Strategies in managing salinity for Avocado Production

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Persea americana Mill.

- 3 horticultural races
- Relatively "new" crop to domestication
- Highly diverse
- Remain adapted to their native neotropical rainforest habitat
- Tree physiology is not well understood

	Mexican	Guatemalan	West Indian
Native Region	Mexican Highlands	Guatemalan Highlands	Tropical lowlands
Climactic Adaptation	Subtropical	Subtropical	Tropical
Cold Tolerance	Most	Intermediate	Least
Salinity Tolerance	Least	Intermediate	Most
Iron Chlorosis	Intermediate	Least	Most
Alternate Bearing	Less	More	Less

Avocado is relatively new to domestication---Breeding

- Breeders worldwide rely on planting thousands of seeds with a selection rate of 0.2–0.3%.
- Avocado trees naturally set fruit on less than 0.01% of blossoms, making controlled pollination difficult.
- Avocado has long juvenile period, thus it takes years before you see potential success for rootstocks or scions.

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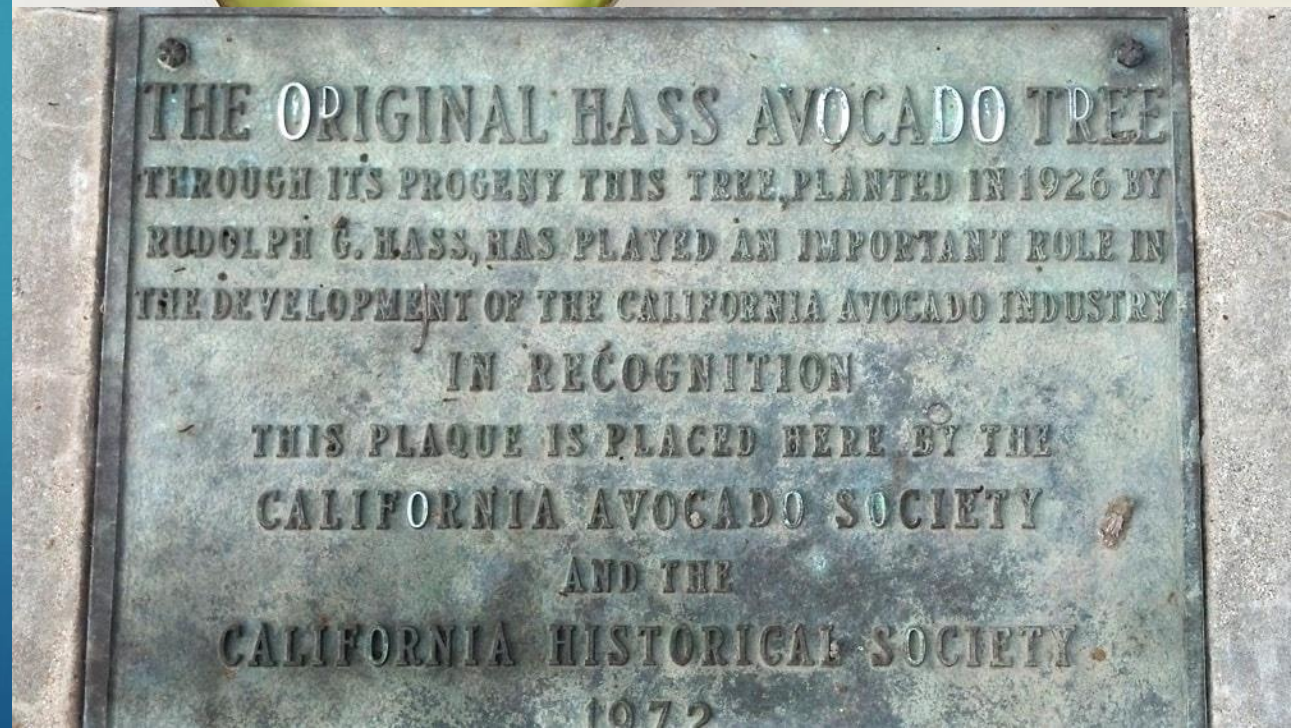
Rudolph Hass, a California postman, patented the Hass avocado variety in 1935.



California Avocado Association 1939 Yearbook 23: 110-112

Effects of pH on the Growth of Avocado Seedlings

A. R. C. HAAS
University of California Citrus Experiment Station, Riverside, California

4.74 4.93 6.48 6.62 6.74

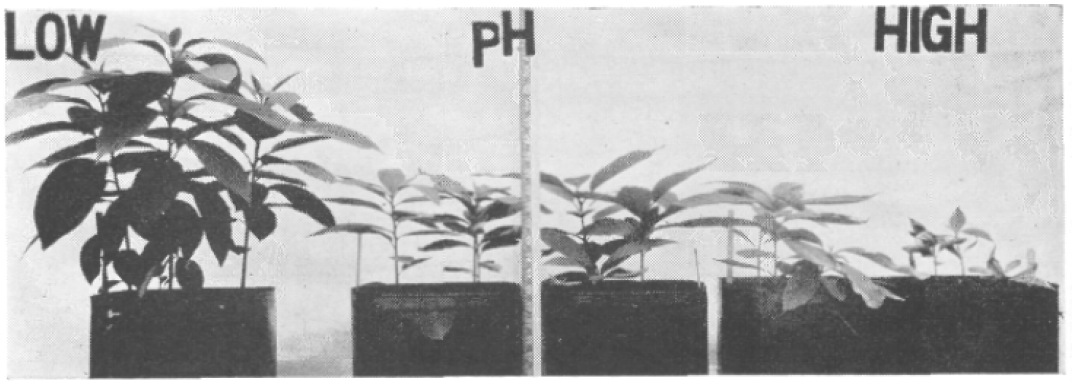


Fig. 2—Effect of soil at different pH values on the growth of avocado seedlings.

It is seen that the avocado seedlings responded very well not only in culture solutions with pH values as low as 4.5 but also in soil cultures having low pH values. Studies are being continued further in the hope of understanding the actual pH at which avocado trees are growing in orchards in the field.

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California Avocado Society 1949 Yearbook 34: 139-143

GROWTH OF AVOCADO SEEDLINGS AS AFFECTED BY THE RATE OF SOIL DRAINAGE

A. R. C. HAAS
Citrus Experiment Station, Riverside, California

The control of soil moisture is frequently interfered with by one or more factors such as silt or clay deposits of varying thickness and continuity, abrupt or marked changes in the pore space at various soil depths, hardpans, excessive rainfall, and an impaired state of health in the rootlets that reduces their absorption of water. When leaves become chlorotic (yellow with the veins remaining green) they utilize less soil moisture and their condition becomes steadily worse unless the amount of irrigation water applied is reduced.

When irrigation water is applied to the soil, it wets to the field capacity all of the soil through which it passes. Prolonged retardation in the movement of soil moisture serves to unduly delay the introduction of air (containing oxygen) into the excessively wet area.

California Avocado Society 1949 Yearbook 34: 139-143

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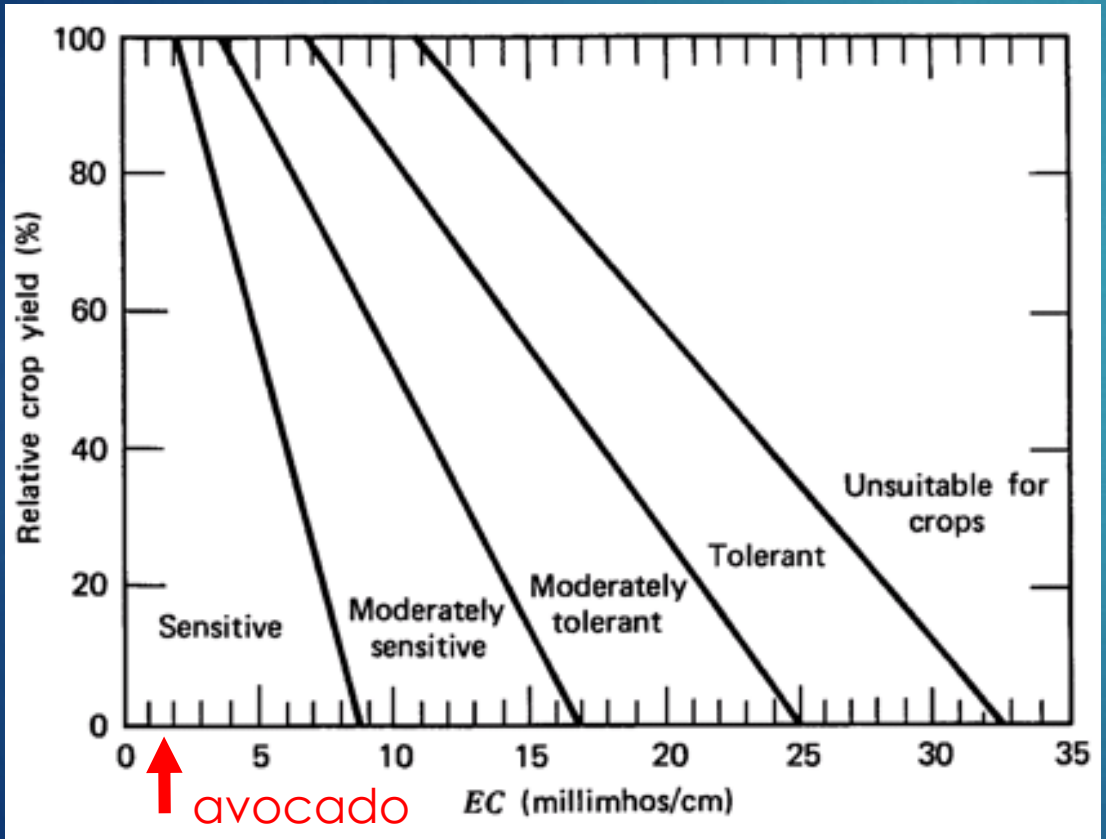
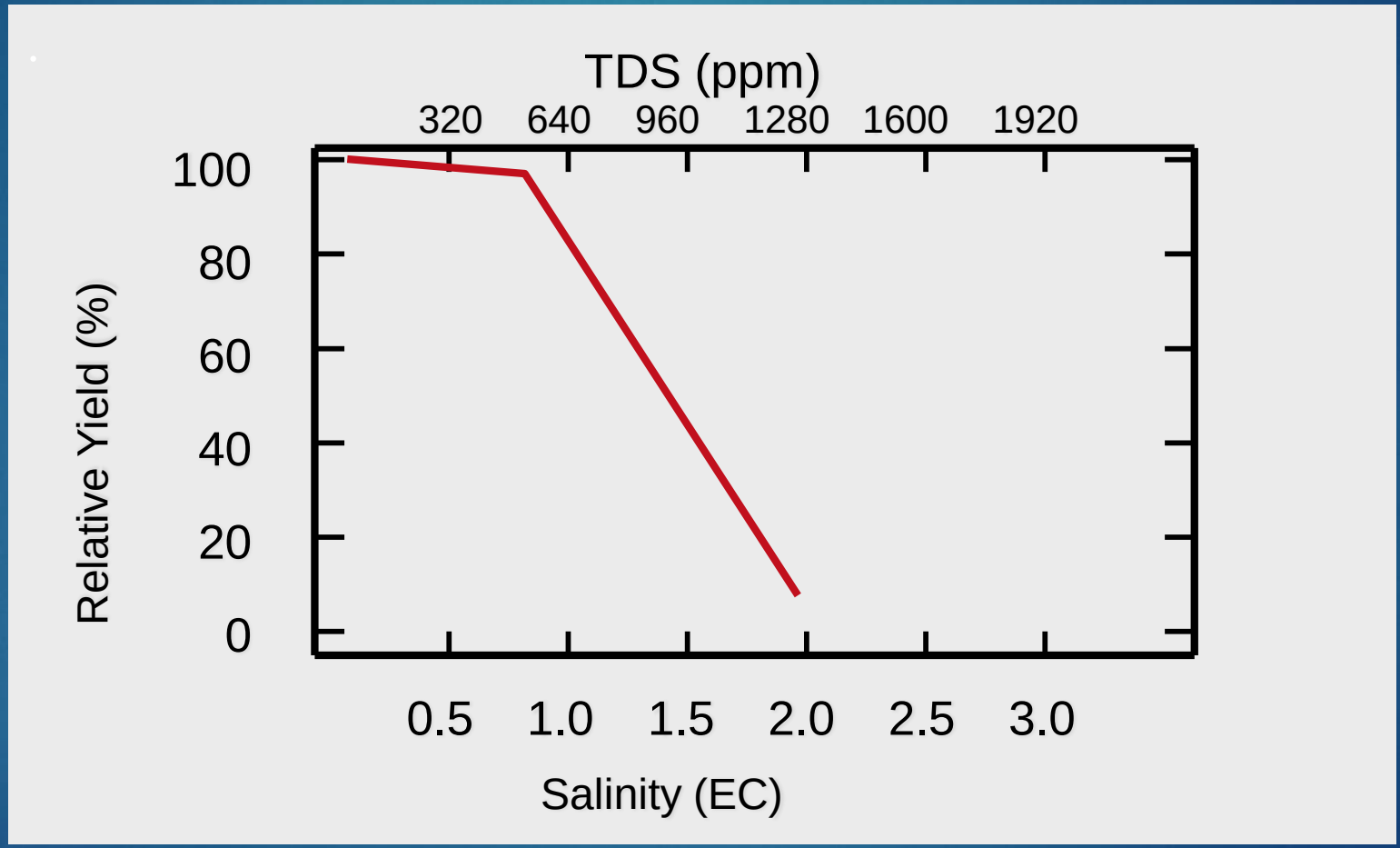
Avocado is one of the most saline sensitive crops and irrigating with saline water leads to yield reduction.



High Salt Tolerance	Medium Salt Tolerance	Low Salt Tolerance
Date Palm	Pomegranate	Pear
	Fig	Apple
	Olive	Citrus
	Grape	Stone fruits
	Cantaloupe	Strawberry
		Lemon
		Avocado (most sensitive)

USDA Handbook 60

Avocado Yield Function for Irrigation Water Salinity



Oster and Arpaia, J. Am Soc. Hort Sci., 2007

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High salinity and chloride toxicity results in reductions in:

- Yield
- Tree size
- Chlorophyll content
- Photosynthesis
- Root growth

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Problem

- Water quality is diminishing. Some water districts are imposing reclaimed water for agricultural users.
- Avocado is sensitive to saline irrigation water resulting in yield loss at EC levels > 0.75 dS/m, 100 ppm Chloride.
- Saline irrigation water is common in California.

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In 2013, we initiated a trial to determine salinity tolerance on new rootstocks.

- We took a newly planted rootstock trial for testing for root rot and transformed it into a salinity trial.

Compound	Concentration (g/l)
$CaCl_2$	1.738
$MgCl_2$	1.517
NaCl	0.241
KNO_3	0.063
$Na_2(SO_4)$	4.965
KCl	0.008

Composition of our saline water treatment mimicked Colorado River water composition and adjusted to an EC of 1.5 dS/m with 175 ppm chloride

Field site

Salinity Sensitive rootstock

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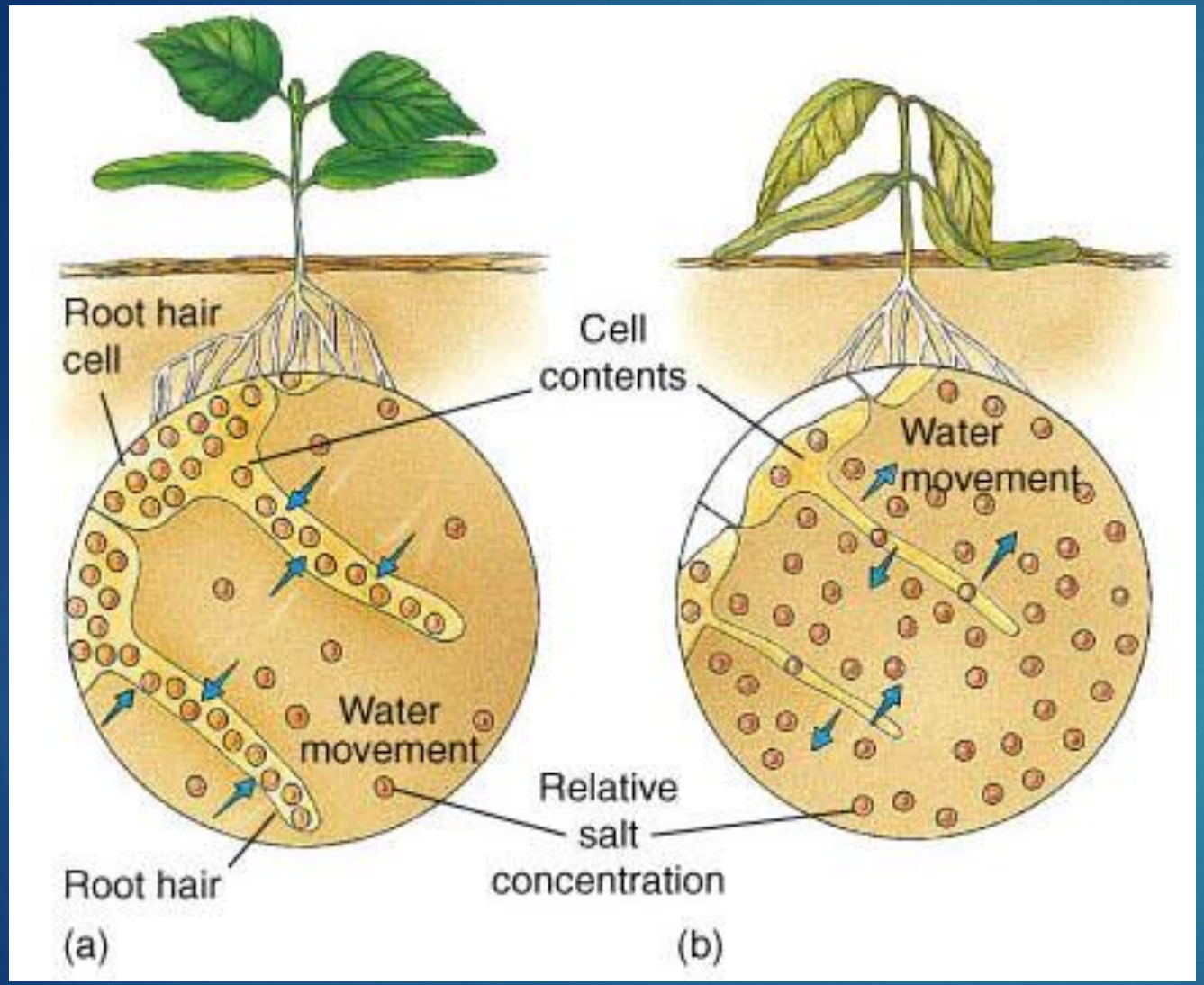

The problem with Total Dissolved Salt is that high salt inhibits plant water uptake

For avocado, this occurs at EC = 4 dS/m

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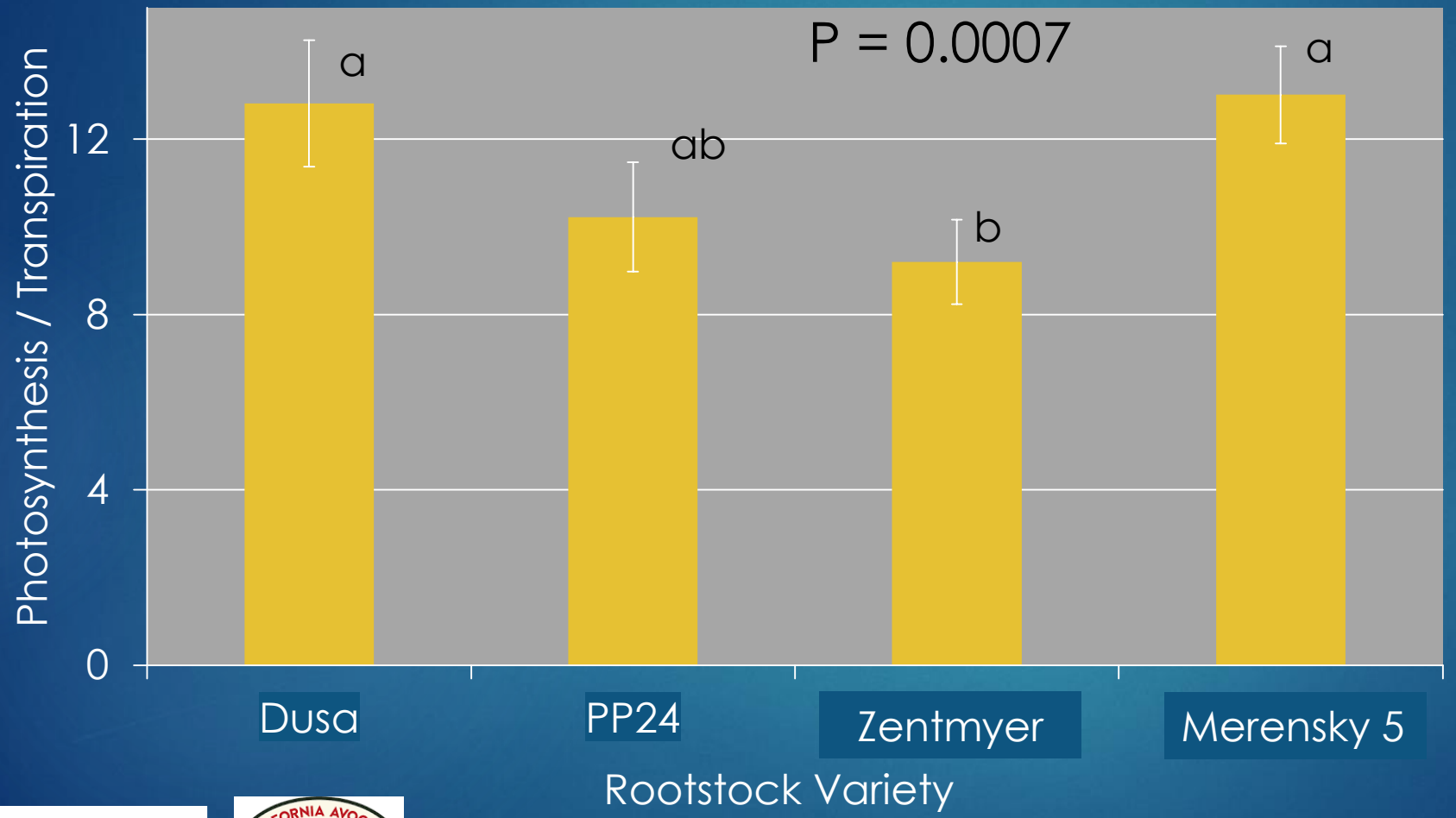
Photosynthesis – Salinity



Zentmyer had reduced photosynthesis and was most sensitive to salinity. Merensky 5 and Dusa were more salt tolerant and this is reflected in the photosynthetic rate.

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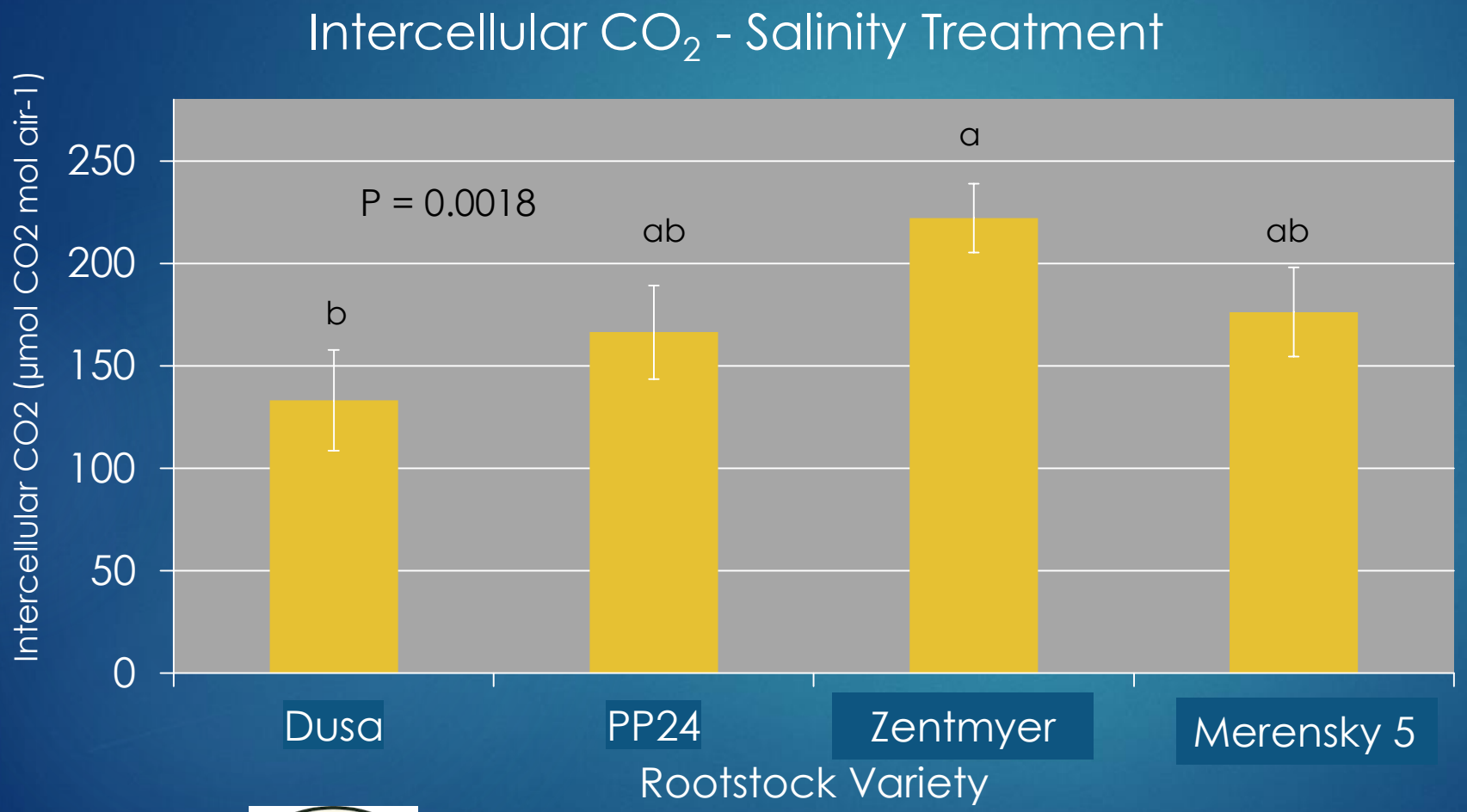
Celis, N., Suarez, D. L., Wu, L., Li, R., Arpaia, M. L., & Mauk, P. (2018) HortScience

Water use efficiency



Zentmyer was the least efficient in water use and most sensitive to salinity.

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Celis, N., Suarez, D. L., Wu, L., Li, R., Arpaia, M. L., & Mauk, P. (2018) HortScience

PP40 – 3 years of salinity treatments. Year 1, we used a 10% leaching fraction. Years 2 and 3, we used a 20% leaching fraction with each irrigation.

Control

Control was at EC 0.06 dS m^{-1}

Salt

Salt treatment was at EC 1.5 dS m^{-1}

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Rootstock results

- One of the best indicators of salinity tolerance is leaf analysis. Rootstocks that exclude chloride have low chloride content in leaf tissue.
- Selections such as Merensky 5 showed a promising increase in water use efficiency under saline conditions.
- Selections such as PP40 (not yet released) showed salinity tolerance as well as root rot resistance.
- Dr. Patty Manosalva (UCR) is conducting numerous trials throughout the state to determine the next best rootstock.

Breeding rootstocks tolerant or resistant to salinity and root rot takes time. Selections are a matter of calculated chances. It takes years to test if the selection is successful.

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Calculated chances?

Designed planting with promising selections positioned to optimize natural cross-pollination and then planting out the progeny.

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Rootstock selection process

Measure yield for 5-8 years

Harvest and plant seeds from breeding blocks

Test for root rot/salinity tolerance

Clonal propagation and plant in field

Observe for other traits (dwarfing)

Plant in expanded trials

Patent, release, adoption

Years 9-20

Years 7-8

Years 2-3

Years 4-6

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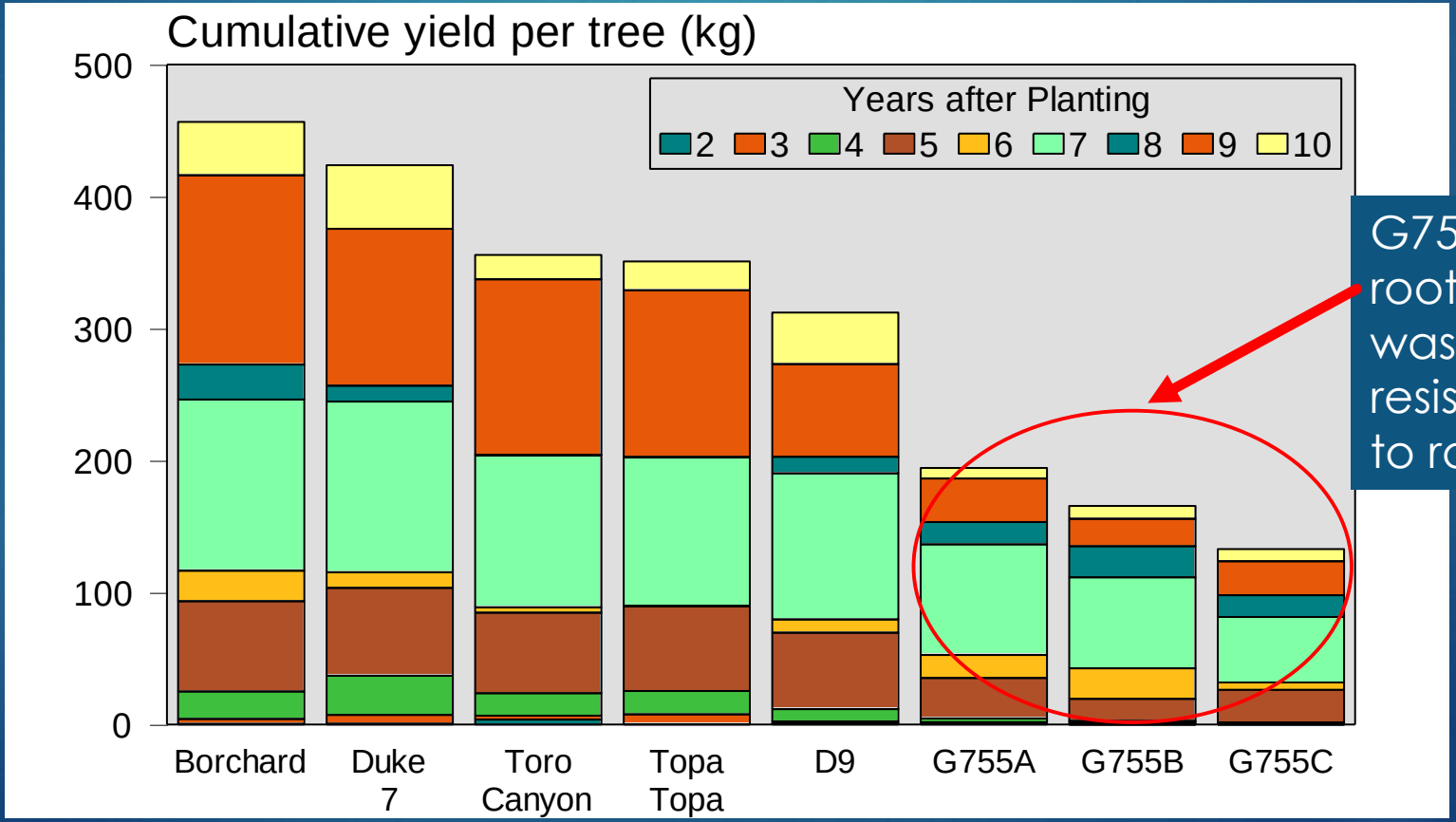
UCR researchers found G775 was very resistant to root rot. It was released. After 10 years of production, G775 yielded less than ½ of Duke 7. It was deemed a failure.



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Rootstock influences yield, tree size, nutrient uptake, salinity tolerance and alternate bearing

Duke 7

G755C

Tree Size – South Africa

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Suitability of Water for Irrigation

Quality	Electrical Conductivity (millimhos/cm)	Total Salts (ppm)	Sodium (% of total salts)	SAR	pH
Excellent	0.25	175	20	3	6.5
Good	0.25-0.75	175-525	20-40	3-5	6.5-6.8
Permissible	0.74-2.0	525-1400	40-60	5-10	6.8-7.0
Doubtful	2.0-3.0	1400-2100	60-80	10-15	7.0-8.0
Unsuitable	>3.0	>2100	>80	>15	>8.0

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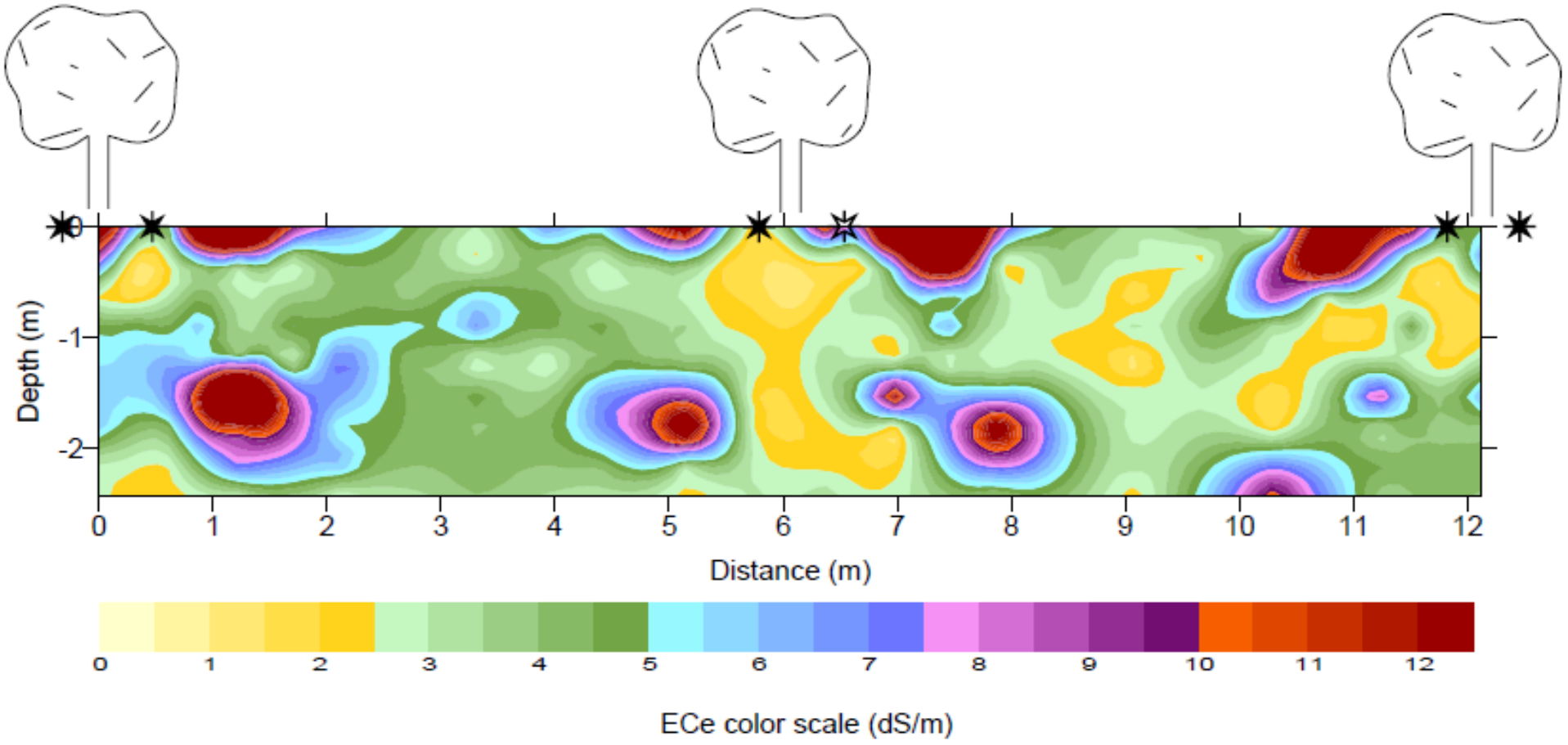
Salt Accumulation in Tree Crop Orchards Using Drip Irrigation



Soil Salinity Accumulation in Orchards with Drip and Micro-spray Irrigation in Arid Areas of California
http://www.itrc.org/reports/salinity/treecropsalinity.pdf ITRC Report No. R 03-005

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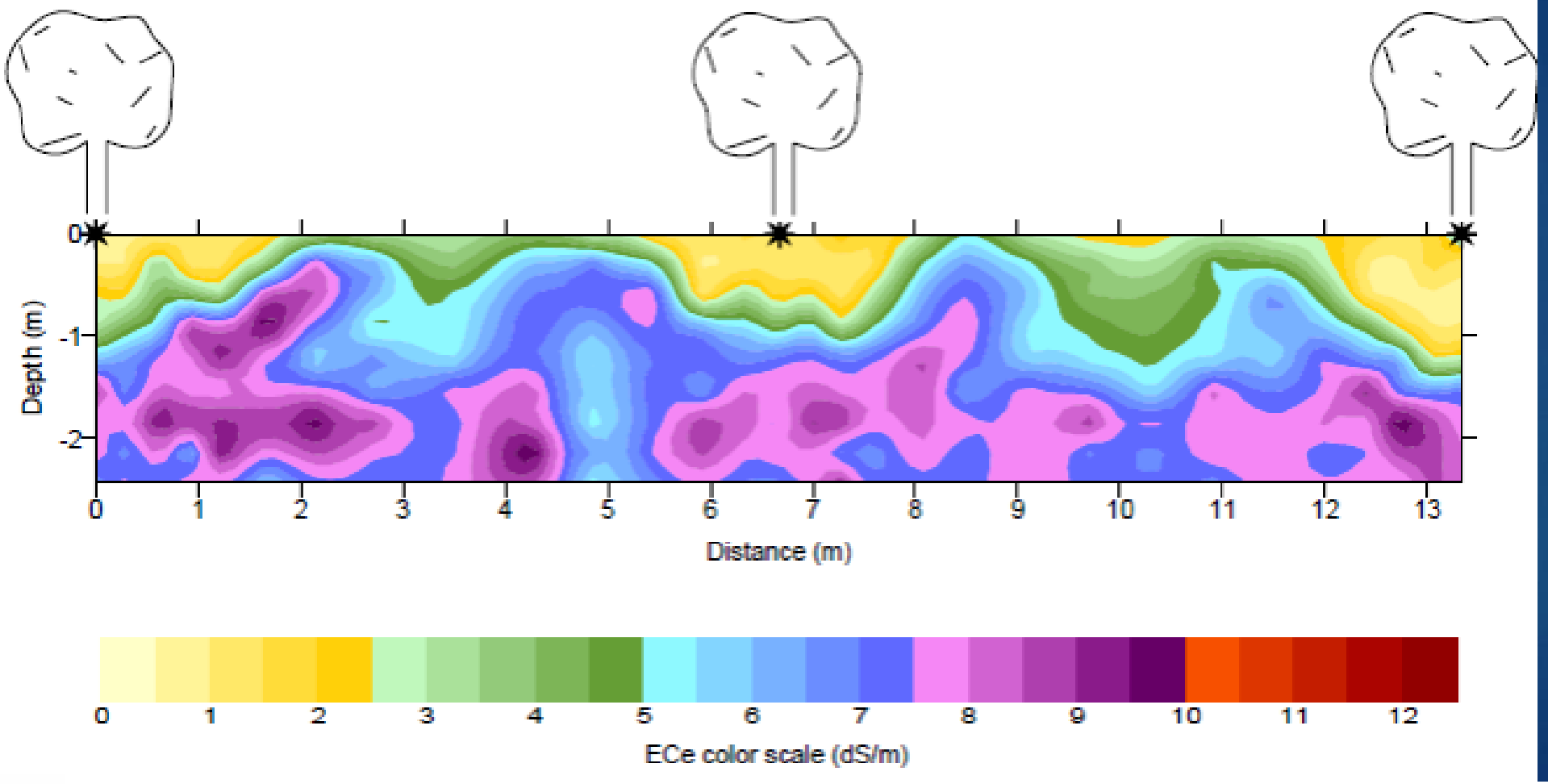
Salt Accumulation in Tree Crop Orchards Using Micro-spray irrigation



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Rooting zone – salinity management

- Avocado feeding roots are in the upper 8-12 inches of soil with a preference for roots on the soil surface under the leaf mulch.
- Salinity management is dependent upon moving salts beyond the root zone.
- Leaching with each irrigation keeps salts moving away from the roots.

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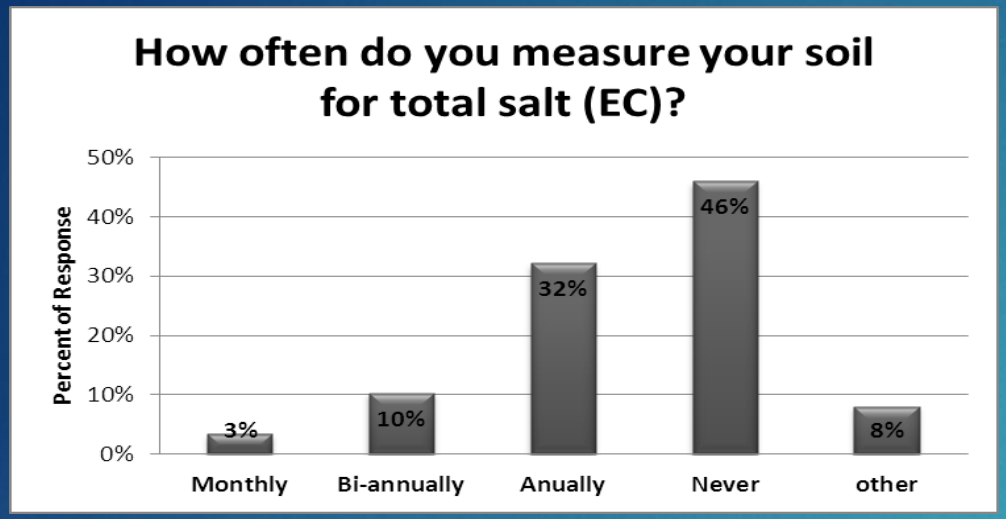
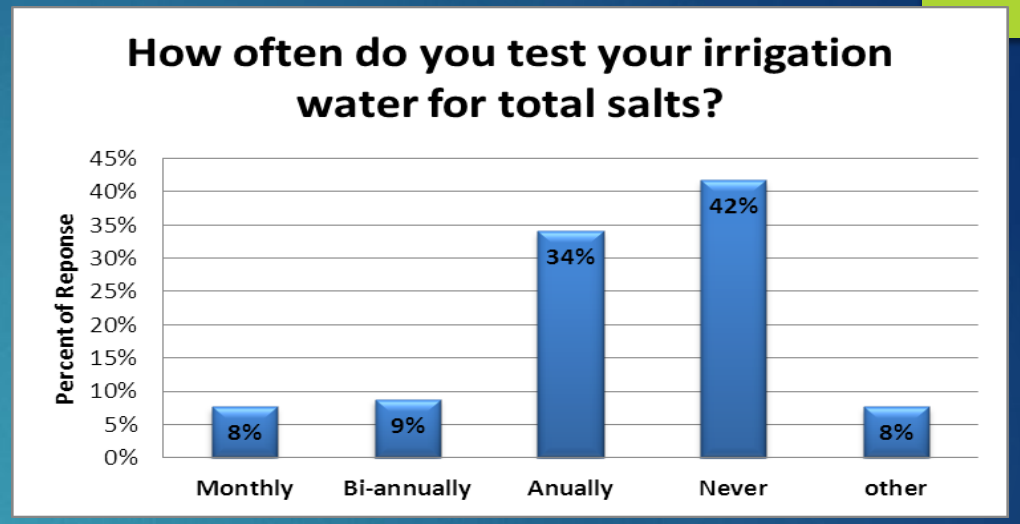
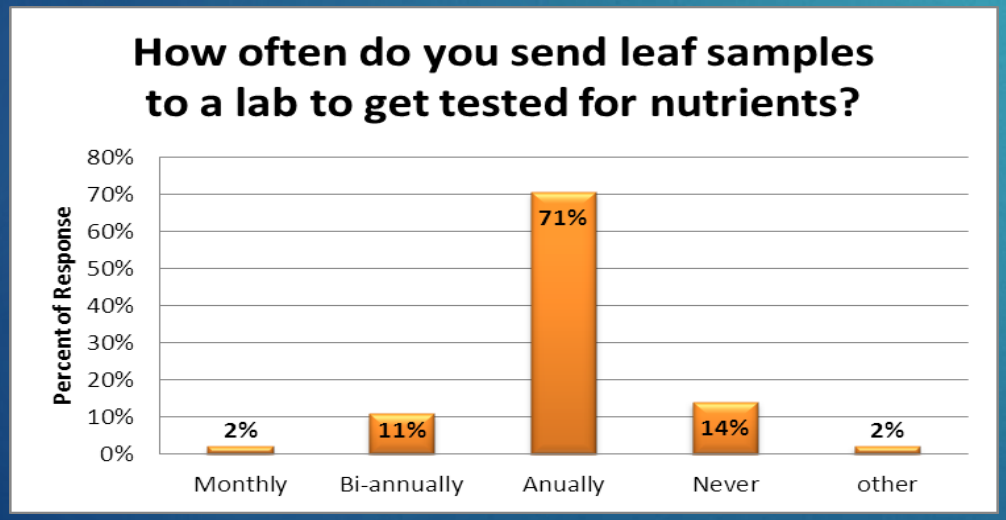
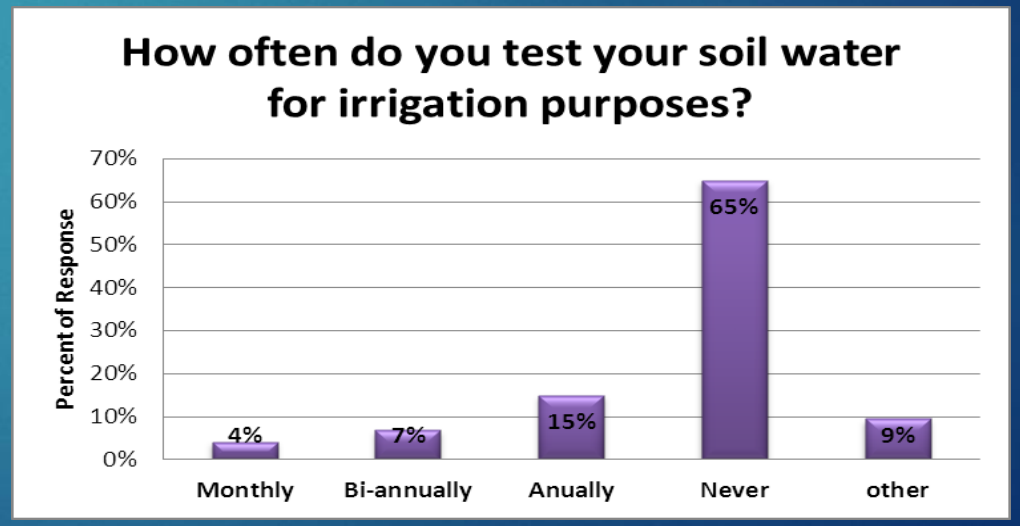
Grower Survey 2014, David Crowley (UCR)









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Recommendations

- One of the best indicators of salinity tolerance is leaf analysis. Rootstocks that exclude chloride have low chloride content in leaf tissue.
- The key to managing salts is to move salts past the rooting zone. Add a leaching fraction.
- Leach soils but consider pulse irrigation to avoid hypoxia in heavy soils, this also provides water savings.
- Lower pH using practical methods, elemental sulfur additions or use a sulfur burners. Avoid sulfuric acid – dangerous.
- Future plantings use the salinity tolerant rootstocks, hopefully more to be released and continue leaching salts.
- Combining tolerant rootstocks with salinity tolerant scions will be the silver bullet.

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