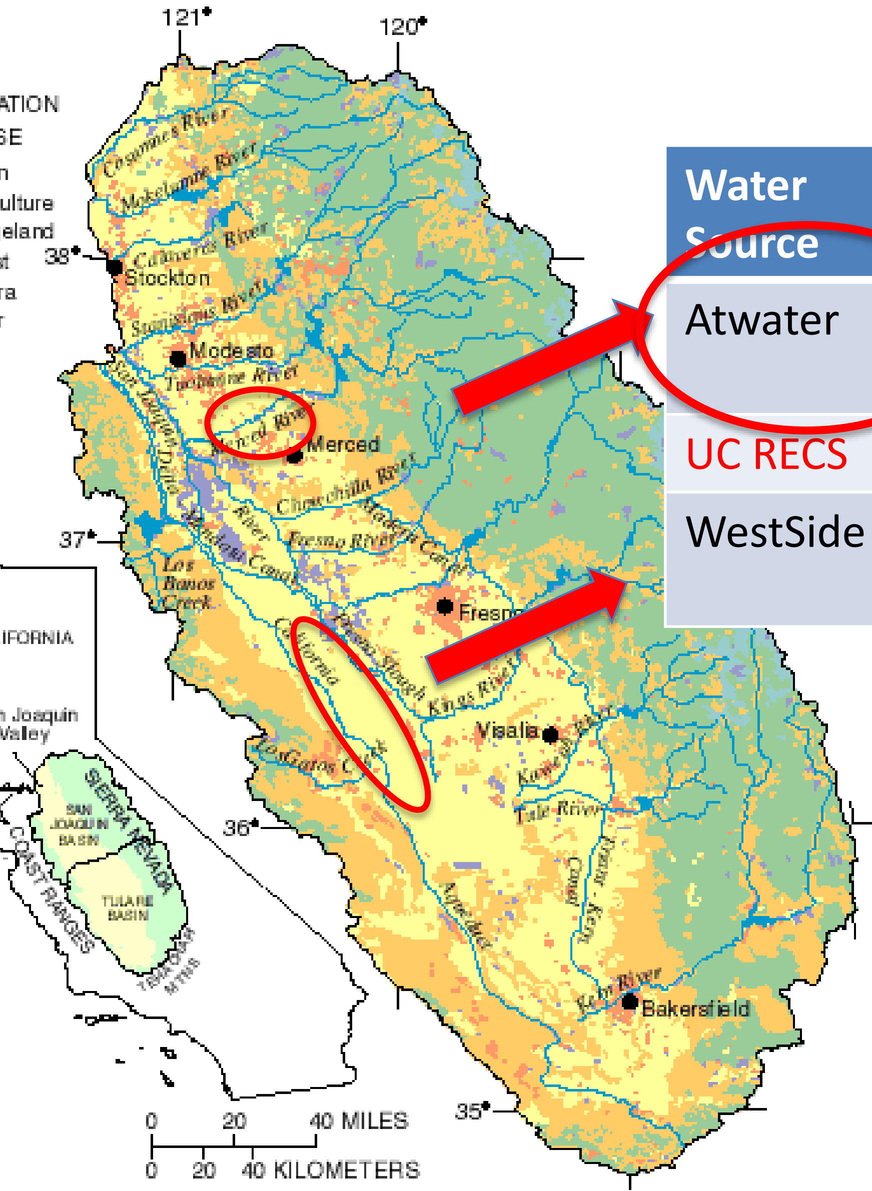
Plant expends energy to create compounds to maintain osmotic gradient; reduces energy for crop

At some level, salt levels increase above the roots capacity to exclude-- uptake occurs

Walnut Leaf Tissue: Toxicity

July Samples	Degree of Restriction		
	None	Increasing	Severe
Sodium (%)	<0.1	0.1-0.3	>0.30
Chloride (%)	<3.0	3.0-0.5	>0.5
Boron ppm	<36	36-200	>200

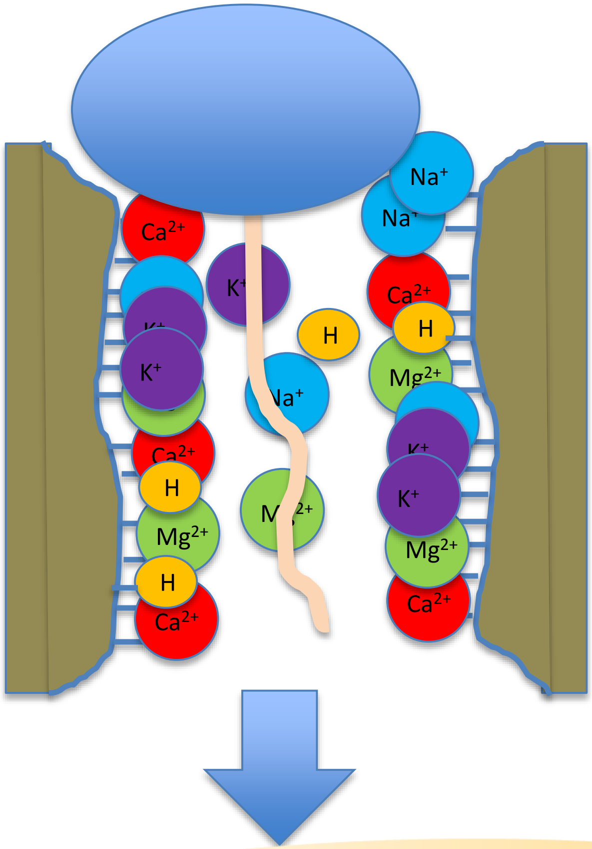
Salinity Issues: Soil Effects



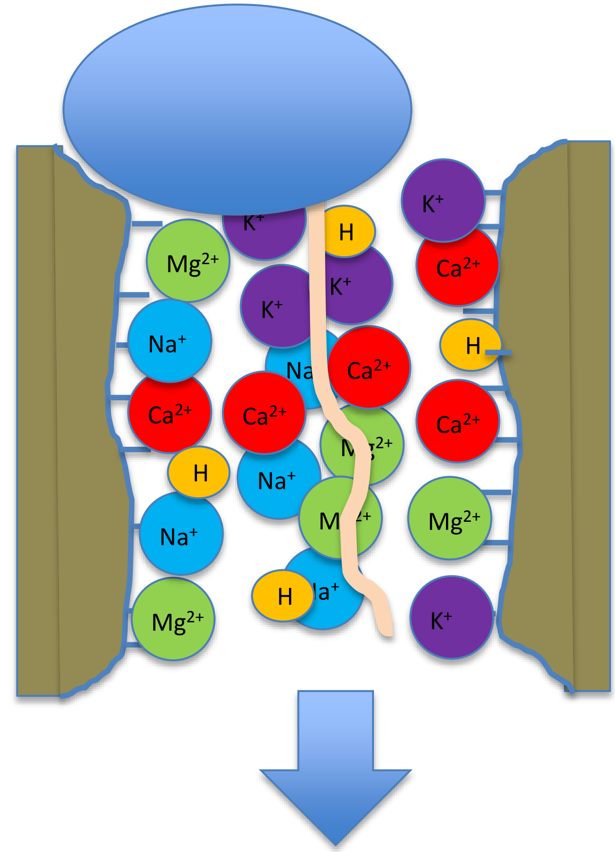
Water Source	pH	EC dS/m	Sodium (meq/l)	Calcium (meq/l)	Mg (meq/l)	SAR/ adj SAR
Atwater	7.6	0.32	6.35	2.10	5.59	3.2/6.15
UC RECS		<1.1	<3.0			
WestSide	8.3	1.24	7.6	3.5	0.7	5.2/11.1

Salinity Issues: Soil Effects

Soil with high CEC



Soil with low CEC



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Salinity Issues: Soil Effects

Low Exchange Capacity Soils will show sodium toxicity before high exchange capacity soils.

Leaf Tissue: Toxicity

- Trees are already experiencing osmotic effects prior to showing symptoms
- Can occur rapidly
- Takes 2-3 years of effective leaching to reduce tissue levels, regain productivity

Salinity Management: Winter Leaching Programs

- Leaching is the primary step to manage salts but it is not necessary every irrigation or perhaps even every season, only when crop tolerances are approached
- Periodic soil testing in the root zone will help determine when and how much leaching is needed
- Leaching is most efficient in the winter when crops are dormant and ET is low. Also this timing does not coincide with critical periods of nitrogen fertilization and uptake

Salinity Management: Winter Leaching Programs

Research based estimates as to how much leaching may be needed to reclaim an orchard back to tolerable levels

Leaching Requirement	Proportion that orchard root zone salinity exceeds threshold salinity				
	1.3X	2X	2.6X	3.3X	4X
Depth of water (inches) per foot of rootzone	0.6	1.8	3.0	4.2	5.4

Walnut Salinity Management: Winter Leaching Programs

- The soil water content must exceed field capacity in the root zone for leaching to occur
  - Have profiled filled prior to beginning of rains (~ early Dec)
  - Have Leaching Program completed by mid-February

- Intermittent periods of irrigation and rainfall will more efficiently leach salts and boron than continuous

Almond Salinity Management: Rootstock Selection

ROOTSTOCK	Boron (ppm)	Chloride (%)	Sodium (ppm)
Black	480 b	0.7 c	56 b
Paradox	667 a	1.8 b	87 b
English	704 a	2.1 a	125 a
Excess Level	300	0.3	100

Rootstock selection does impact salinity tolerance with Black more tolerant than English (Study by J. Caprille).

Concluding Thoughts

- Spend some time to improve distribution uniformity in orchard
- Be careful with too salty of water – may do more harm than good!
- Know your water, soil, and utilize a leaching program
- Monitor tissue levels consistently