Managing Avocado Fertilization and Irrigation Practices for Improved Yields and Fruit Quality

David Crowley, Mary Lu Arpaia, Ariel Dinar, Julie Escalera
Dept of Environmental Sciences, University of California, Riverside, and UC Kearney Agricultural Center, Parlier, CA

ISSUE BRIEF

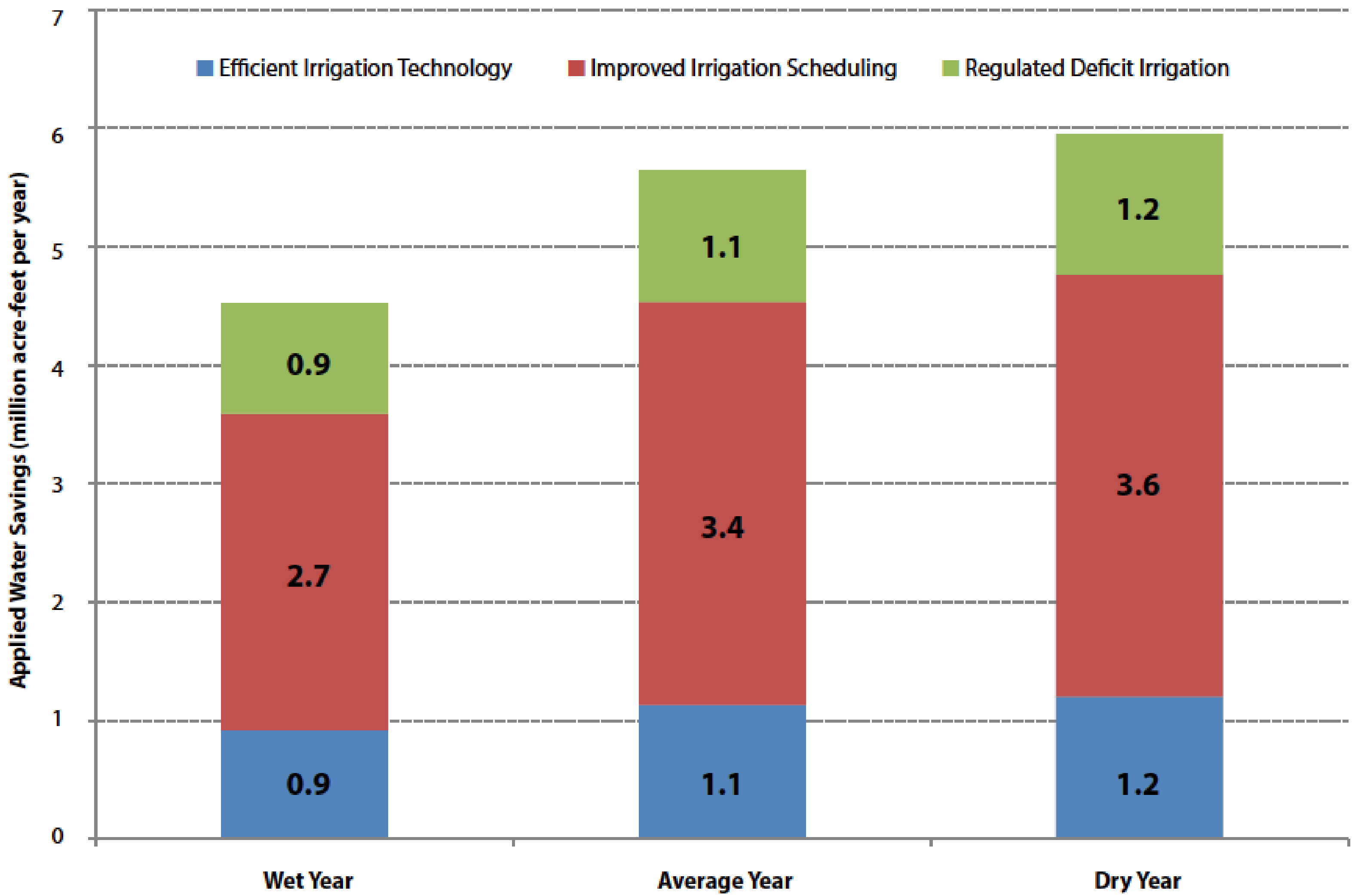
JUNE 2014
IB:14-05-F

Agricultural Water Conservation and Efficiency Potential in California

Agriculture uses about 80 percent of California's developed water supply. As such a large user, it is heavily impacted by the availability and reliability of California's water resources. Agriculture can also play an important role in helping the state achieve a more sustainable water future. The challenge is to transition to an agricultural sector that supplies food and fiber to California and the world and supports rural livelihoods and long-term sustainable water use.

Fertilization and Irrigation

Figure 4. Potential reductions in agricultural water use (in million acre-feet) in wet, average, and dry years



Source: Cooley et al. (2009).

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

How Much Salt is in Your Water?

4 Acre Feet:

612 - 968 kg NaCl

2464 kg total dissolved salt


Salt Burn: Chloride Toxicity

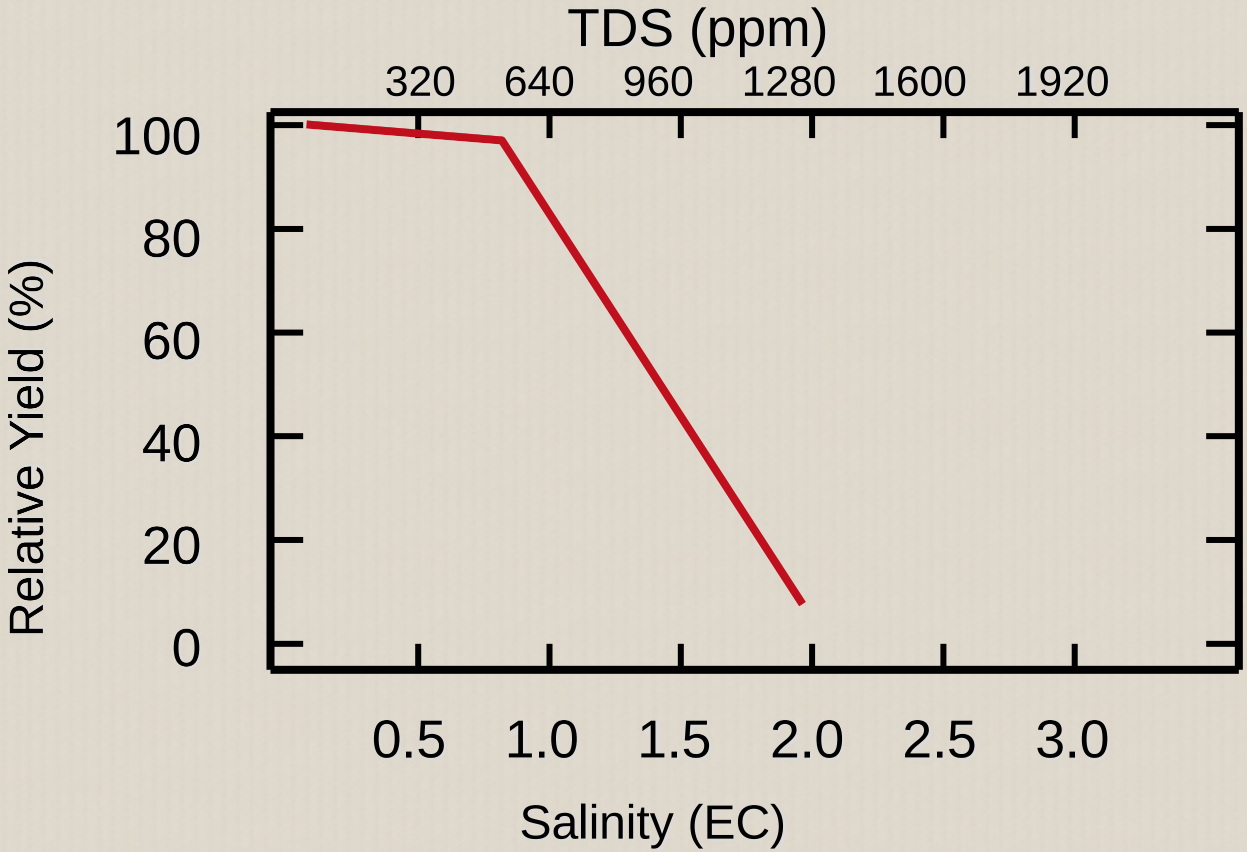
Combined Effects of Chloride and Sodium Toxicity on Avocado Trees

Chloride 0.58%
Sodium 0.35%

Chloride 0.61%

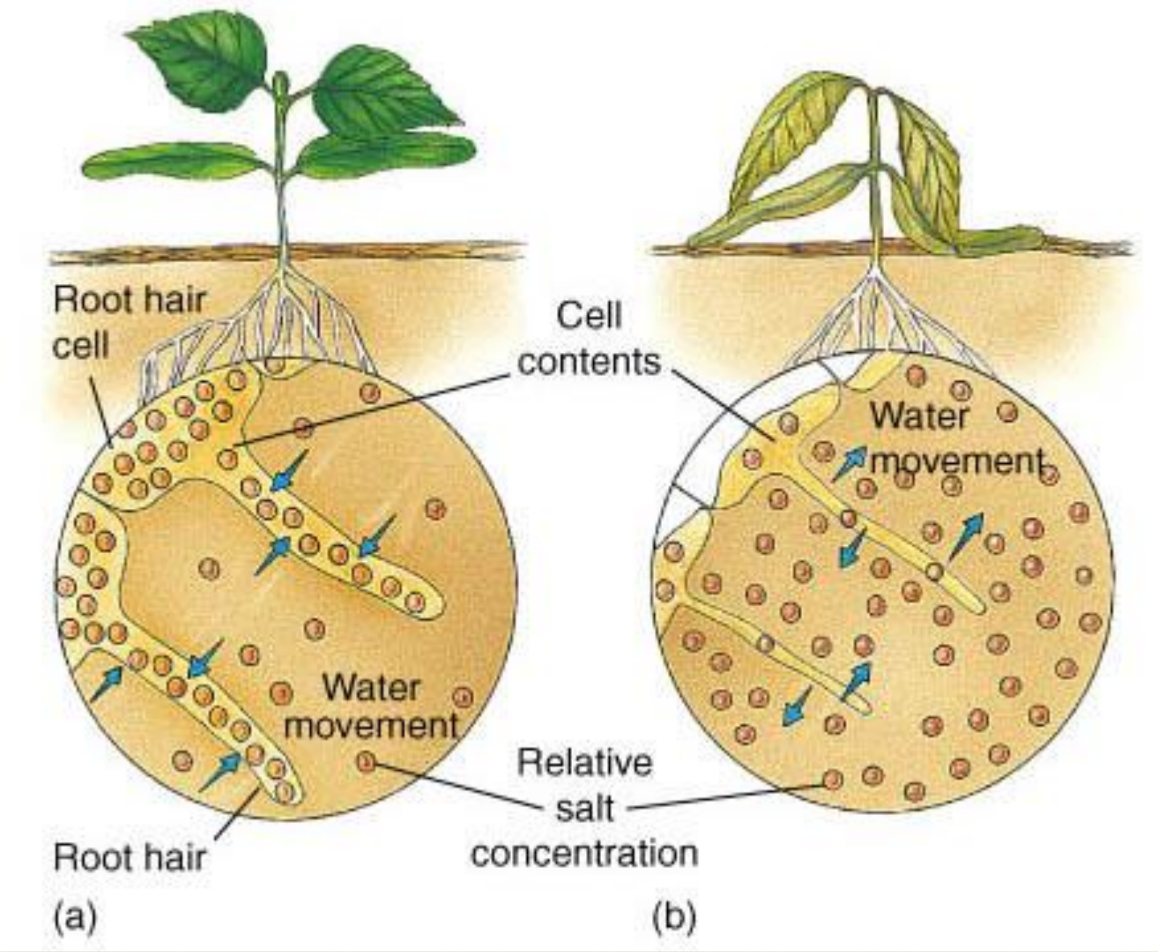
Kadman (Avocadosource.com)

Avocado Yield Function for Irrigation Water Salinity



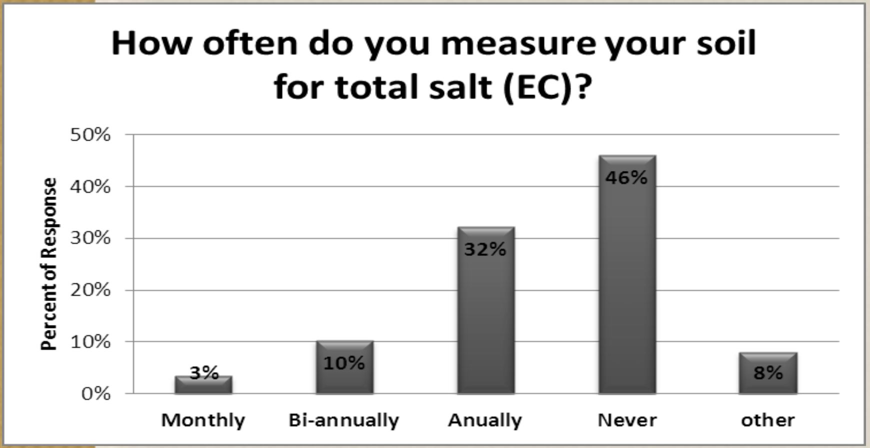
Oster and Arpaia, J. Am Soc. Hort Sci. 2007

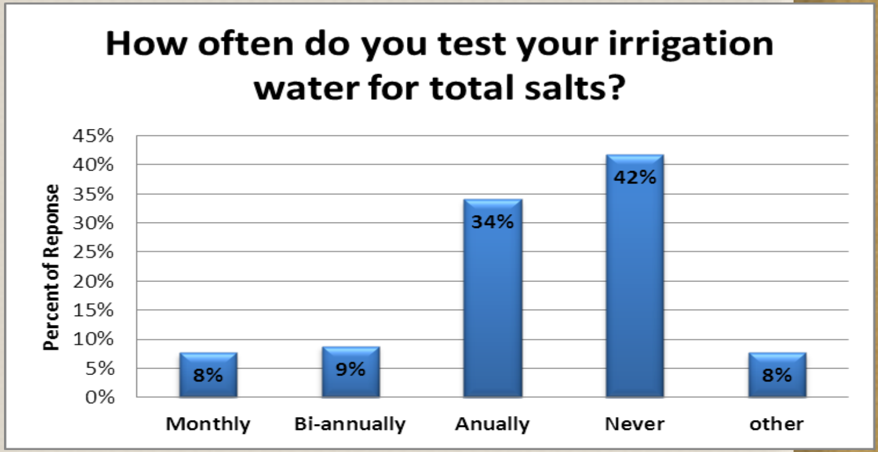
The Problem with Total Dissolved Salt:
High Salt Inhibits Plant Water Uptake

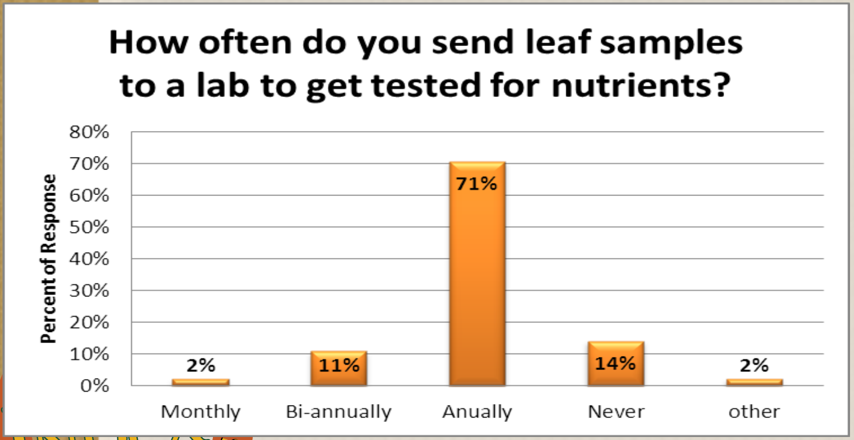


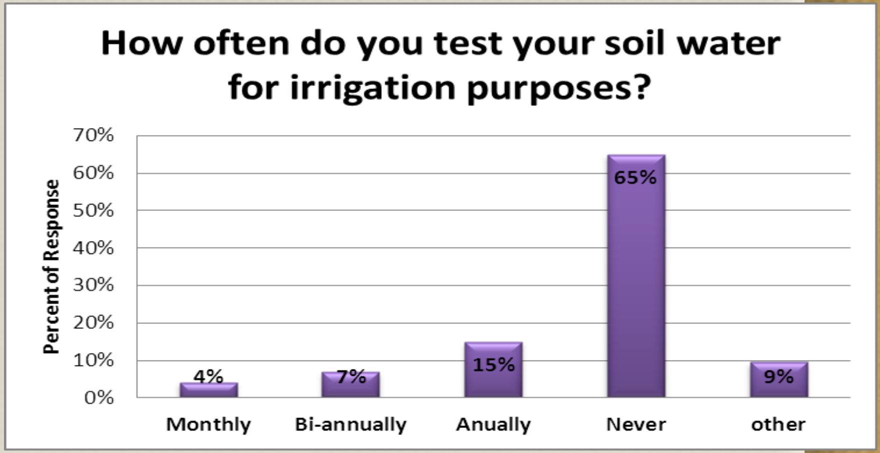
For avocado, this occurs at EC = 4 dS/m

Grower Survey 2014









TDS/Conductivity/Salinity Pen

Collect Soil Cores

0-6”, 6-12”, 12-18”

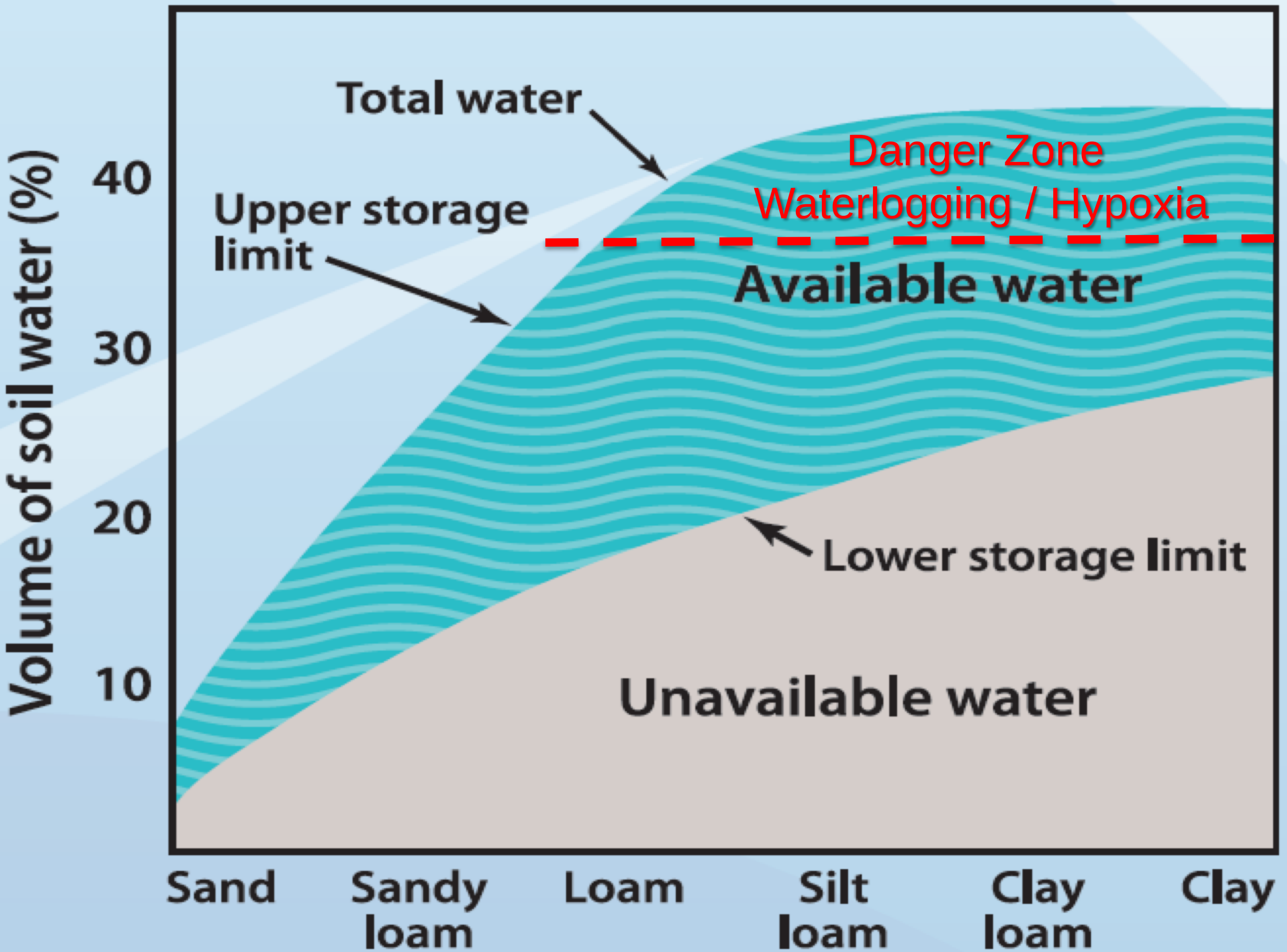
Prepare 2:1 Water:Soil Extracts

Distilled Water

Measure EC

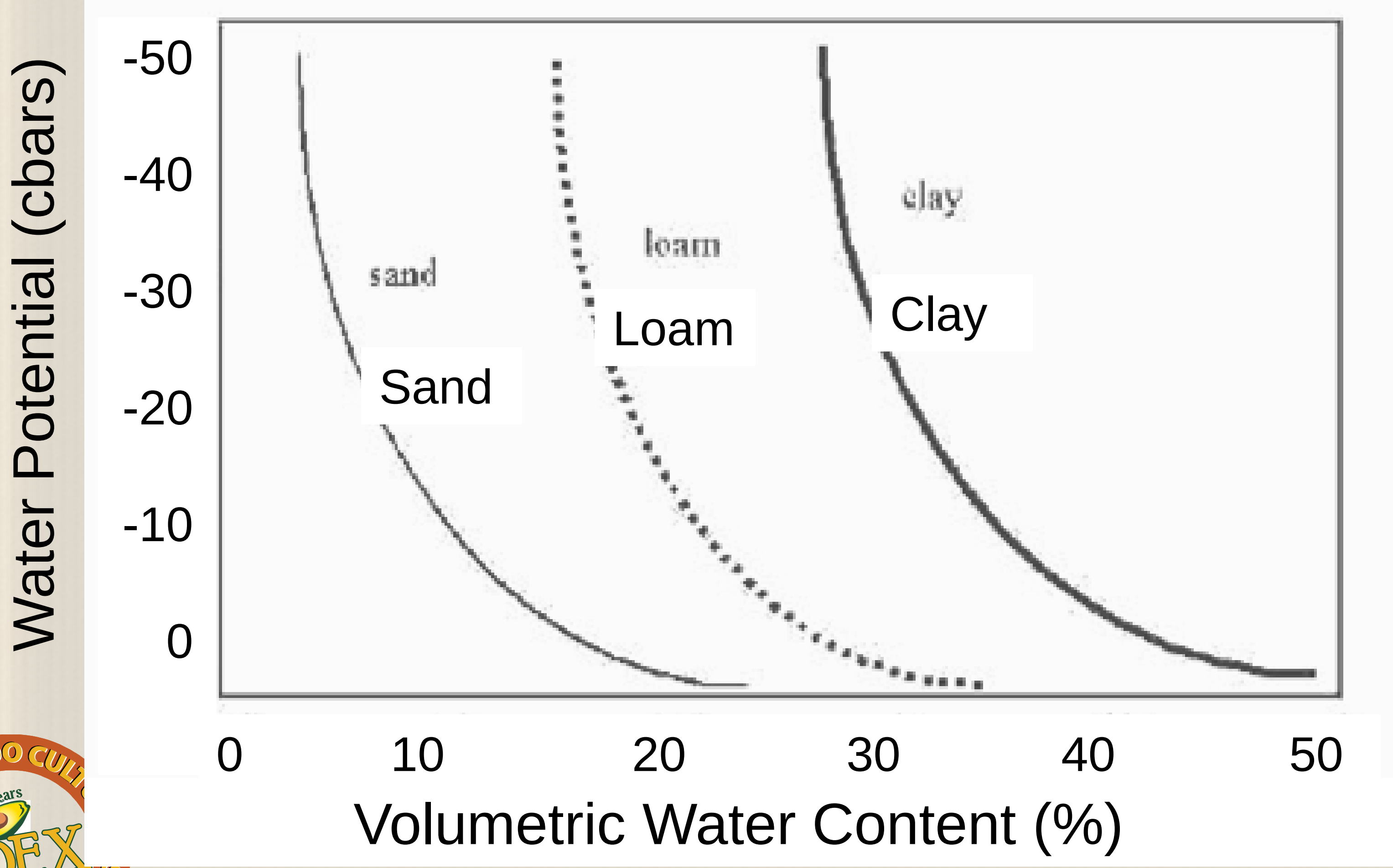
Multiply x 4 (to estimate soil EC_{sat})

If EC > 0.5 dS m^{-1} for 2:1 water extract then it is time to leach (equivalent to an EC_{sat} of 2.0 at field capacity)



Volume of soil water (%)
40
30
20
10
Total water
Upper storage limit
Danger Zone
Waterlogging / Hypoxia
Available water
Lower storage limit
Unavailable water
Sand
Sandy loam
Loam
Silt loam
Clay loam
Clay

Soil Water Potential vs Volumetric Water Content



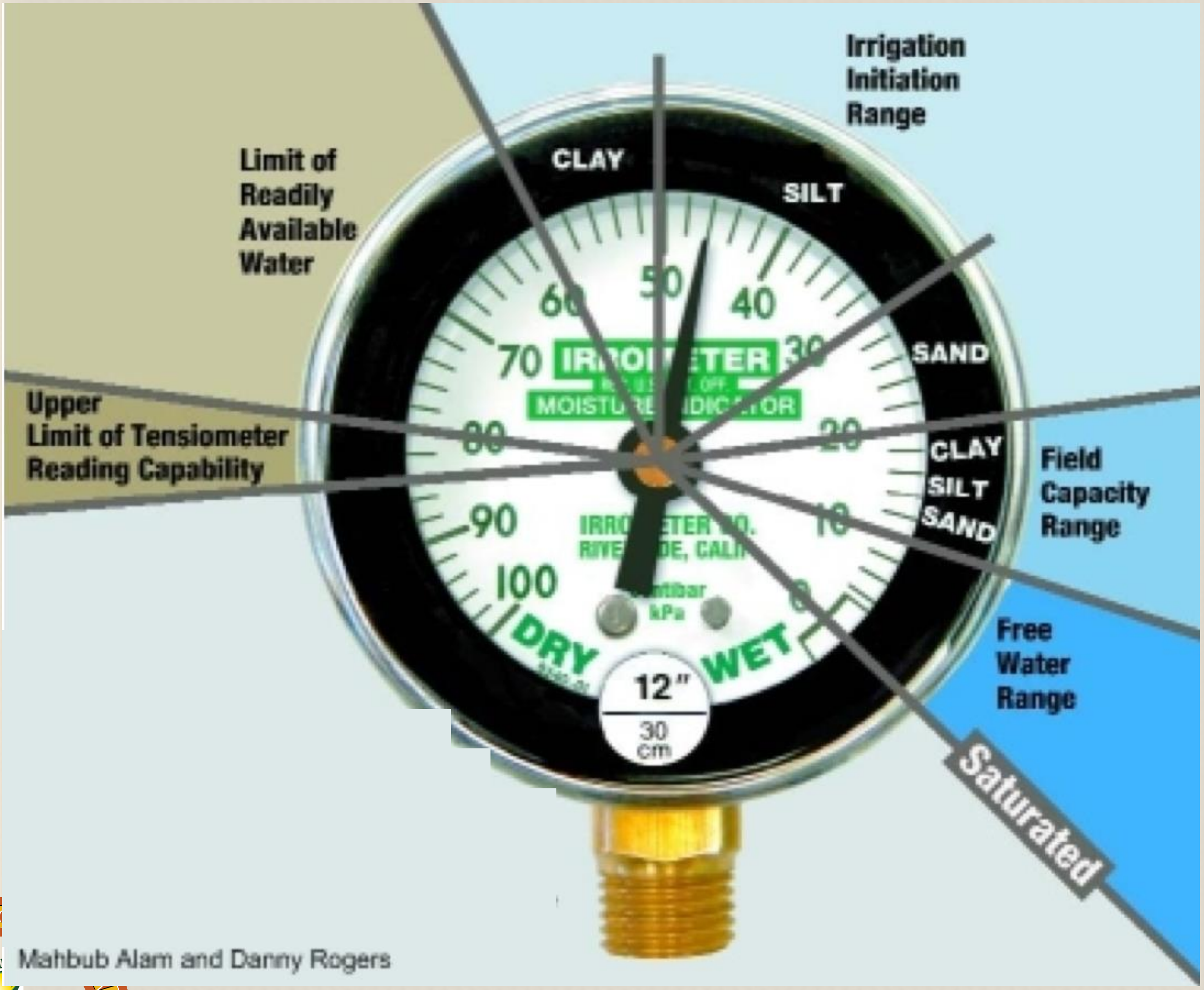
Measurement of Soil Water Potential

Time Domain Reflectometery (TDR)

Absorbent Blocks

Tensionmeter

Fertilization and Irrigation

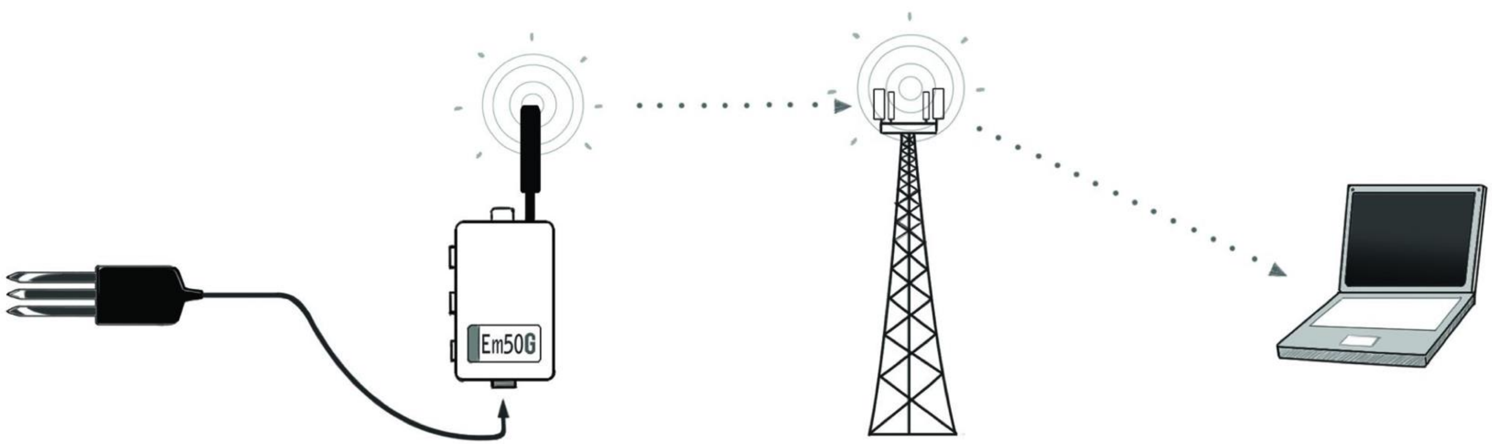


Research Focus: Soil Water Management

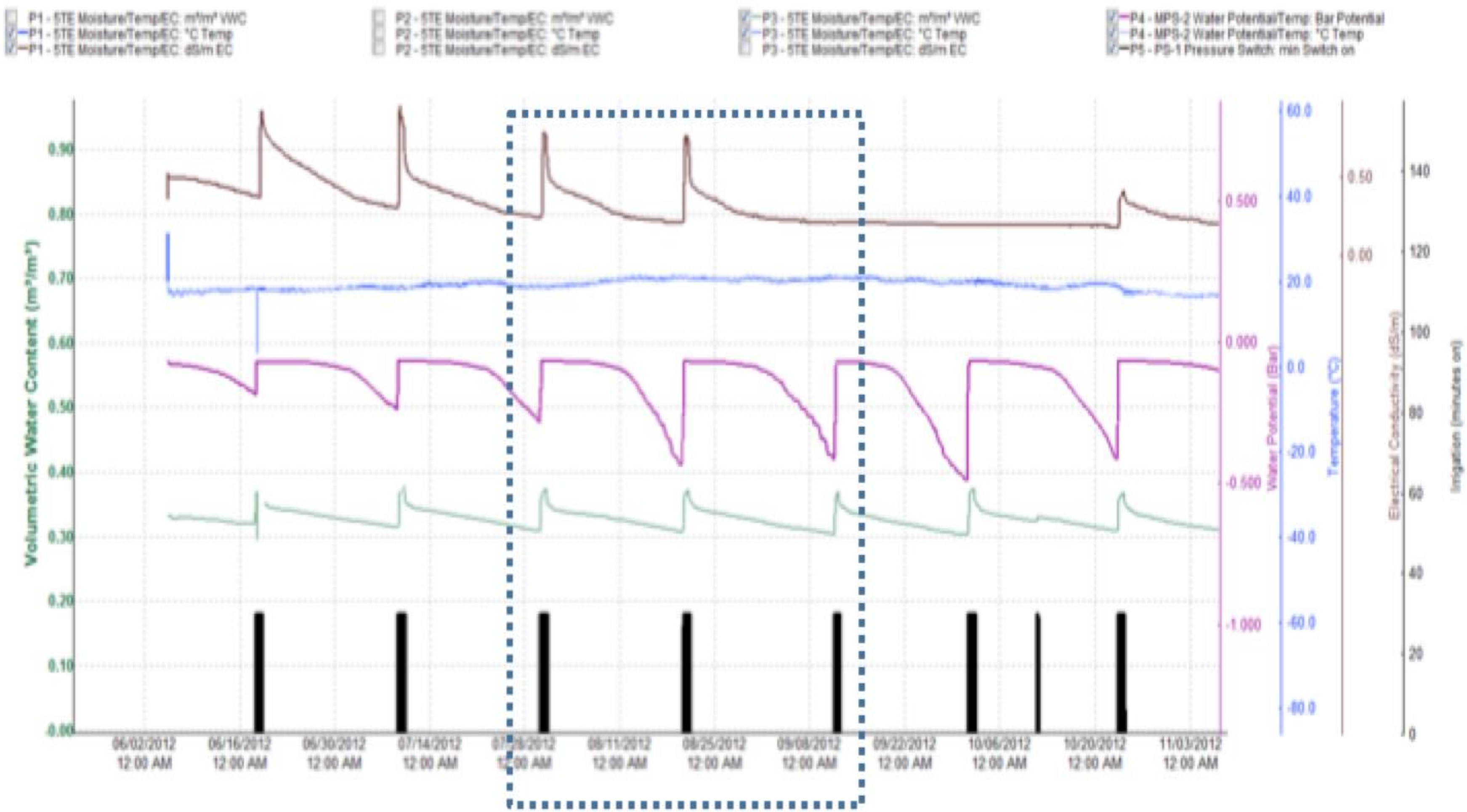
Salinity
Volumetric water content
Temperature

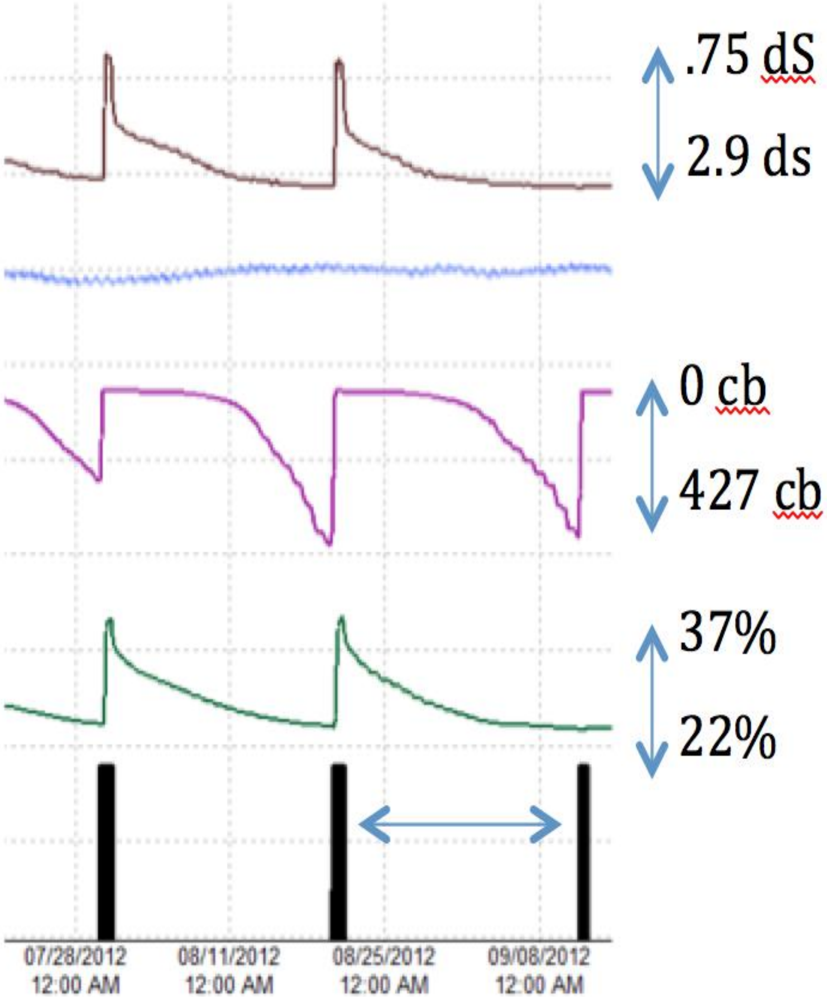
Soil water potential

Data logger



Interpreting Soil Water Status / Irrigation Reports





Salt flush at beginning of each irrigation set. EC range between leaching is .75 to 2.9 dS/m.

Soil water potential (plant available water decreases from 0 to -427 cbars between irrigation sets.

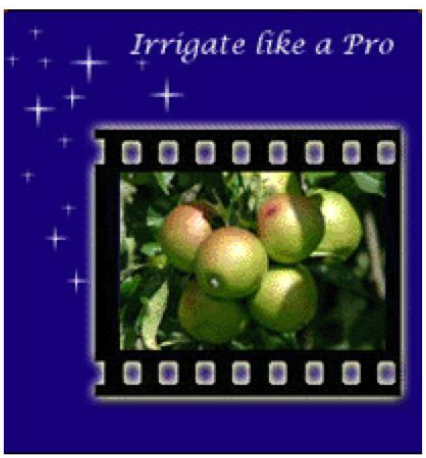
Soil volumetric water content at saturation is 37% decreasing 15% % as soil water potential reaches wilting point. Total available water ~40%.

Irrigation timer indicates that trees are being watered every 3 weeks.

NOTICES

The CIMIS ET-XML service will soon be discontinued. FTP service will be changing in the near future.

See the System News for more details.



Overview | Getting Started | CIMIS Staff | System News | FAQs

printer friendly version

Getting Started

CIMIS provides data from two sources; CIMIS stations and Spatial CIMIS. Both types of data can be scheduled and emailed to you. Station data include measured parameters such as solar radiation, air temperature, soil temperature, relative humidity, wind speed, and wind direction and derived parameters such as vapor pressure, dew point temperature, reference and evapotranspiration (ETo). Spatial CIMIS data comes from satellite and CIMIS station data and consists of ETo and solar radiation only. Station data can be retrieved from the DATA navigation bar whereas Spatial CIMIS can be retrieved from the SPATIAL navigation bar.

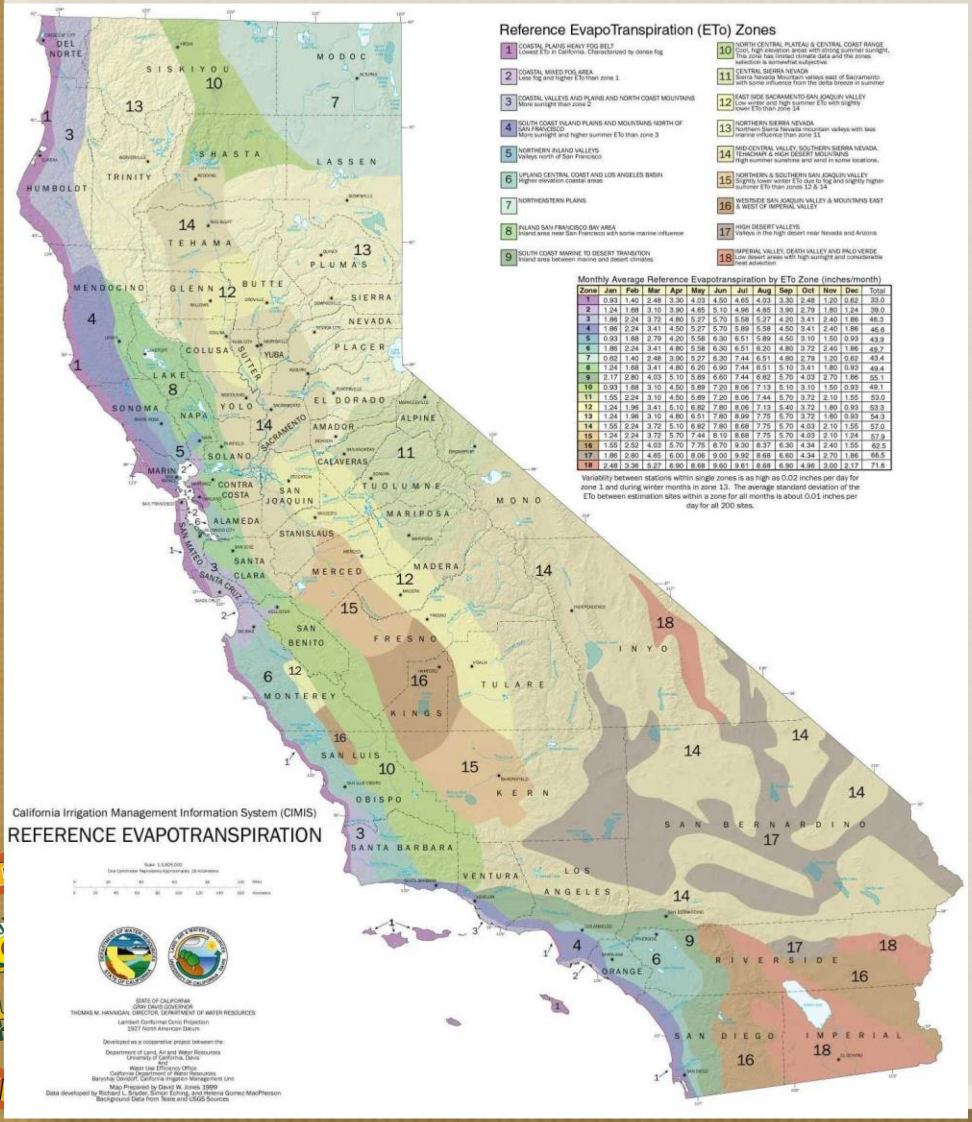
Follow the steps below to access current and archived reference evapotranspiration (ETo) and station weather data. Non-registered users can retrieve current station data within preset parameters. Registered and logged in users have unlimited access to current and archived CIMIS data and all the website features, including email scheduling and SPATIAL data. Getting Started provides information about the following: Non-registered Users, Registered Users or To Register, Other Data Report Options for Registered – logged in Users, and Navigation Bar Content Summary. Please click on the arrow to the right of each title below to access the section.

Non-registered Users

Limited Data

- Click on the DATA navigation bar. Select the Limited Hourly, Limited Daily, or Limited Monthly Report style using the dropdown menu arrow. The time period for hourly is today's date and 7 days prior. The time period for daily data is the previous 7 days. Monthly data is the previous 12 months.
- Select the unit of measure: English units are the default.

California Irrigation Management Information System (CIMIS)

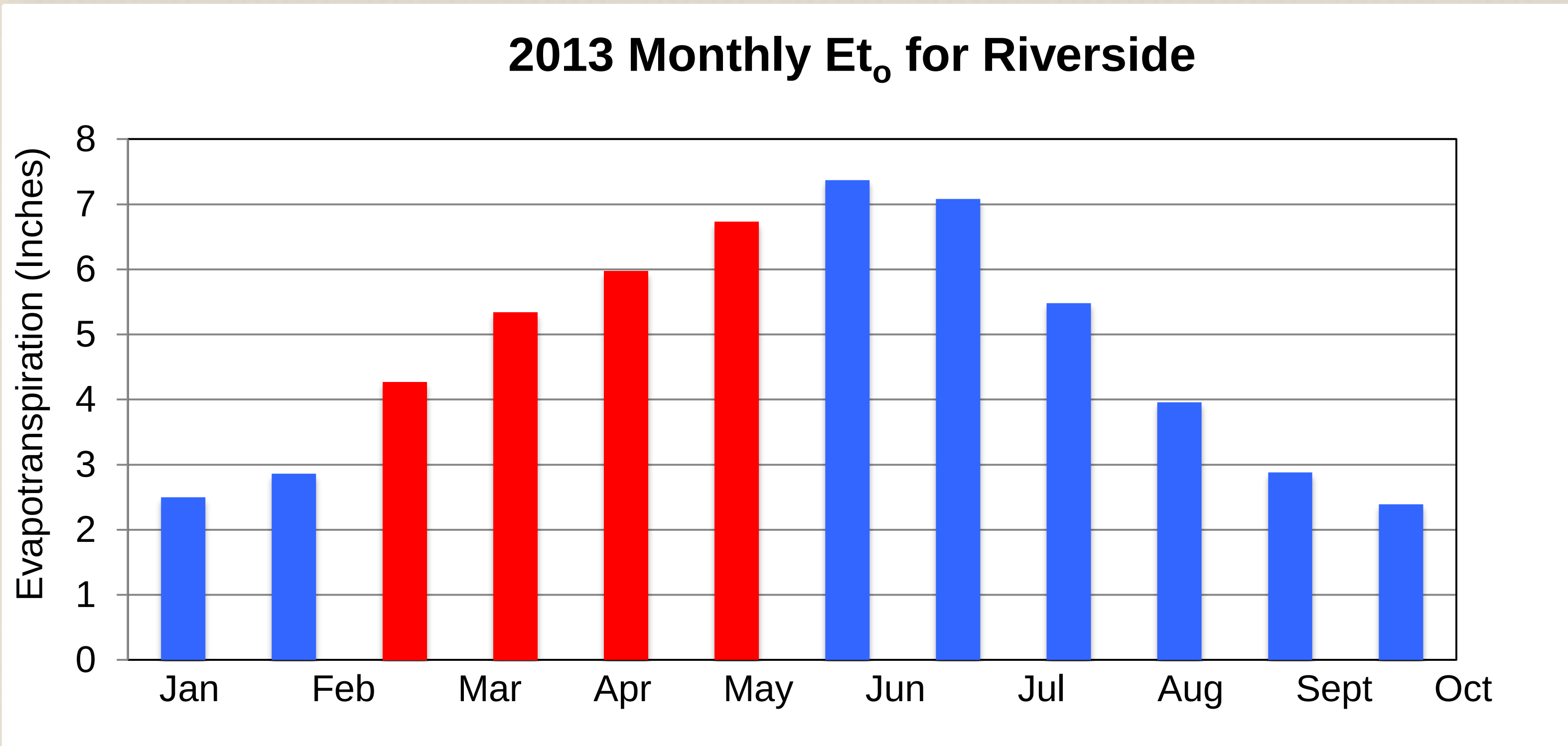


Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variability between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

Use CIMIS to Determine Water Requirements



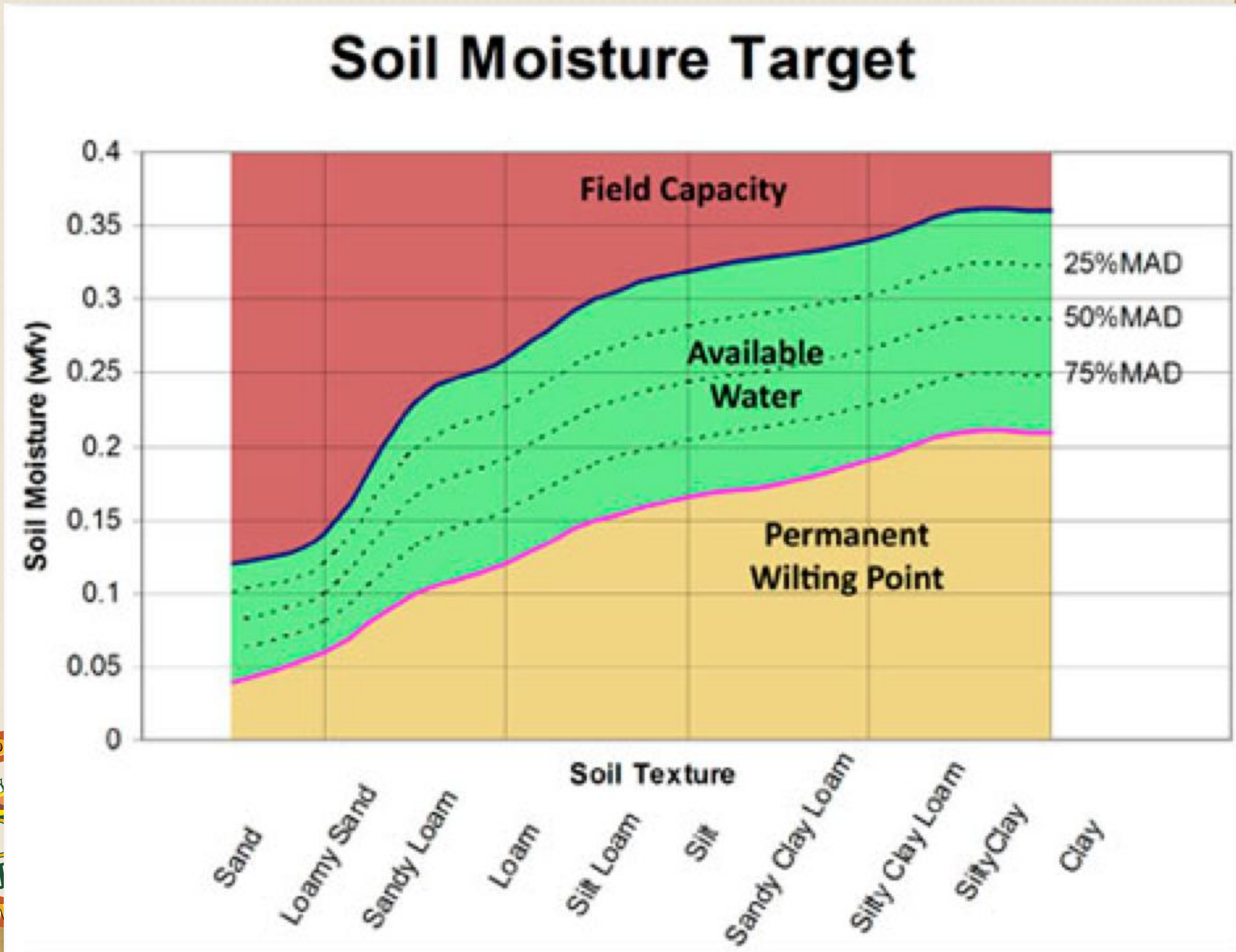
Irrigation and Water Use Efficiency

AVOCADOSOURCE.COM Search Tools Site Index: <SELECT PAGE>

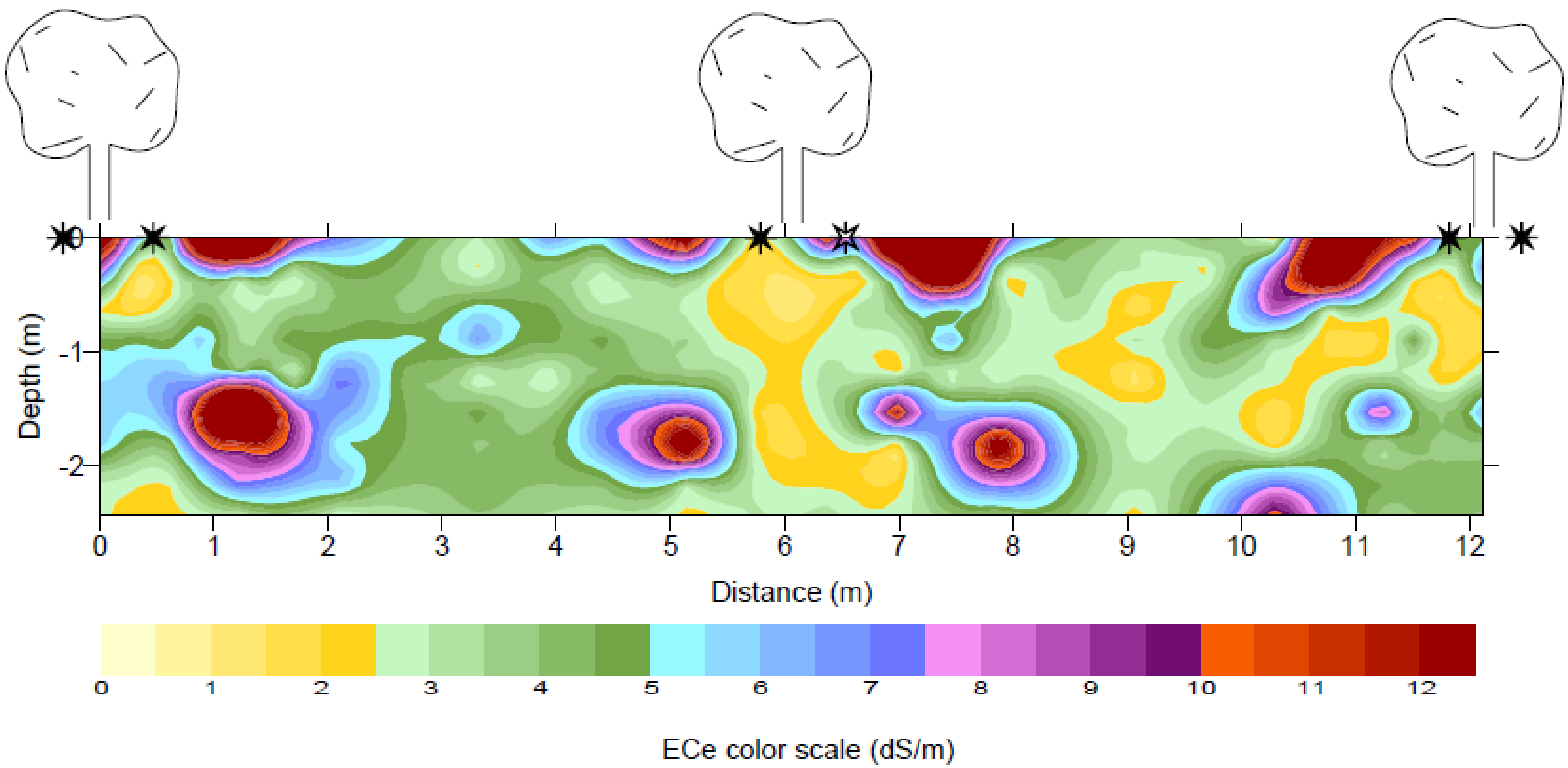
Instructions for the Irrigation Scheduling Calculator

(•) English ( ) Español

Principles of Irrigation	Select a Crop: Avocado
Kc Source:	California (New Values) (•) English Units ( ) Metric Units
Reference Evapotranspiration (ETo):	[ ] in./day or period Data Source: <SELECT SOURCE>
Crop Coefficient (Kc):	[ ] Get Kc for a month <SELECT>
Distribution Uniformity (DU):	[ ] %
Leaching Requirement (LR):	[ ] %
Method:	(•) Trees per Acre: [ ] ( ) Tree Spacing [ ] by [ ] ft.
Number of Emitters per Tree:	1
Surface area under tree canopy (ft^2):	[ ] (enter only when surface area covered by canopy is less than 65%)
Emitter Output (Gal/Hour):	[ ]
Grove Size (acres):	1
	All fields with yellow boxes must be filled out, white fields are optional.
	Calculate Click on 'Calculate' after any changes are made to recompute totals.
Water per tree per day or period:	[ ] gallons
Watering time per tree per day or period:	[ ] hours, [ ] minutes
Total Water Requirements for Grove:	[ ] gallons
Allocated Water for Grove:	[ ] gallons
Shortfall:	[ ] gallons

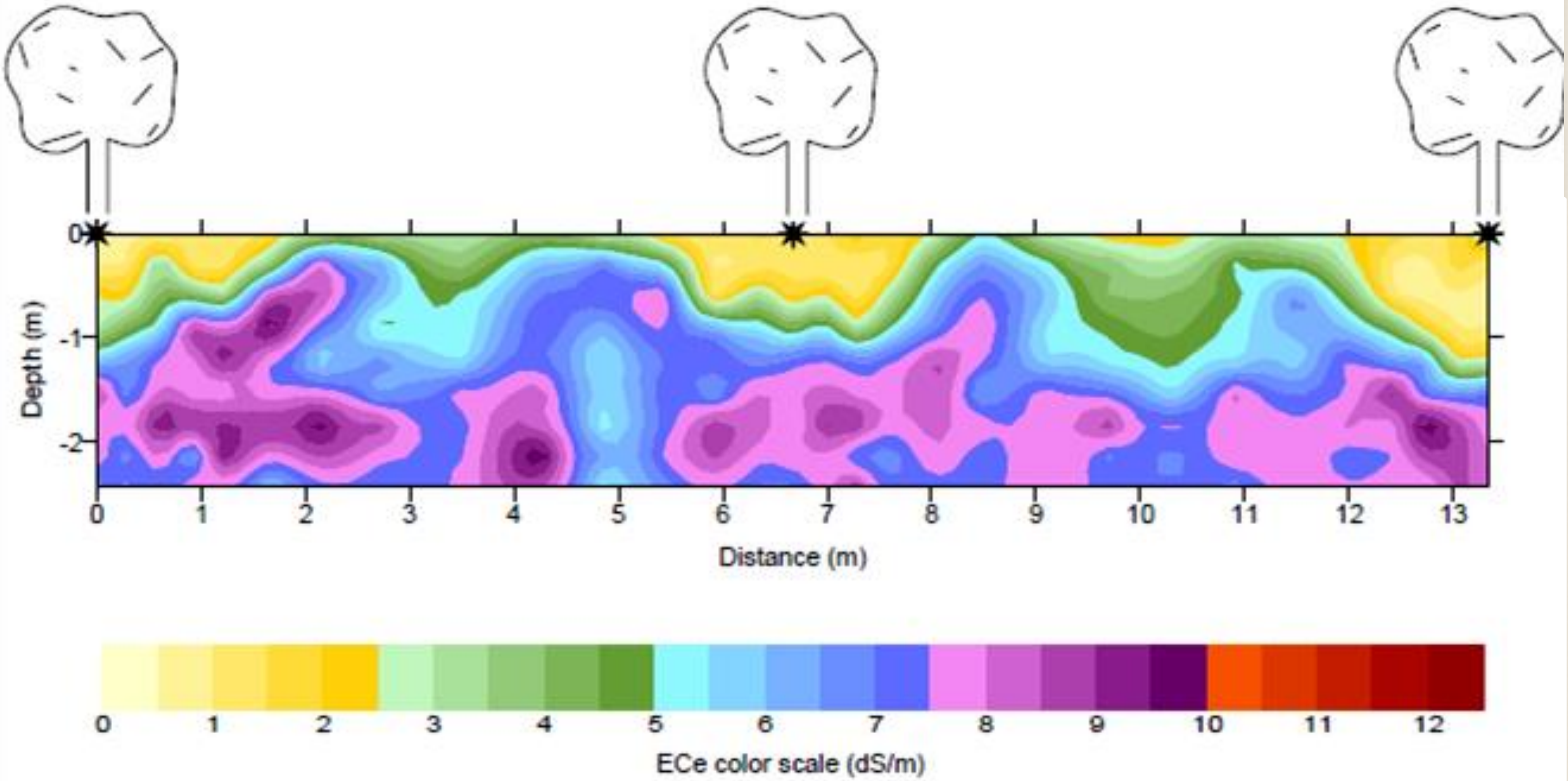

Soil Moisture Target
Field Capacity
Available Water
Permanent Wilting Point
25%MAD
50%MAD
75%MAD
Soil Moisture (wfv)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Soil Texture
Sand
Loamy Sand
Sandy Loam
Loam
Silt Loam
Silt
Sandy Clay Loam
Silty Clay Loam
SiltyClay
Clay

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

Salt Accumulation in Tree Crop Orchards Using Micro-Spray Irrigation



CDWR 2003

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

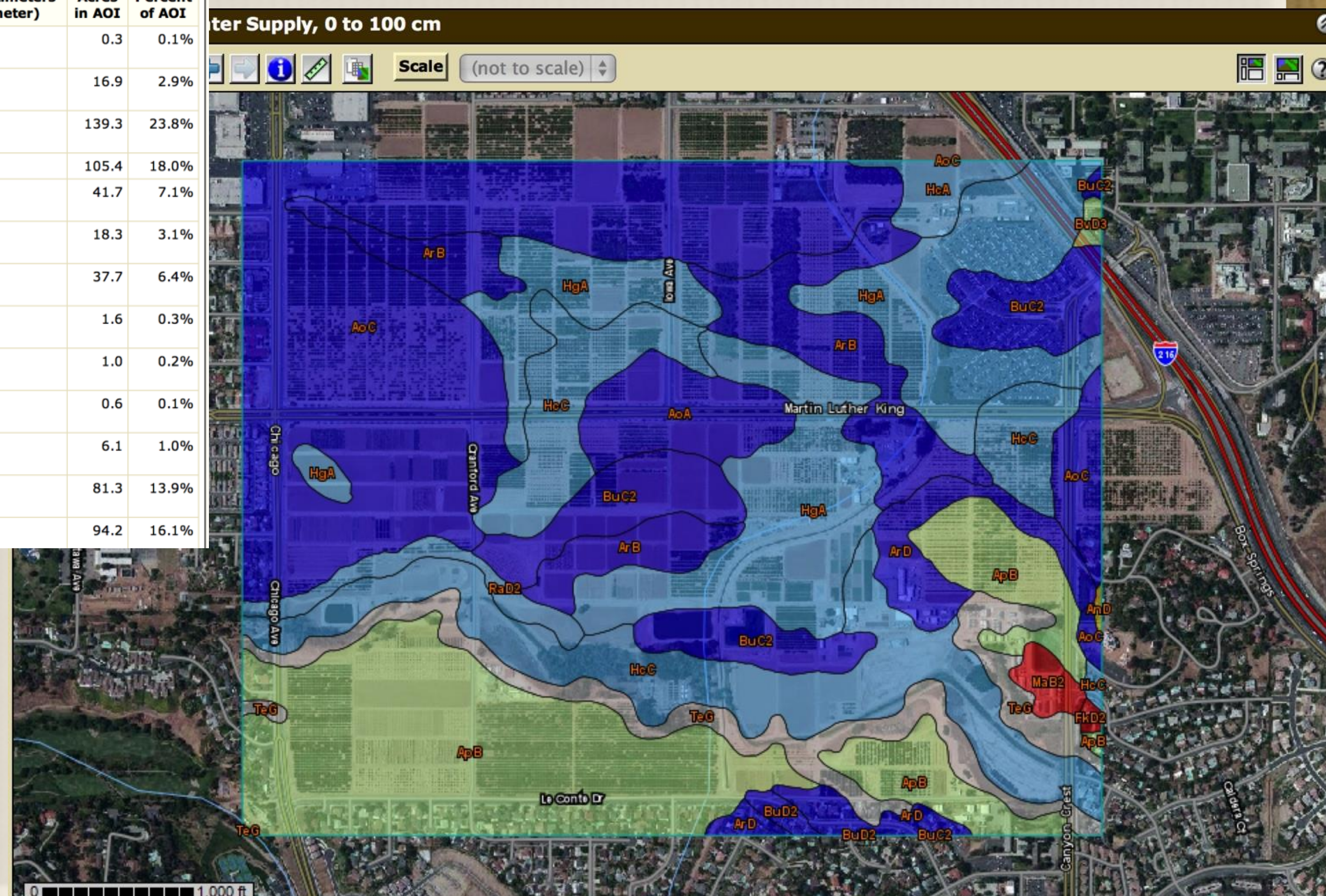
Know Your Soils

http://websoilsurvey.sc.egov.usda.gov/

Tables — Available Water Capacity — Summary By Map Unit

Summary by Map Unit — Western Riverside Area, California (CA679)

Map unit symbol	Map unit name	Rating (centimeters per centimeter)	Acres in AOI	Percent of AOI
AnD	Arlington fine sandy loam, 8 to 15 percent slopes	0.11	0.3	0.1%
AoA	Arlington fine sandy loam, deep, 0 to 2 percent slopes	0.11	16.9	2.9%
AoC	Arlington fine sandy loam, deep, 2 to 8 percent slopes	0.11	139.3	23.8%
ApB	Arlington loam, 2 to 5 percent slopes	0.15	105.4	18.0%
ArB	Arlington loam, deep, 0 to 5 percent slopes	0.15	41.7	7.1%
ArD	Arlington loam, deep, 5 to 15 percent slopes	0.15	18.3	3.1%
BuC2	Buren fine sandy loam, 2 to 8 percent slopes, eroded	0.13	37.7	6.4%
BuD2	Buren fine sandy loam, 8 to 15 percent slopes, eroded	0.13	1.6	0.3%
BvD3	Buren loam, 5 to 15 percent slopes, severely eroded	0.16	1.0	0.2%
FkD2	Fallbrook fine sandy loam, shallow, 8 to 15 percent slo pes, eroded	0.14	0.6	0.1%
HcA	Hanford coarse sandy loam, 0 to 2 percent slopes	0.13	6.1	1.0%
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	0.13	81.3	13.9%
HgA	Hanford fine sandy loam, 0 to 2 percent	0.13	94.2	16.1%



Search

Enter Keywords [Go]
All NRCS Sites

Browse by Subject

- Soils Home
- National Cooperative Soil Survey (NCSS)
- Archived Soil Surveys
- Status Maps
- Official Soil Series Descriptions (OSD)
- Soil Series Extent Mapping Tool
- Geospatial Data Gateway
- eFOTG
- National Soil Characterization Data
- Soil Geochemistry Spatial Database
- Soil Quality
- Soil Geography

The simple yet powerful way to access and use soil data.

START WSS

Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Soil surveys can be used for general farm, local, and wider area planning. Onsite investigation is needed in some cases, such as soil quality assessments and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center or your NRCS State Soil Scientist.

Four Basic Steps

1 Define.

Use the Area of Interest tab

I Want To...

- Start Web Soil Survey (WSS)
- Know the requirements for running Web Soil Survey — will Web Soil Survey work in my web browser?
- Know the Web Soil Survey hours of operation
- Find what areas of the U.S. have soil data
- Find information by topic
- Know how to hyperlink from other documents to Web Soil Survey

Announcements/Events

- Web Soil Survey 3.1 has been released! View description of new features and fixes.
- Web Soil Survey Release History
- Sign up for e-mail updates via GovDelivery

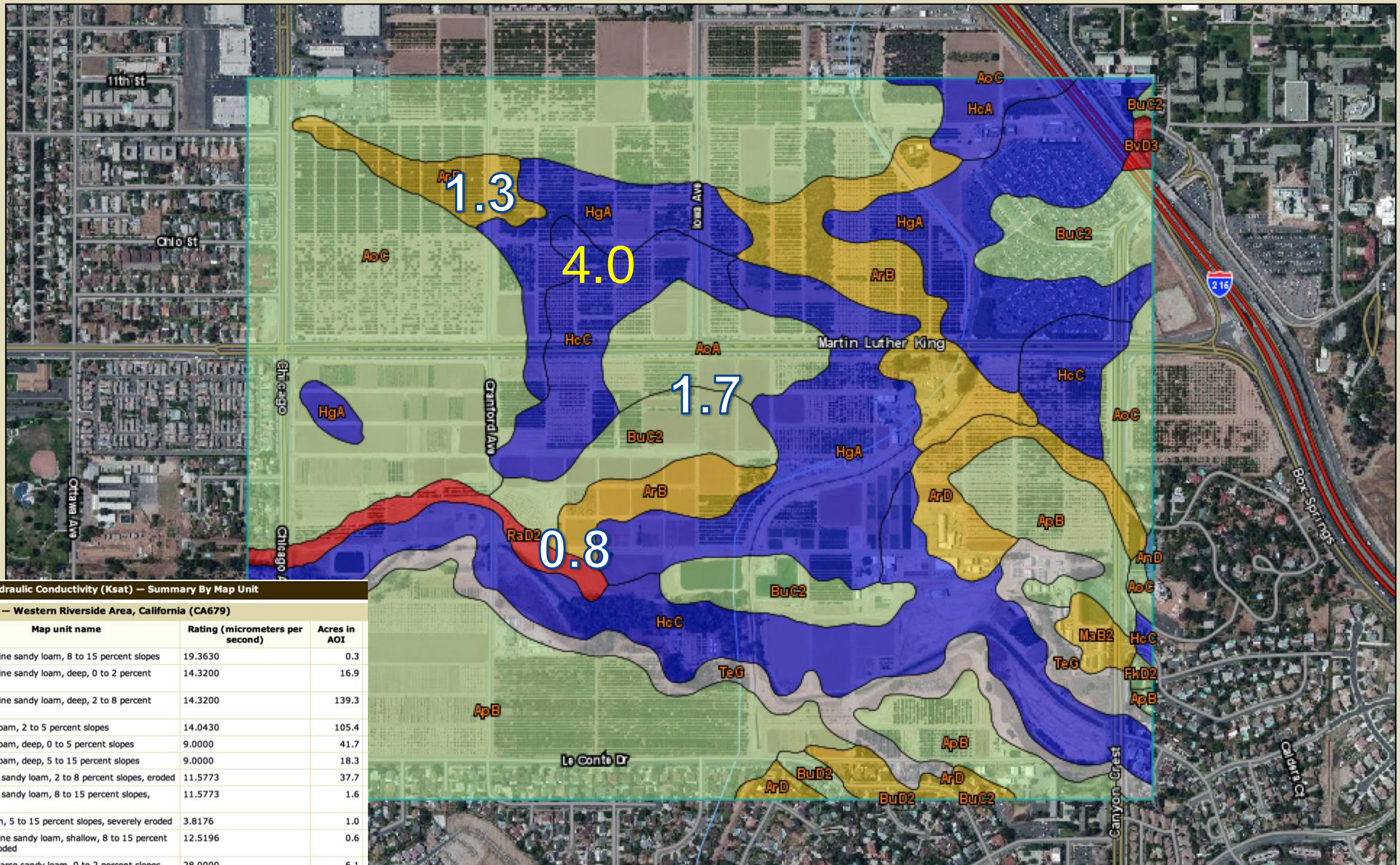
I Want Help With...

- Getting Started With Web Soil Survey

Water Infiltration Rates (inches / hour)

Map — Saturated Hydraulic Conductivity (Ksat)

Scale (not to scale)



Tables — Saturated Hydraulic Conductivity (Ksat) — Summary By Map Unit

Summary by Map Unit — Western Riverside Area, California (CA679)

Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI
AnD	Arlington fine sandy loam, 8 to 15 percent slopes	19.3630	0.3
AoA	Arlington fine sandy loam, deep, 0 to 2 percent slopes	14.3200	16.9
AoC	Arlington fine sandy loam, deep, 2 to 8 percent slopes	14.3200	139.3
ApB	Arlington loam, 2 to 5 percent slopes	14.0430	105.4
ArB	Arlington loam, deep, 0 to 5 percent slopes	9.0000	41.7
ArD	Arlington loam, deep, 5 to 15 percent slopes	9.0000	18.3
BuC2	Buren fine sandy loam, 2 to 8 percent slopes, eroded	11.5773	37.7
BuD2	Buren fine sandy loam, 8 to 15 percent slopes, eroded	11.5773	1.6
BvD3	Buren loam, 5 to 15 percent slopes, severely eroded	3.8176	1.0
FkD2	Fallbrook fine sandy loam, shallow, 8 to 15 percent slo pes, eroded	12.5196	0.6
HcA	Hanford coarse sandy loam, 0 to 2 percent slopes	28.0000	6.1
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	28.0000	81.3

Apparent chloride toxicity symptoms in an over-irrigated avocado tree.

California Avocado Society 1949 Yearbook 34: 139-143

California Avocado Society 1949 Yearbook 34: 139-143

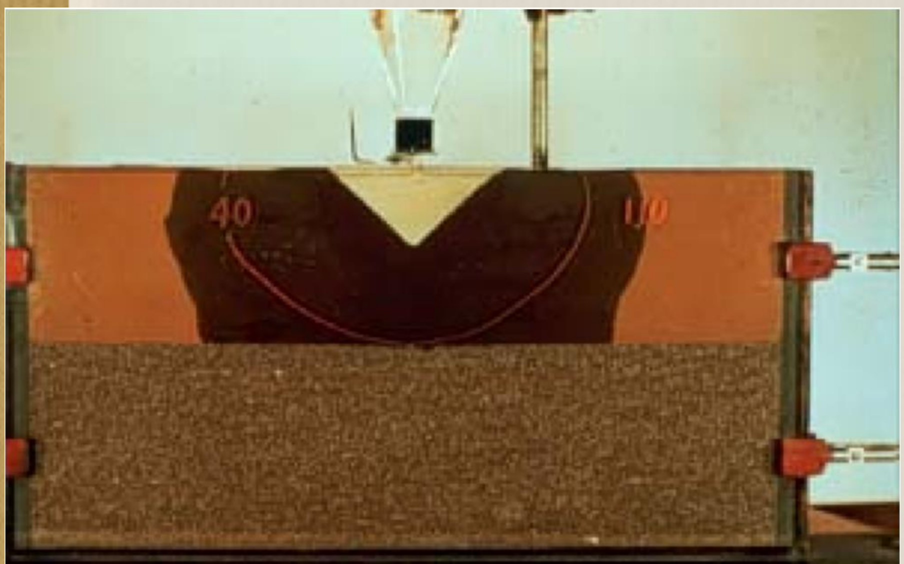
GROWTH OF AVOCADO SEEDLINGS AS AFFECTED BY THE RATE OF SOIL DRAINAGE

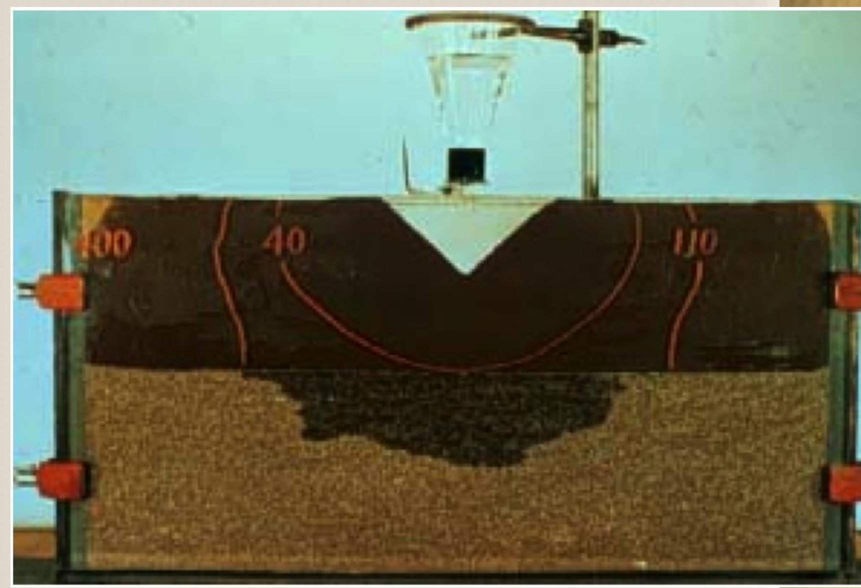
A. R. C. HAAS
Citrus Experiment Station, Riverside, California

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.

Water perching caused by a sandy (coarse) soil layer over a clay or silt layer (fine particle size).





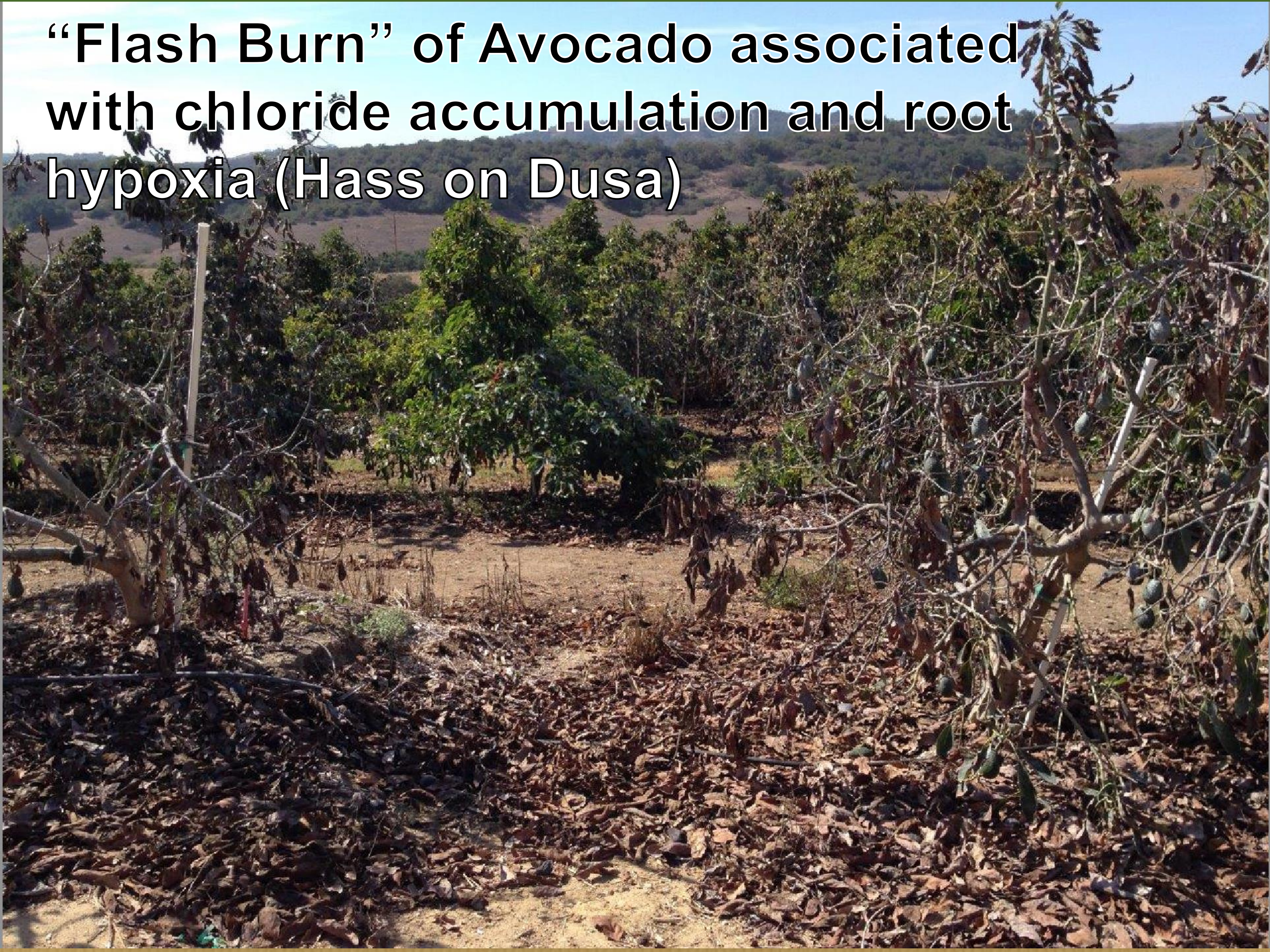
http://personal.psu.edu/asm4/water/drain.html

Effects of Waterlogging on Leaf Chloride Uptake

Plant Species	Days	Leaf Cl %		% Cl Increase
		Drained	Waterlogged	
Atriplex	14	4.12	8.53	210
Casuarina	84	0.27	0.72	270
Eucalyptus	77	0.49	1.37	280
Lycopersicum	15	0.92	2.68	290
Nicotiana	10	0.93	1.87	200
Triticum	7	0.59	0.91	160
Vitis vinifera	7	0.19	0.68	306

Review Paper: Barrett-Lennard. 2003. The interaction between waterlogging and salinity in higher plants: causes, consequences and implications. Plant and Soil 253:35-54

"Flash Burn" of Avocado associated with chloride accumulation and root hypoxia (Hass on Dusa)



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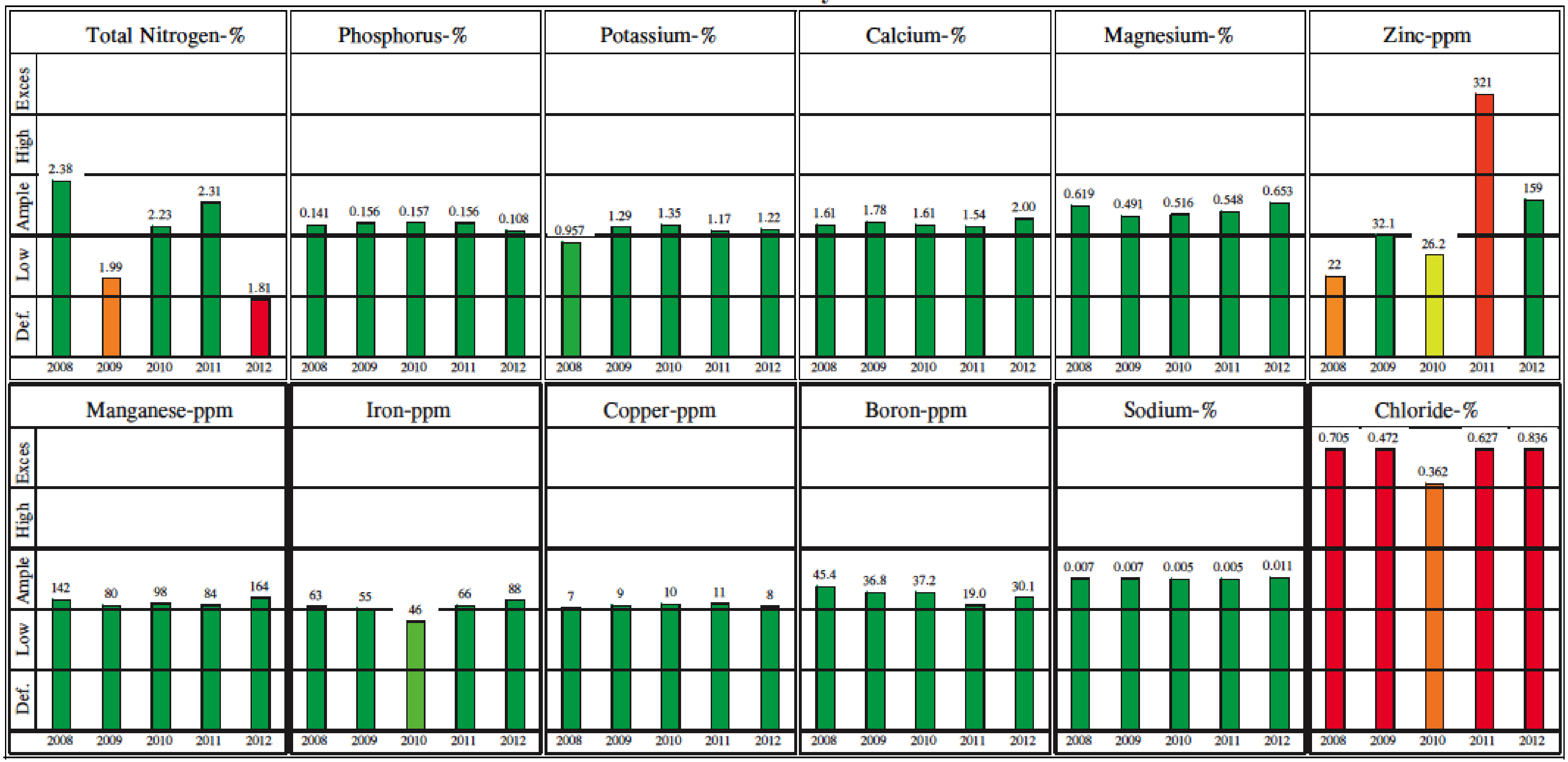
Fertilization and Irrigation

FGL ENVIRONMENTAL AGRICULTURAL
Analytical Chemists

December 4, 2012
Fruit Growers Laboratory, Inc.
Sample: Tree # 03
[redacted]

Lab ID : SPM12Y725A-003
Sampled By : Stephen Qi
Sampled On : November 6, 2012

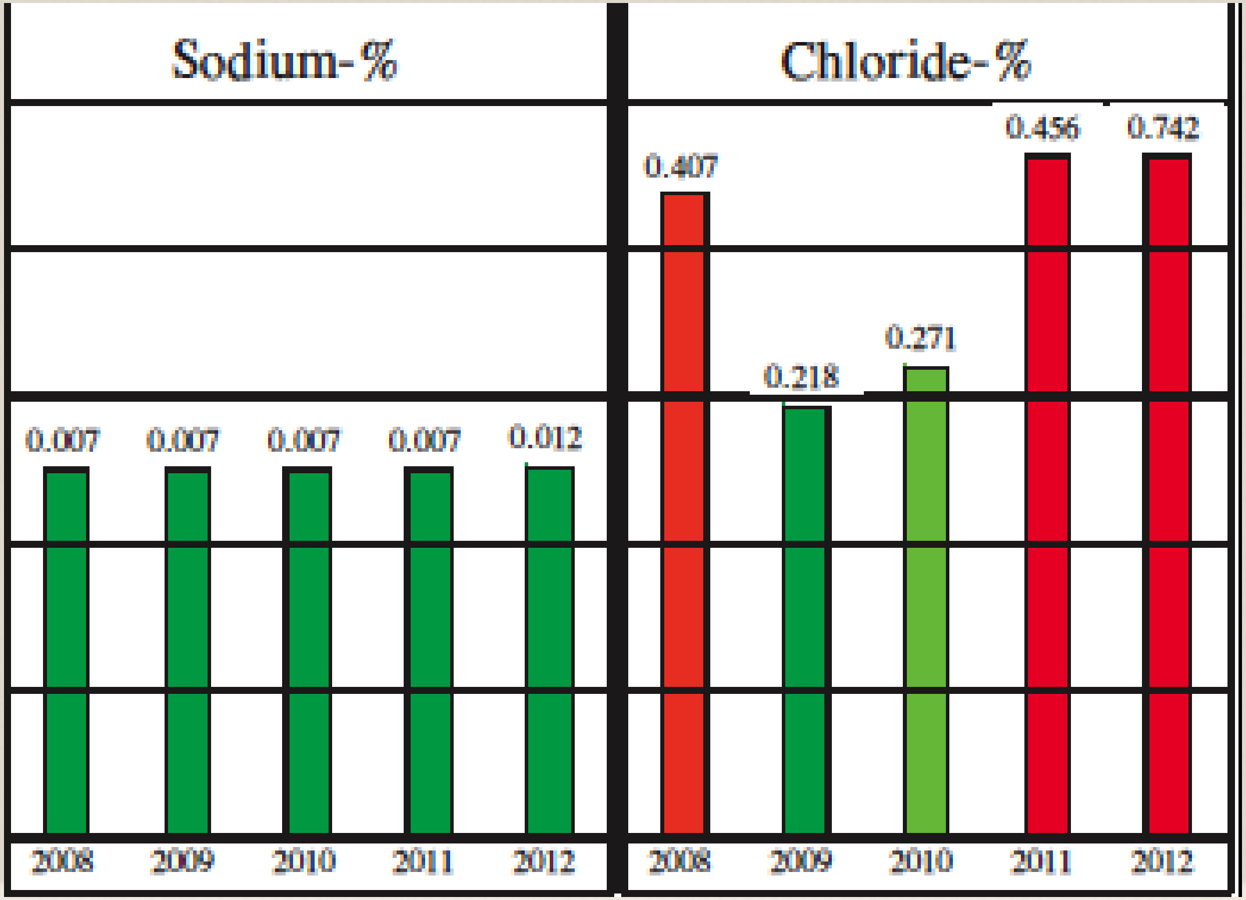
Hass Plant Tissue Analysis: 2008-2012



Good Problem Indicates physical conditions and/or phenological and amendment requirements.

Note: Color coded bar graphs have been used to provide you with 'AT-A-GLANCE' interpretations.

Year to Year Variation in Chloride Toxicity for Same Tree, Same Soil, Same Irrigation Water and Same Management



Tissue Analysis Results – Avocado (98% sand soil)

2 X Week
Irrigation / Leaching

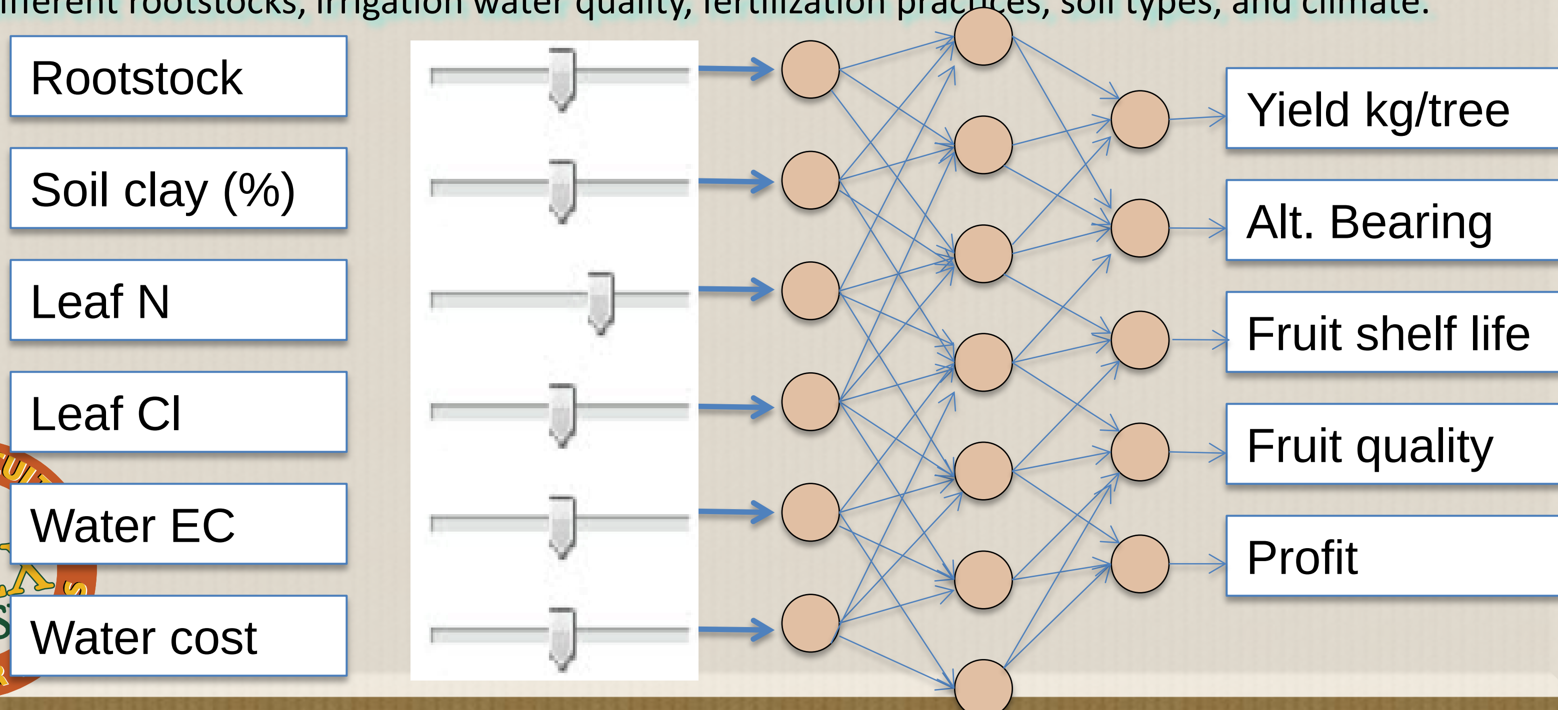
Nutrient	Unit	Optimum Range	Jul-13	Aug-13	Sep-13	Dec-13	May-14	Jul-14
Nitrogen	% N	2.2 - 2.4	2.38	2.17	2.11	2.53	2.4	2.9
Phosphorus	% P	.08 - 0.44	0.24	0.29	0.29	0.21	0.21	0.35
Potassium	% K	1.0 - 3.0	1.26	1.49	1.68	1.32	1.45	1.53
Calcium	% Ca	1.0 - 4.5	0.29	0.61	0.53	1.02	0.76	0.5
Chloride	Cl %	<0.25	0.37	0.47	0.94	1.32	0.62	0.27
Manganese	ppm	50-300	32	66	89	111	66	45

Decision Support Tools for Avocado Production and Fruit Quality

David Crowley, Mary Lu Arpaia, and Ariel Dinar

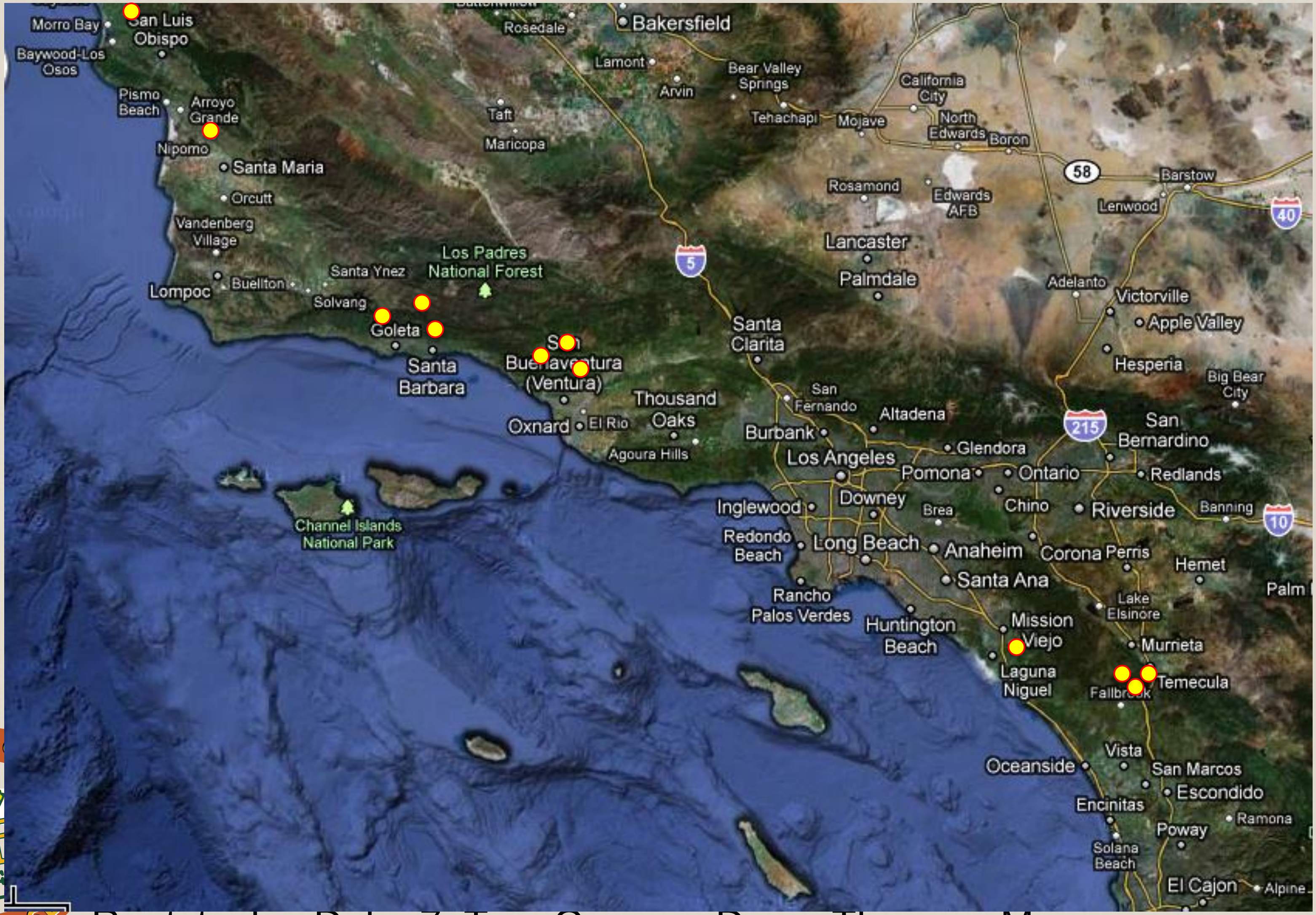
Objectives: Develop an internet based set of decision support tools that can be used to predict fruit yields, fruit quality, alternate bearing patterns, and profit.

Research Plan: Construct artificial neural network and economic models that are trained and validated using data collected from a transect of avocado orchards across S. California having different rootstocks, irrigation water quality, fertilization practices, soil types, and climate.



Avocado Production Transect

12 Locations
450 Total trees



Rootstocks: Duke 7, Toro Canyon, Dusa, Thomas, Mexican

INDEX FRESH INC.™

Fertilization and Irrigation

Statistical Analysis and Pattern Recognition Using Artificial Neural Networks

EC

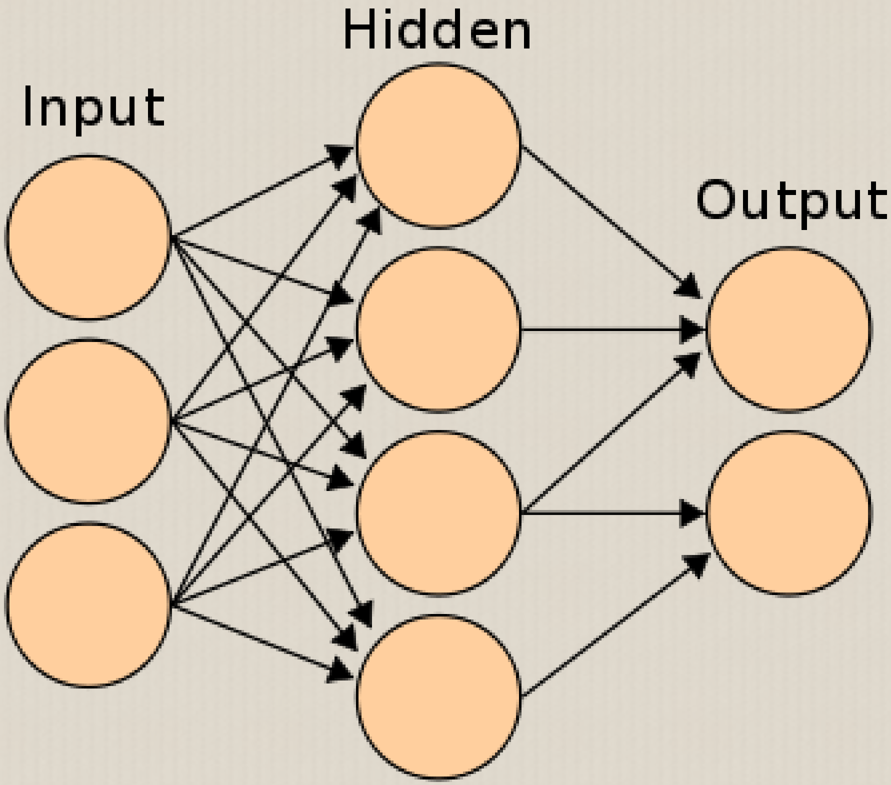
Chloride

% Clay

Rootstock

Fertilization

……

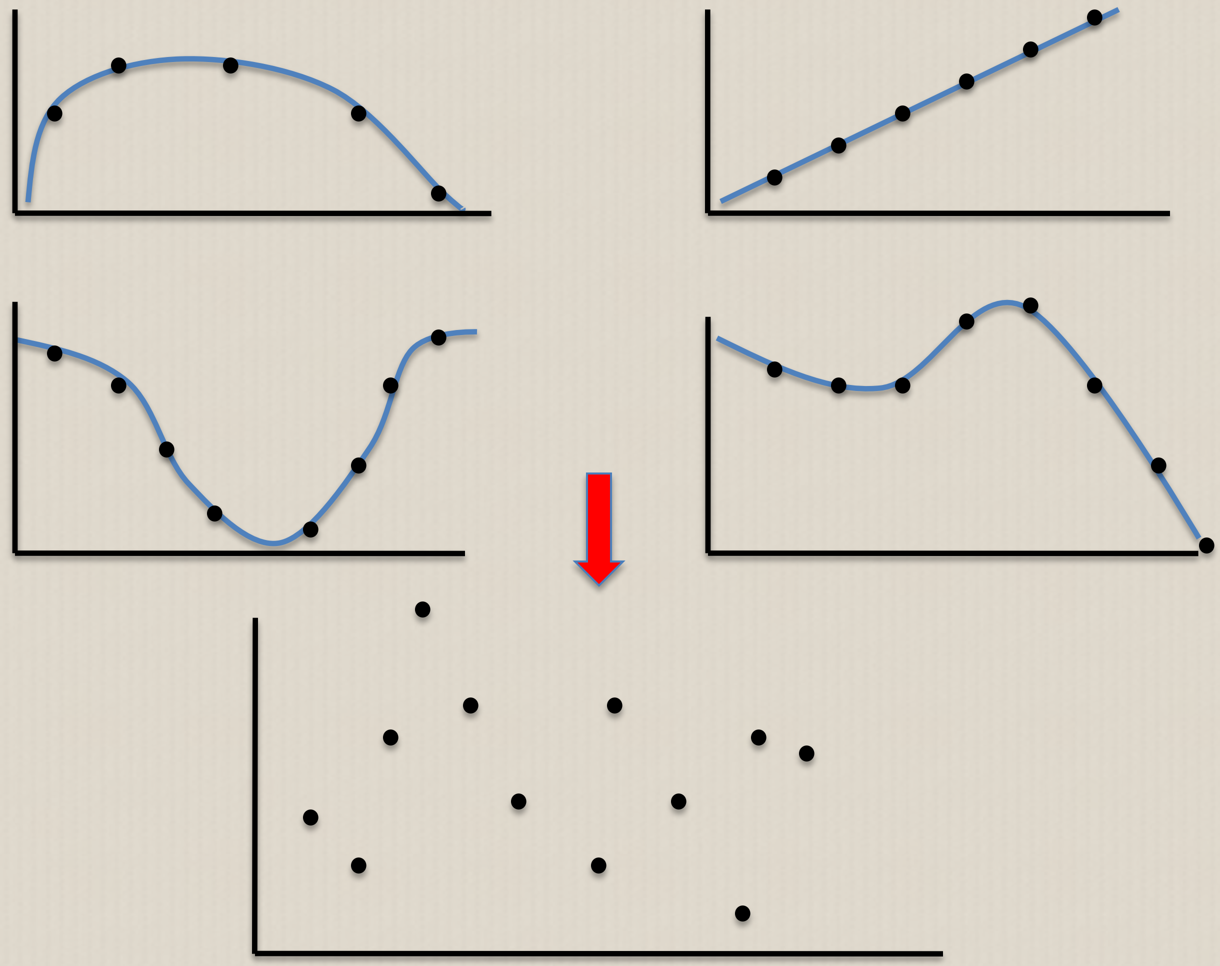


Root Growth

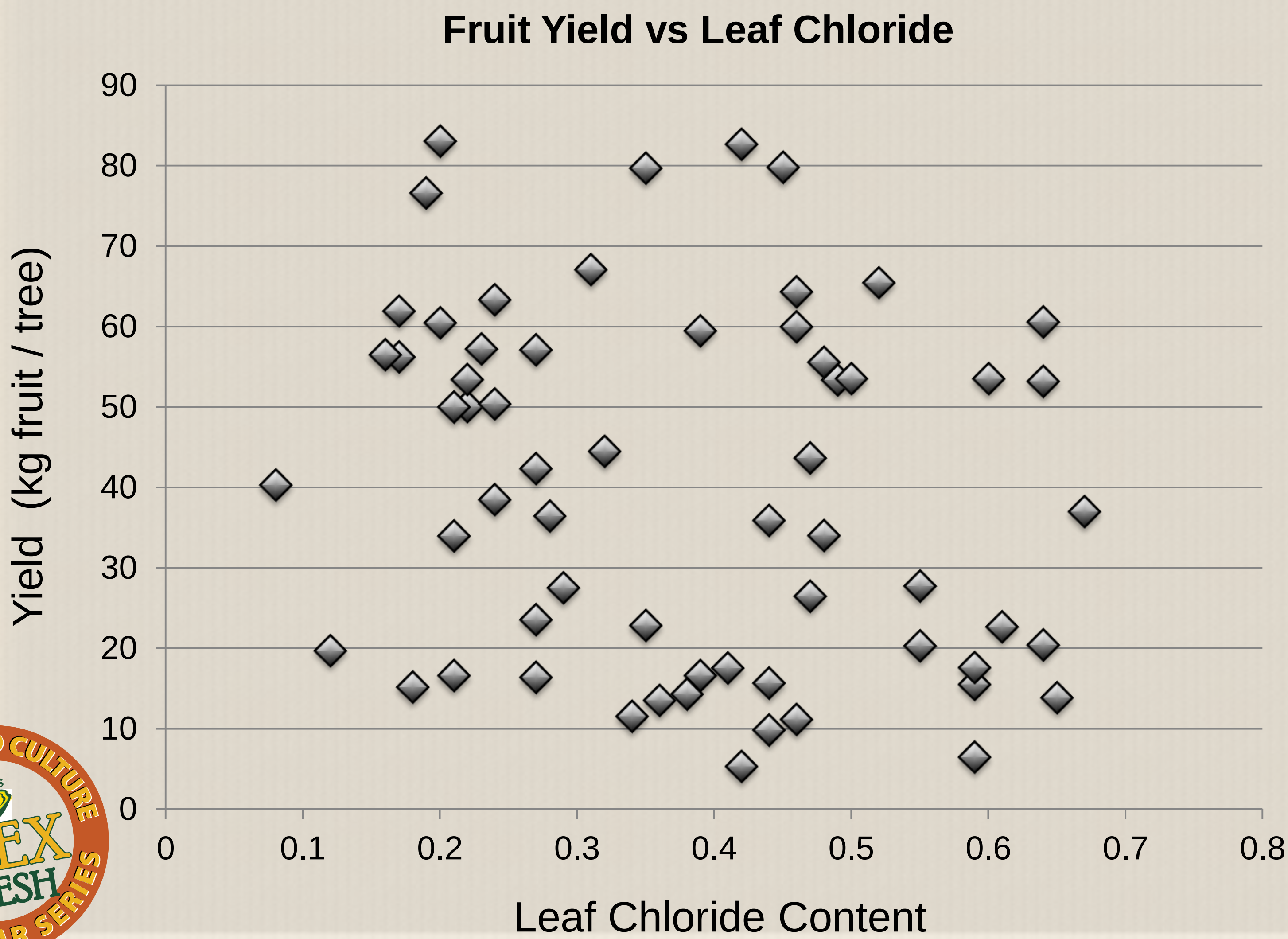
Fruit Yields

http://www.answers.com/topic/artificial-neural-network

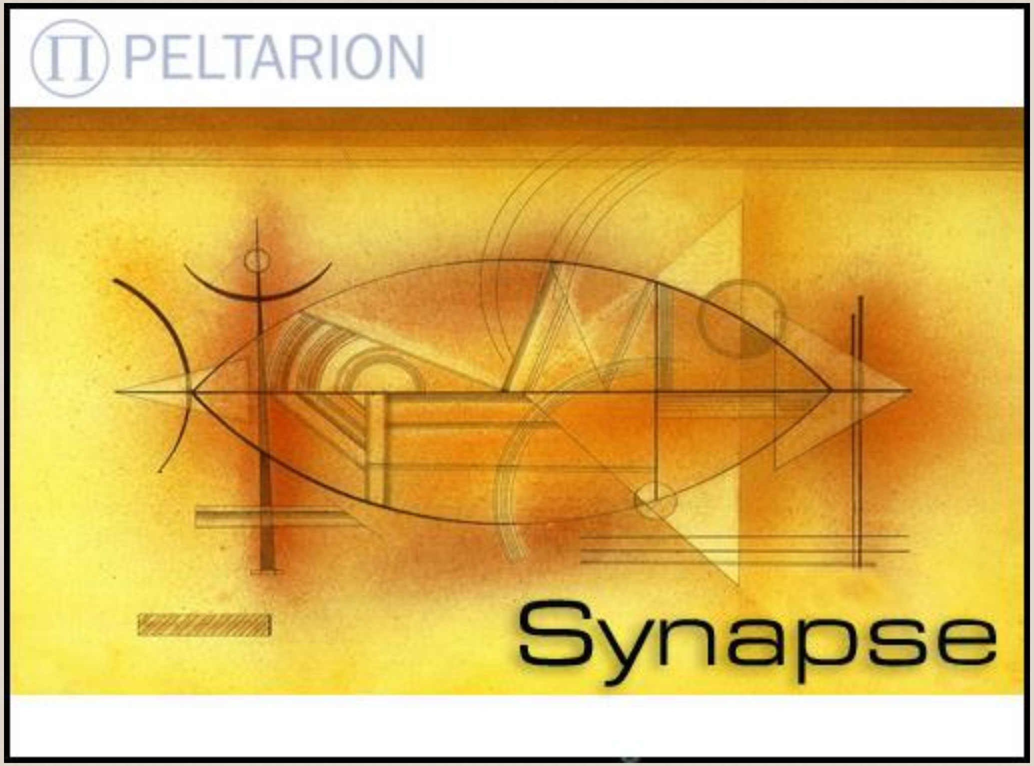
When there are many interacting factors that affect plant yields, it is often difficult or impossible to separate out the effects of individual variables using traditional statistical procedures.



Due to nutrient interactions that affect yield, scatter plots show no apparent relationship. Between chloride toxicity and fruit yields.



Neural Net Software and Programs



http://www.peltarion.com/WebDoc/index.html

Experimental Variables for Production Function Model

Soil

- Texture (clay, silt, sand)
- pH, salinity (EC), chloride
- ave soil water content (Watermark data)
- organic matter, mulch

Water Quality

- EC, chloride

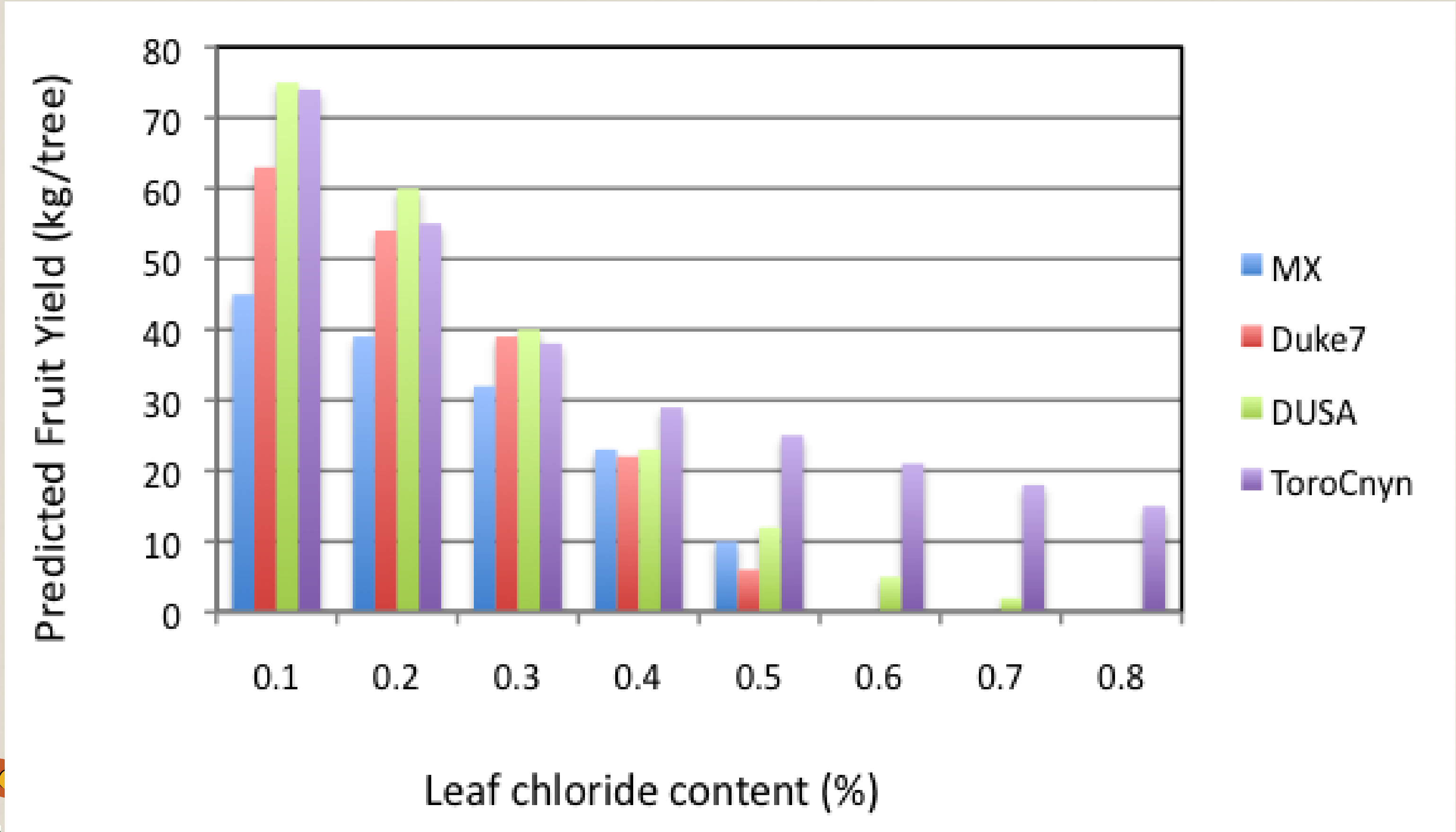
Plant

- rootstock (5 types)
- leaf nutrient contents
- leaf chloride

Output

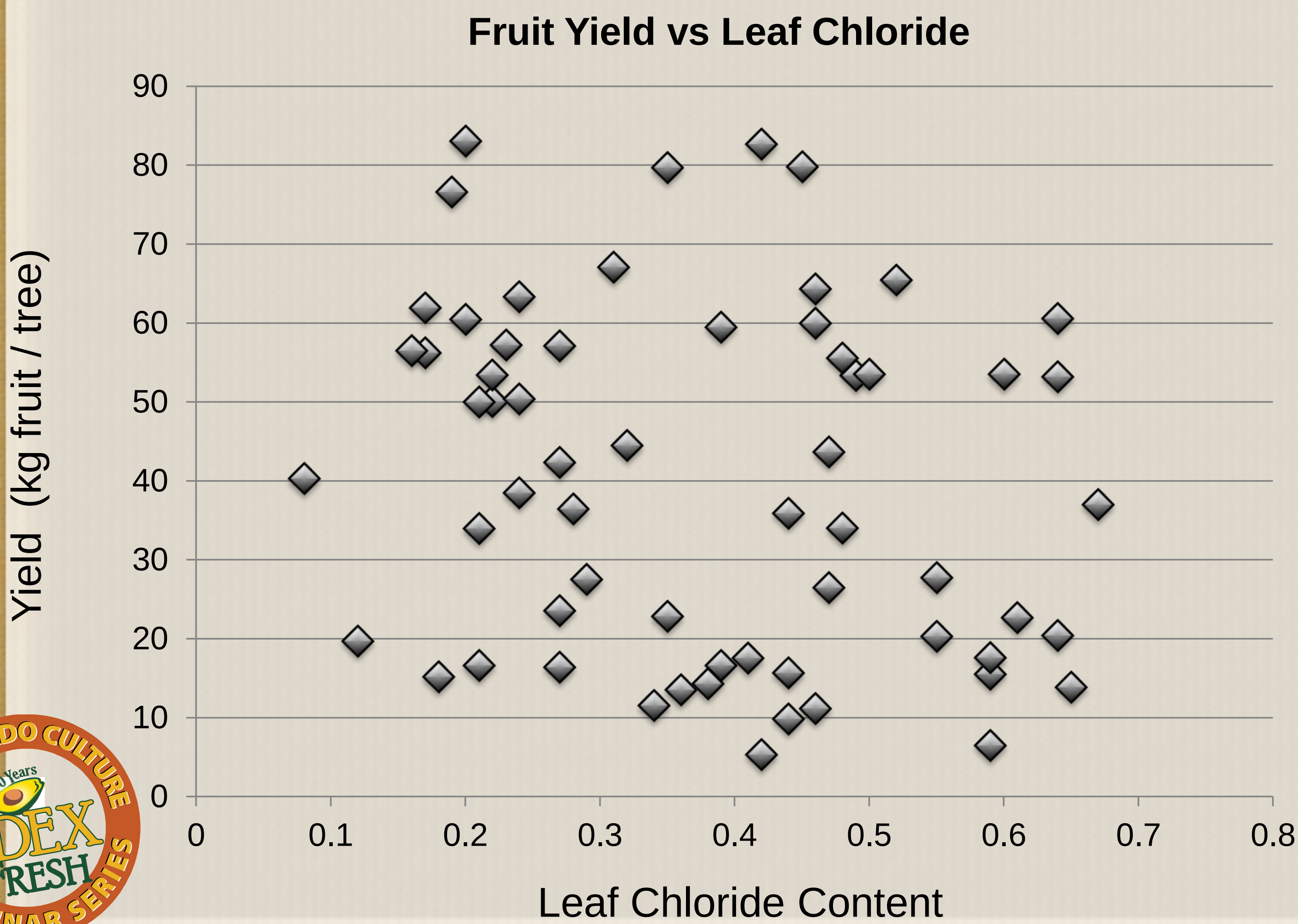
- Root health (root mass, PGPR bacterial densities)
- Fruit yields
- Alternate bearing index
- Water use efficiency (fruit yield/ unit of water)

ANN predicted fruit yields as affected by leaf chloride content for Hass avocado grafted on to different rootstocks under "average" nutrient conditions.

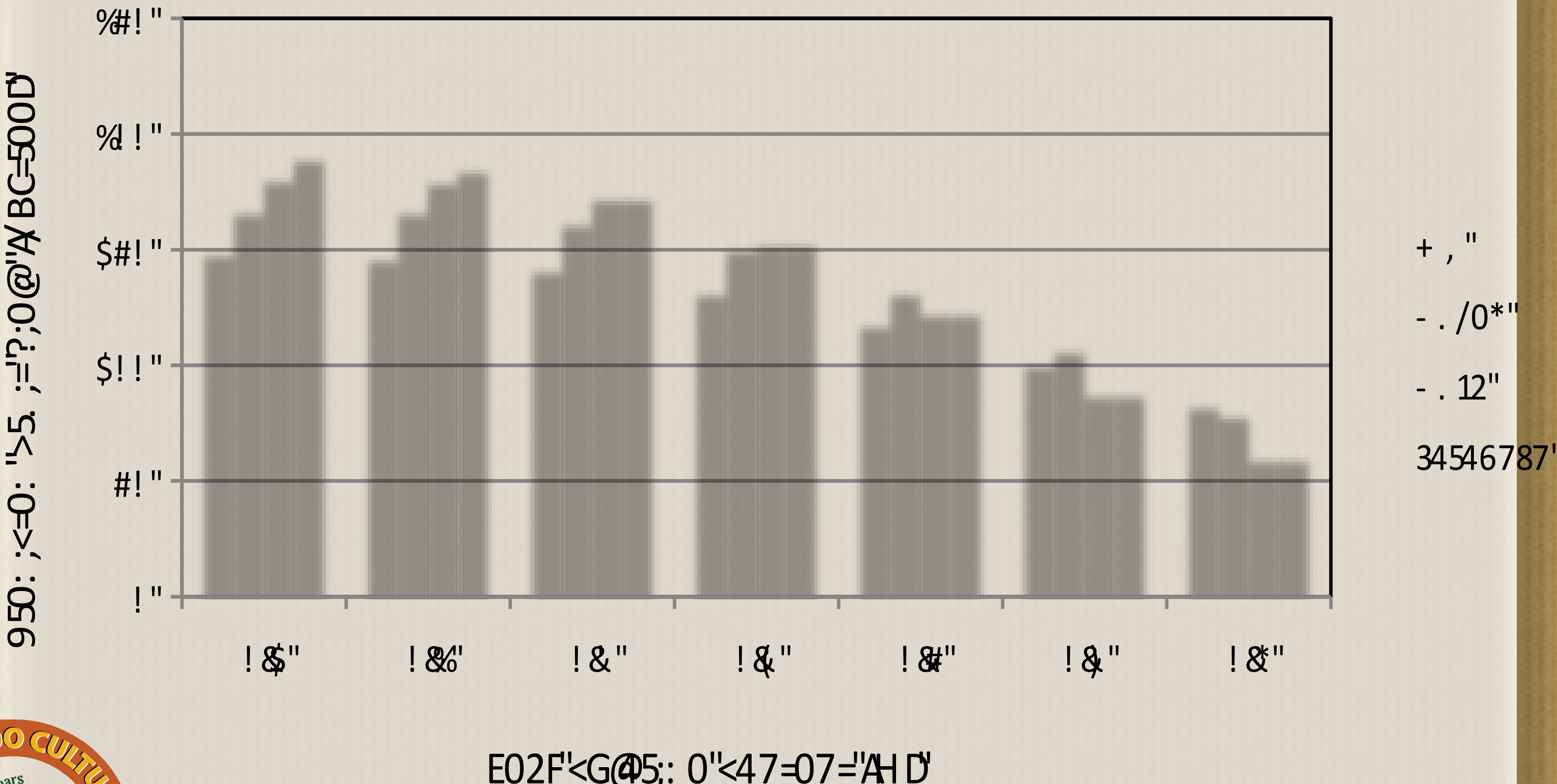


Yield values predicted from an artificial neural network model using fixed values for all nutrients except chloride (values fixed at average levels for entire orchard: N 2.4%, P 0.18%, K 1.2%, Ca 1.5%, Mg 0.4%, Na 0.015%, Zn 30 ppm, Fe 84 ppm, B 40 ppm.

Due to nutrient interactions that affect yield, scatter plots show no apparent relationship. Between chloride toxicity and fruit yields.

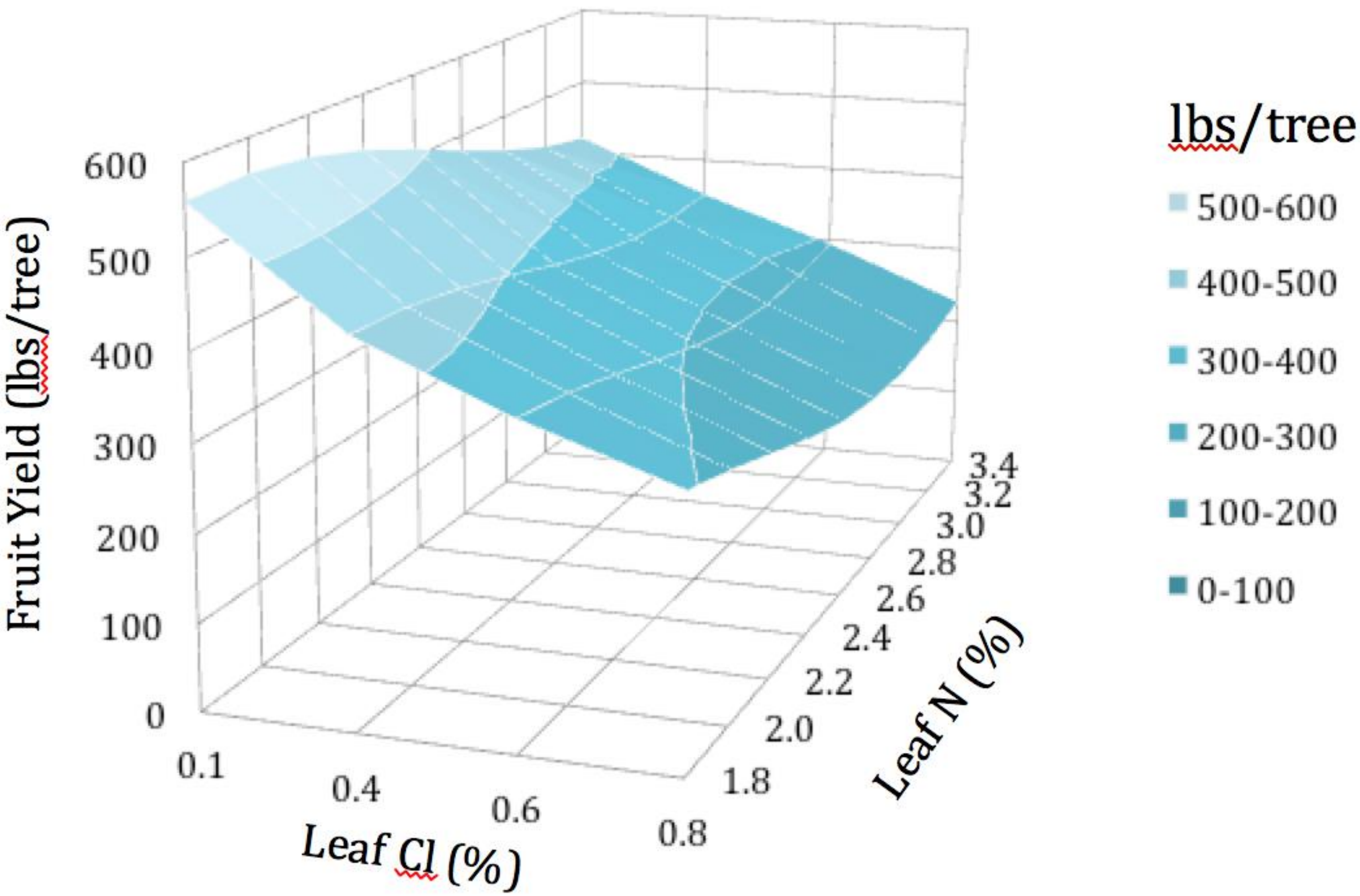


Fruit yield as affected by leaf chloride content for Hass avocado grafted on to different rootstocks under “optimal” nutrient conditions.

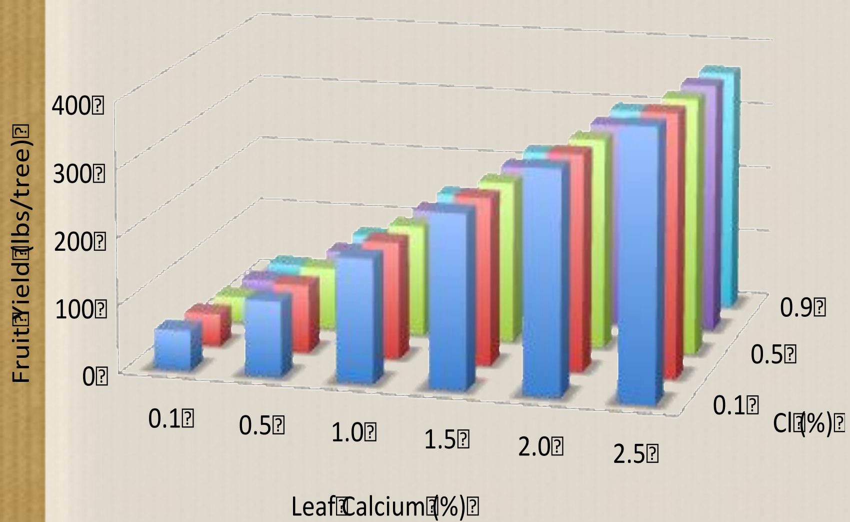


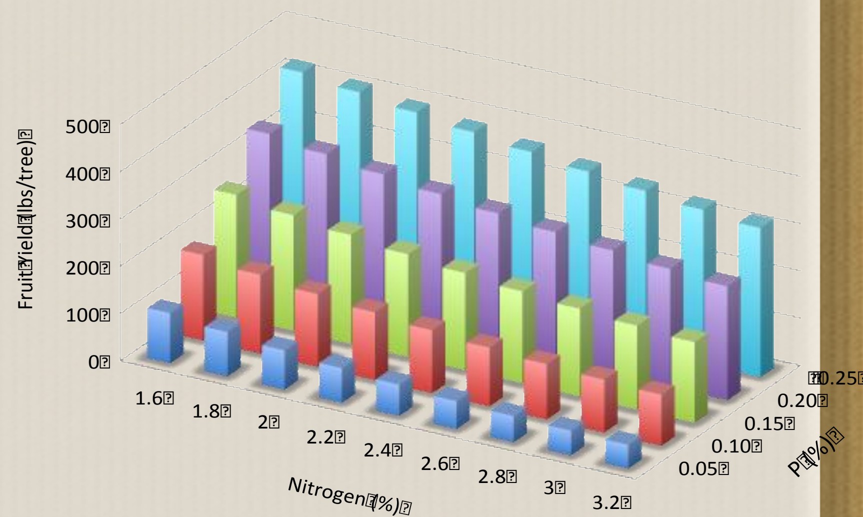
Predicted fruit yield for trees with foliar nutrient values optimized for maximum yields, while varying leaf tissue chloride content for each rootstock. Optimized nutrient levels were N 1.7%, P 0.26%, K 1.3%, Ca 1.14%, Mg 0.28%, Na 0.015%, Zn 31ppm, Fe 100 ppm, B 40 ppm.

Combined Effects of Increasing Chloride and Excess Nitrogen On Avocado Yields Predicted by ANN Modeling



ANN Model Prediction: Fertilization with gypsum (Ca) and phosphorus improves avocado yields in saline soils.





Positive assocations between leaf calcium (Ca) and phosphorus (P) concentrations with fruit yields. The ANN models suggest that yield losses associated with increasing leaf Cl and nitrogen concentrations can be partially offset by fertilization with phosphorus and calcium fertilizers.

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Scientia Horticulturae 78 (1999) 127–157

SCIENTIA HORTICULTURÆ

Salinity–mineral nutrient relations in horticultural crops

S.R. Grattan[a,*], C.M. Grieve[b]

[a] *Department of Land, Air and Water Resources, University of California, Davis, CA 95616, USA*
[b] *USDA/ARS Salinity Laboratory, 450 W. Big Springs Road, Riverside, CA 92507, USA*

"Nutrient additions, on the other hand, have been more successful in improving crop quality such as the correction of Na-induced Ca deficiencies by supplemental calcium."

"Champagnol (1979) reviewed 17 publications and found that P, added to saline soils, increased crop growth and yield in 34 of the 37 crops studied…. In most cases, salinity decreases the concentration of P in plant tissue (Sharpley et al., 1992)…research indicates that salinity stress may increase the P requirement."

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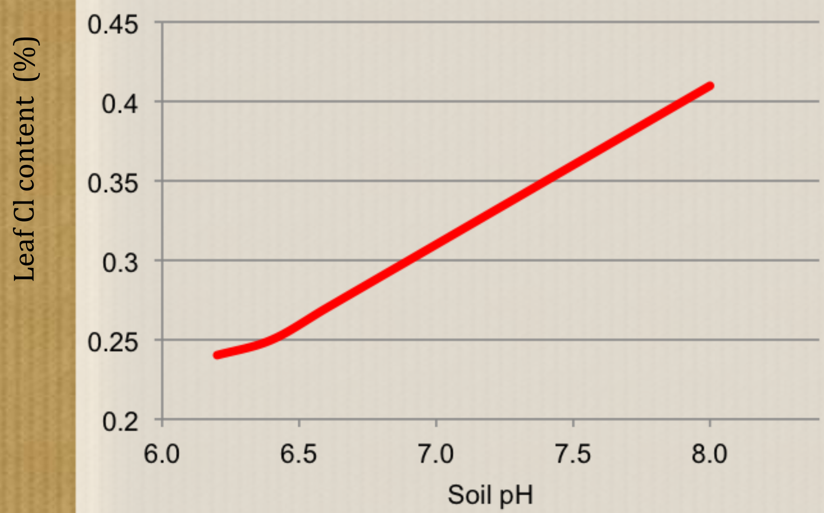
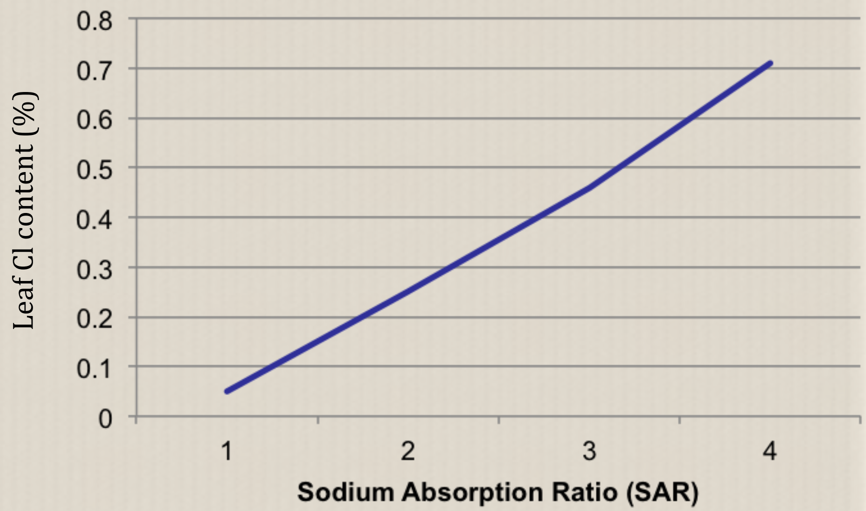
“As the salt concentration in the root zone increases, plant requirement for calcium also increases (Gerard, 1971; Bernstein, 1975).”

“Maintaining an adequate supply of calcium in saline soil solutions is an important factor in controlling the severity of specific ion toxicities, particularly in crops which are susceptible to sodium and chloride injury (Maas, 1993).”

In citrus grown under saline conditions, calcium was found to be effective at reducing the transport of both sodium and chloride from roots to leaves, thereby alleviating foliar injury and/or defoliation (BanÄuls et al., 1991; Zekri, 1993a, b; Zekri and Parsons, 1990; BanÄuls et al., 1997; Zid and Grignon, 1985; Zekri and Parsons, 1992).

ANN Predicted Effects of Soil pH and SAR on Leaf Cl





Analysis of the model predictions based on the 2012 harvest data confirmed the observation that chloride uptake is greater for trees in high pH soil. Trees in soil at pH 6.5 accumulated 0.25% Cl, whereas trees in soil at pH 7.5 had 0.35% Cl. These data suggest that further experiments should be done to lower soil pH and determine whether this is a cause and effect relationship

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

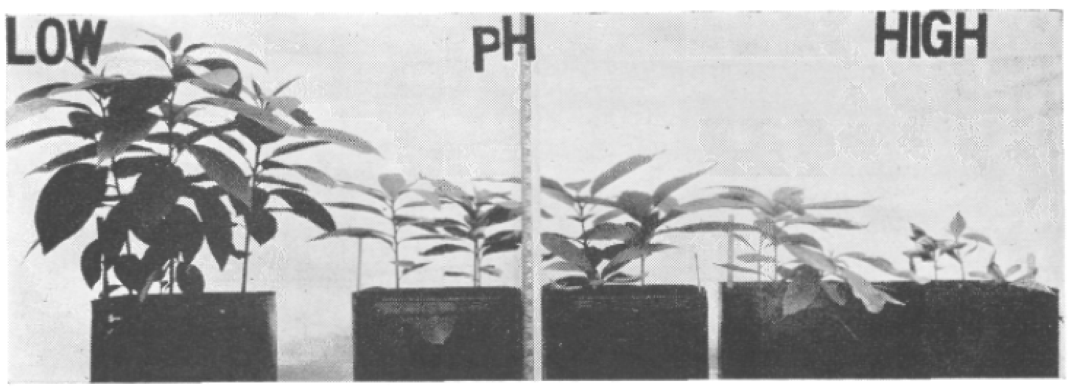
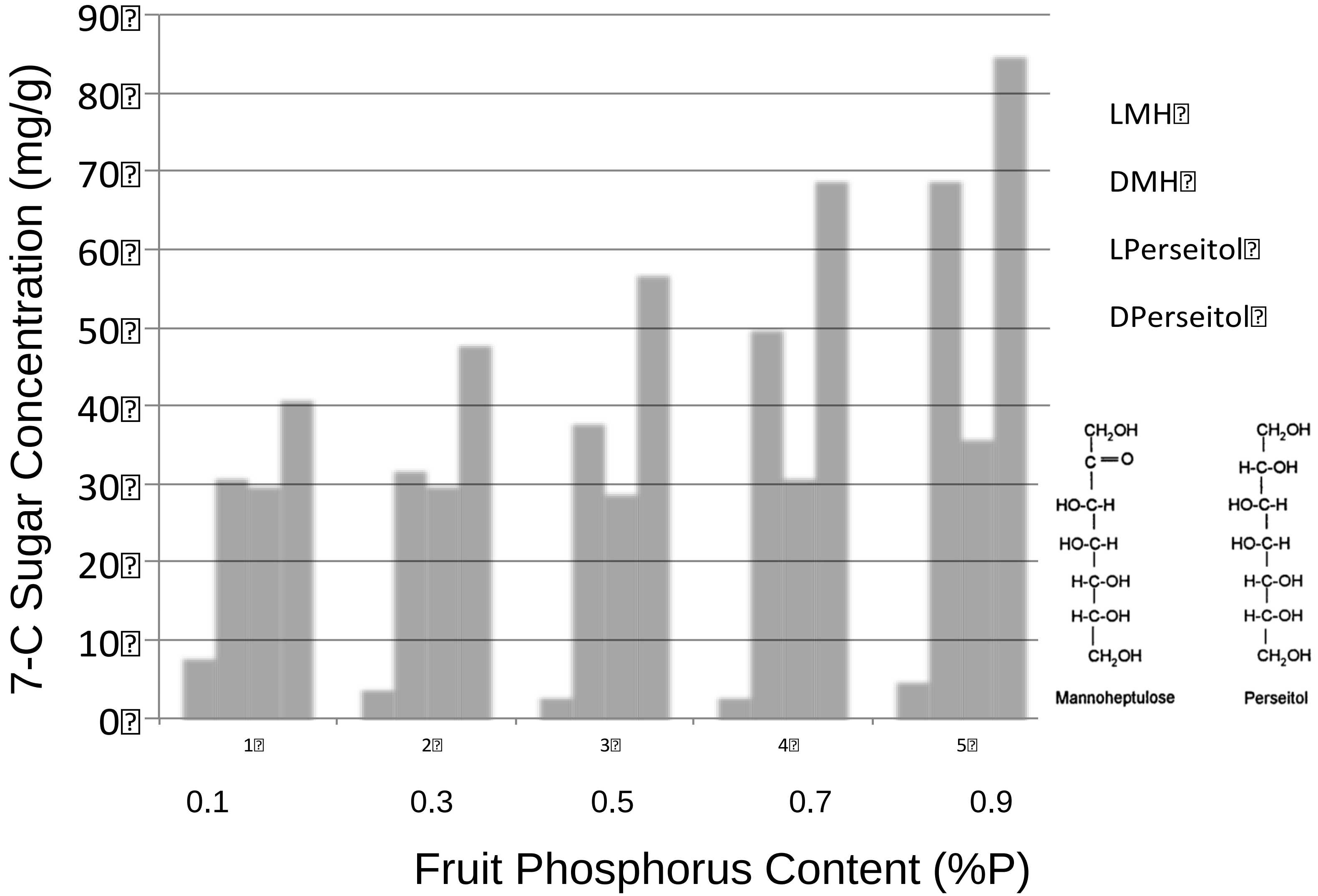


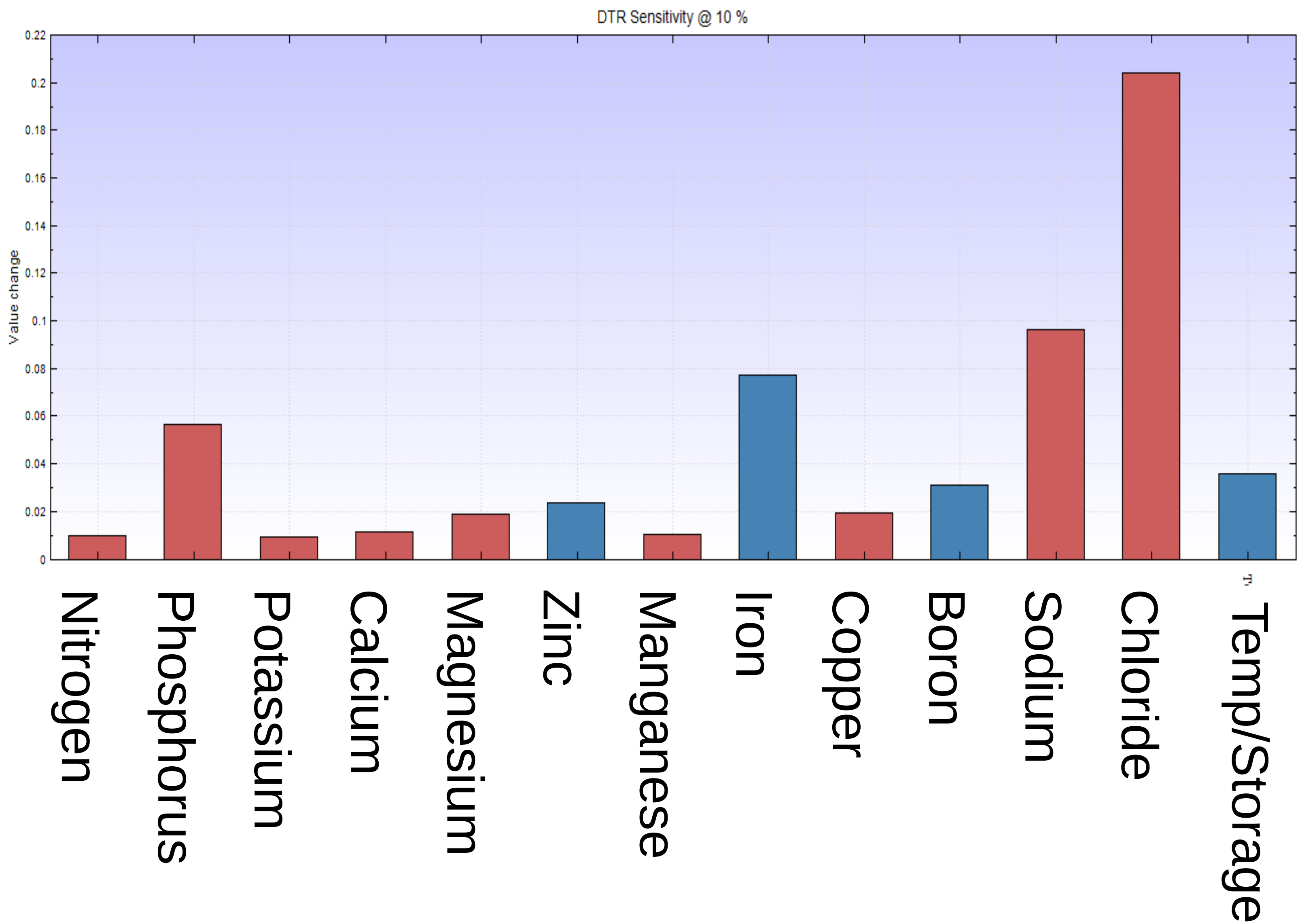
Fig. 2—Effect of soil at different pH values on the growth of avocado seedlings.

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.

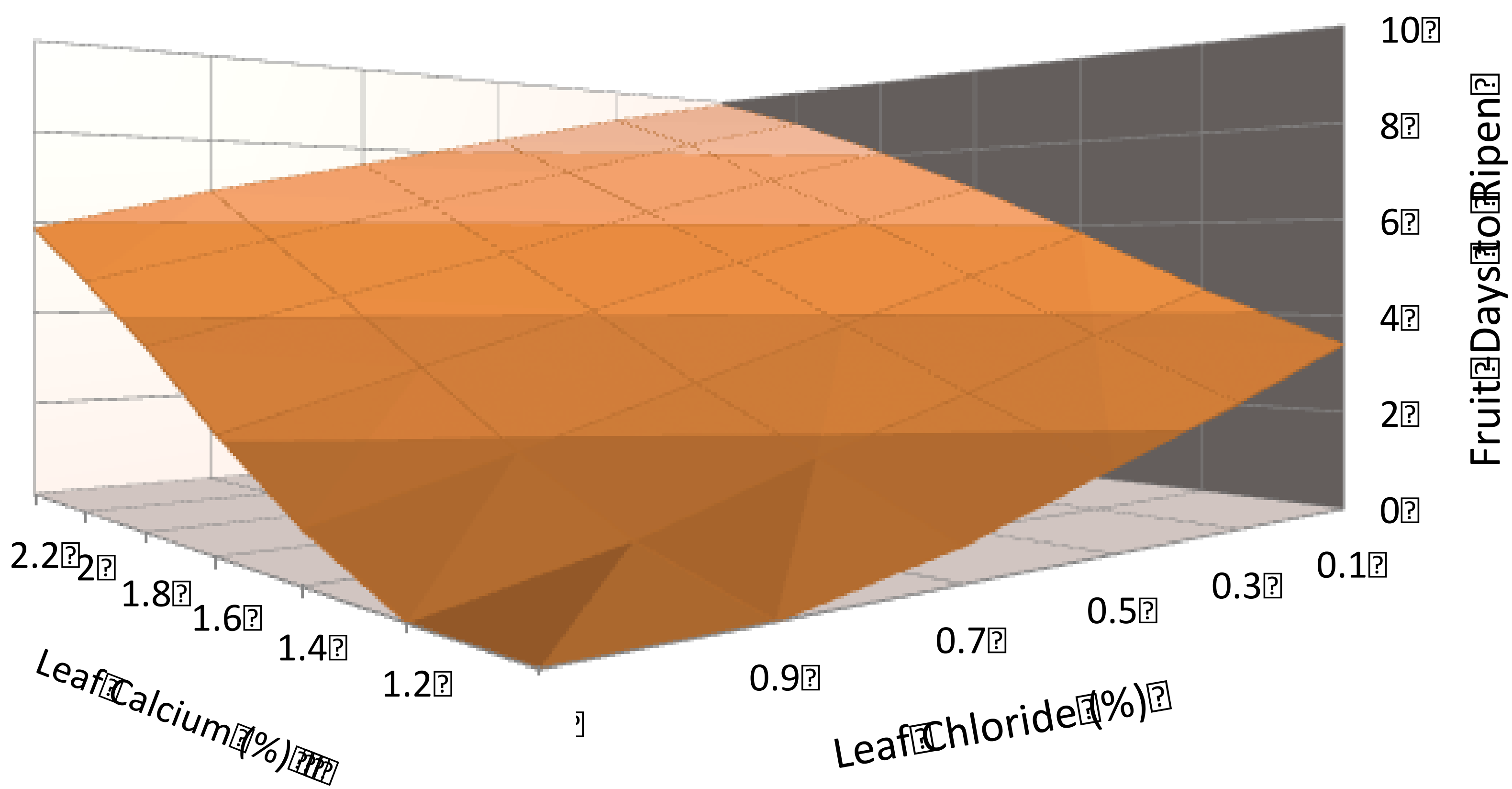
Effect of Fruit Phosphorus Content on Fruit Sugars for Hass on Mexican Rootstocks



Sensitivity Analysis of Leaf Nutritional Factors on Fruit Time to Ripen



Interactions of Leaf Chloride and Calcium Contents on Fruit Time to Ripening for Hass Avocado



Current Status

Artificial neural network models correctly identify well established nutrient relationships associated with plant salinity tolerance.

ANN models quantify the beneficial effects of maintaining a low soil pH, calcium additions via use of gypsum, and increased requirements for phosphorus.

Artificial intelligence works!

Recommendations

- Know your soils and their water holding capacity
- Use CIMIS to determine Et and water requirement
- Maintain a water budget, avoid stress at bloom, fruit set and early fruit development.
- Use soil water monitoring equipment to measure the soil water potential (plant available water) and a capacitance probe (EC and volumetric water content VWC) to monitor the movement of the water front to the desired soil depth that encompasses the root zone.

Recommendations

Avoid hypoxia and waterlogging. This can occur in all soils, but is most likely in heavy clay, rocky, or very sandy soils.

Leach soils but consider pulse irrigation to avoid hypoxia in heavy soils, also provides water savings.

Lower pH using practical methods, element sulfur additions or use a sulfur burners that produce sulfurous acid. Avoid sulfuric acid - dangerous.

N-furic should be used to supply nitrogen, but not as a primary tool to lower soil pH.

Future Directions

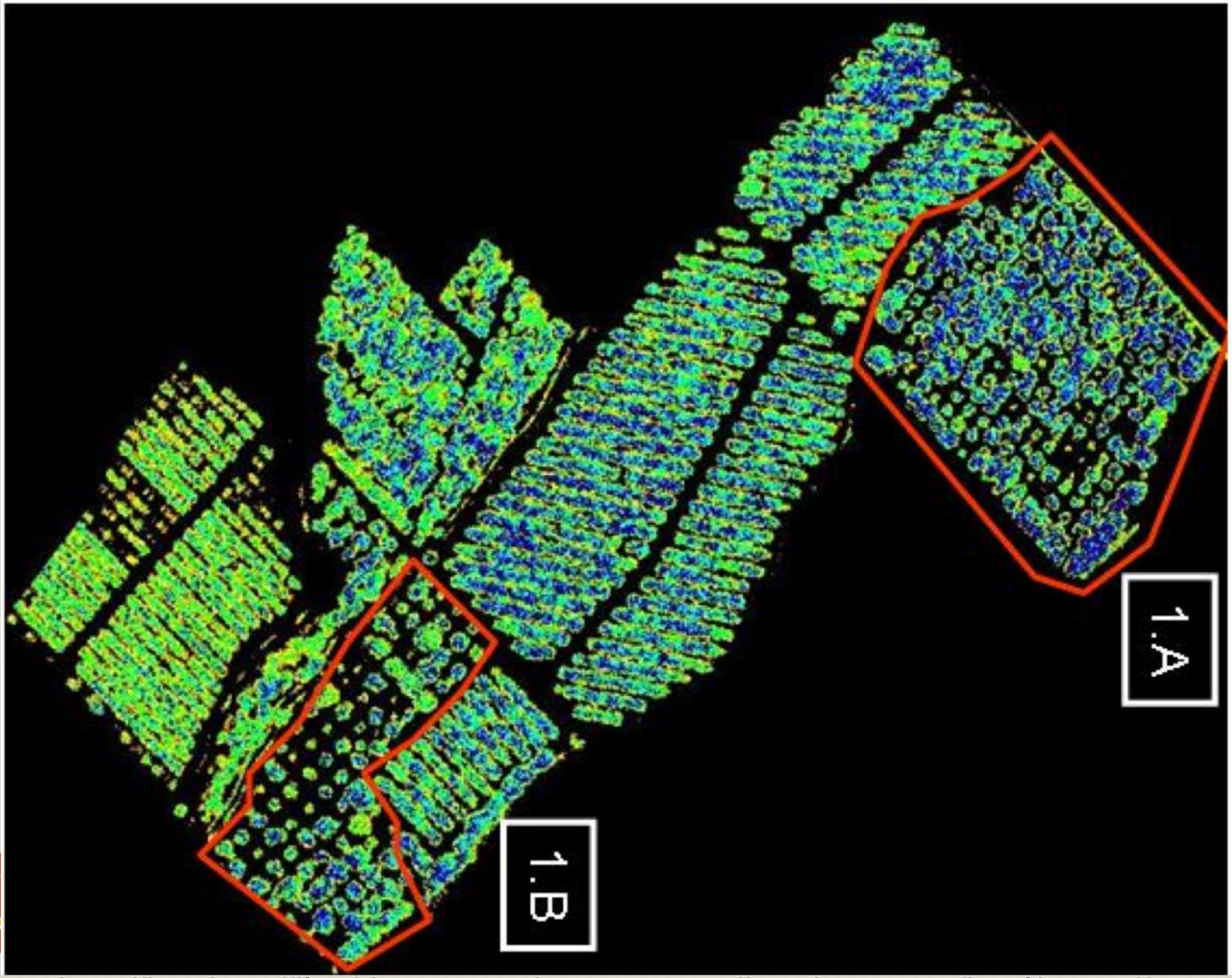
- Computer automated scheduling of irrigation.

  Pulsed irrigation leaching methods
  Automated calculation of water volumes
  Leak detection

- Optimization of nutrient management via precision fertilization

- Use of aerial photography combined with ANN programs to detect and monitor irrigation uniformity, trees suffering from hypoxia, nutrient levels, salinity damage, and insect damage.

Agricultural stress measurement tool for avocado based on multispectral image analysis.

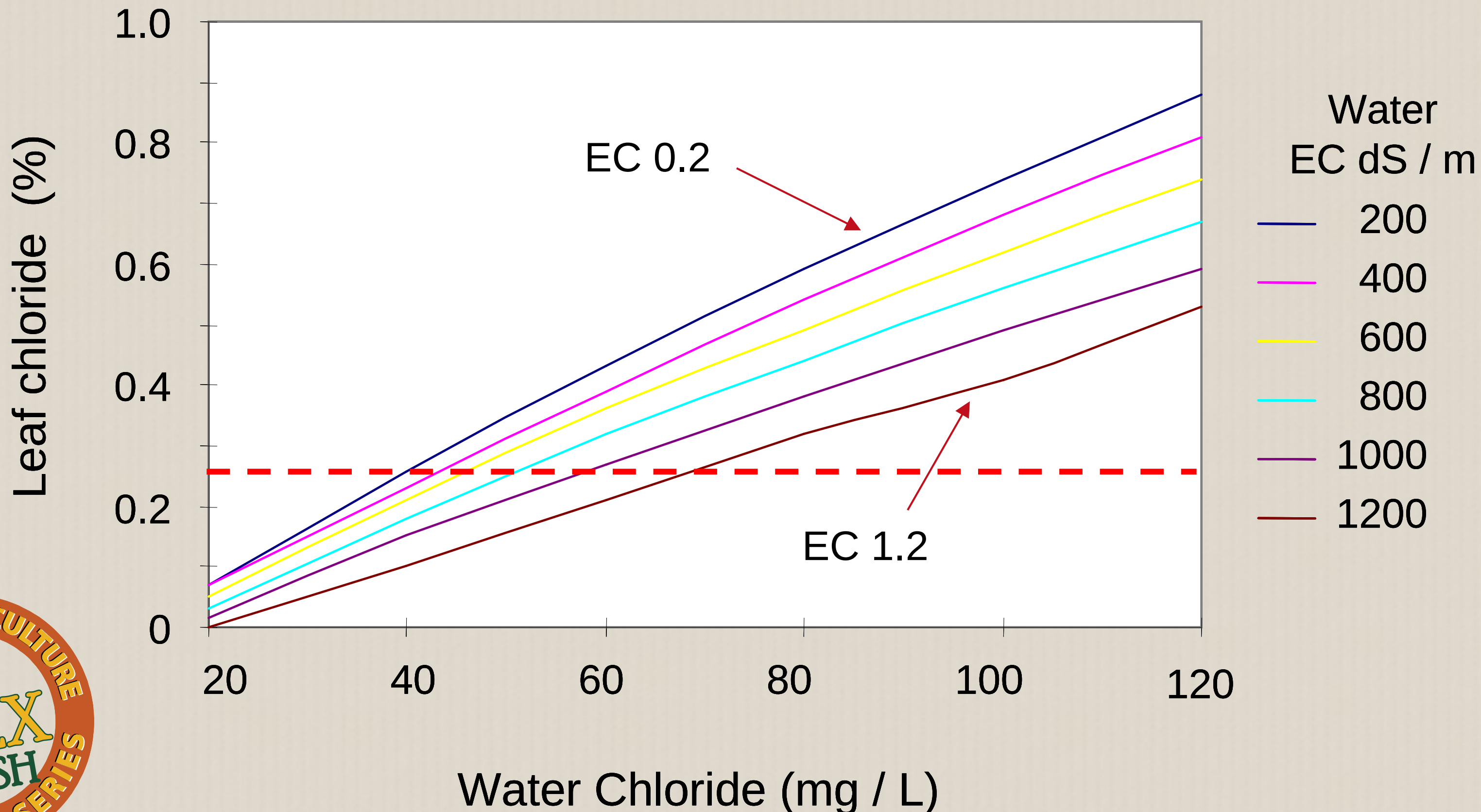


http://icaci.org/files/documents/ICC_proceedings/ICC2009/html/nonref/11_24.pdf

Benefits to the Industry

- Cost-benefit analysis of water quality effects on fruit yields for trees grown on different rootstocks and in different soil types.
- Data driven recommendations for ways to improve water use efficiency, sustainability, and profitability through good irrigation practices.
- Basic information on mechanisms of salinity stress and tolerance in avocado rootstocks. Improved guidance to growers for appropriate rootstock selection.
- Optimization of fertilization and irrigation programs for maximum yields under specific soil, water, and management conditions

ANN model output illustrating the inverse relationship between irrigation water salinity and chloride concentrations on accumulation of chloride in leaves of Hass on Toro Canyon rootstock. Fixed model values were pH 7, 35% Clay, soil ECe 2.0, and soil Cl at 4 mg/kg



Summery

Decision support tools are being developed to predict tree fruit crop yields under different salinity, soil fertility, and management practices.

The use of an artificial neural network model allows the separation of nonlinear interactions between variables to examine the relationships between specific individual variables and fruit yield.

The production function model further allows optimization of fertilization programs to maximize production – and suggest that proper fertilization can offset much of the yield loss under mild to intermediate salinity conditions.

Good irrigation and leaching practices are central to managing soil salinity. Chloride toxicity, leaf burn, and yield reductions are linked to root hypoxia in wet soils or that are slow to drain.