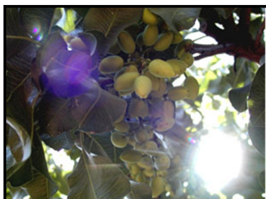
Site Selection: Location Evaluation, Modification, Water Quality, Salinity Management and Reclamation

Advances in Pistachio Production – Short course

Mae Culumber
Nut Crops Advisor, Fresno

9th Advances in PISTACHIO PRODUCTION

November 2, 2020



Evaluate potential for :
- Uniformity
- Rapid maturity
- Quality/nut size
- High yield

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What to evaluate?

Pistachio Crop:

Life cycle, water use, rooting characteristics, spacing, canopy structure, harvest requirements, field traffic

Land:

cost, soil texture, drainage chemistry and amendments

Development:

Cost of land leveling, irrigation system, energy

Irrigation method, distribution, frequency, pressure regulation, filtration, durability, monitoring, maintenance/ repairs,

Water supply: reliability, cost, chemistry, amendments

Where to start

UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION

2020

SAMPLE COSTS TO
ESTABLISH and PRODUCE

PISTACHIOS

SAN JOAQUIN VALLEY - SOUTH

https://coststudies.ucdavis.edu/en/current/

CAPITAL INVESTMENT CONCERNS

"Expensive" ground

- **$15,000/acre ground,** no amendments needed + 5% simple interest over 10 years = $7,500
- **FINAL COST**

$22,000/ac or ...

"Inexpensive" ground

$7,000/acre ground

- Year 1: 1.5 t/ac Sulfur $800
- Year 2 thru 10: $300/yr
  - Extra acid and gypsum through the system $3,000

(Simple interest, 10 yrs @ 5% $3,500)

- Year 7 - 10:
  - 1000 lb/ac cumulative yield loss compared to other ground $2,400

FINAL COST $19,400/acre

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Cost Comparison for 150 Acres @ 121 trees/ac (18 x 20 foot spacing)

EVALUATION COST :

Four zones–1, 2, 3 & 5 foot

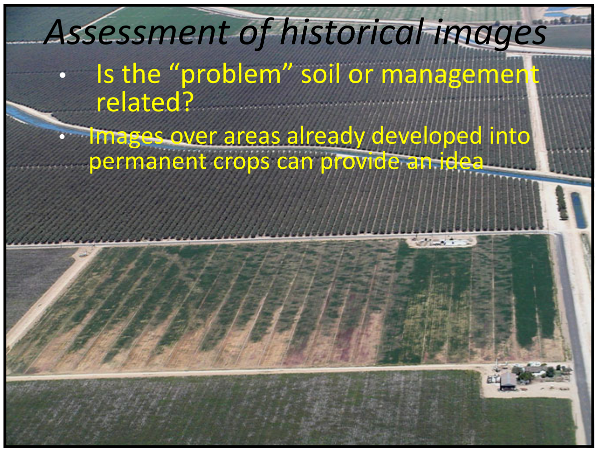
Soil analyses	**1,000**
Water analysis	**50**
Backhoe	**500**
Consultant	**600**
TOTAL	**$2,150**

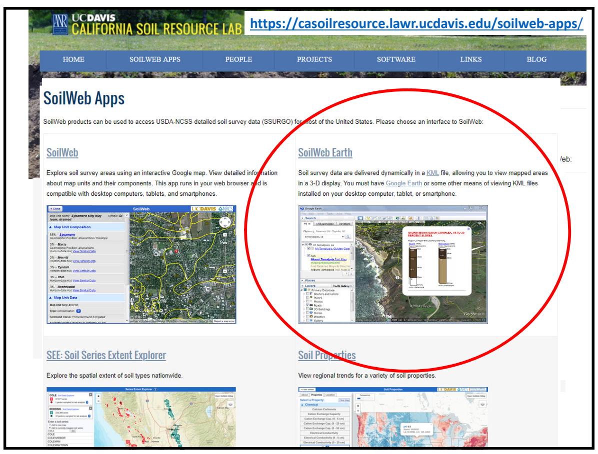
ORCHARD COST:

18,150 trees, stake, bud, train @ $12/tree	**217,800**
Irrig System @ $1,500	**225,000**
Land @ $10,000	**1,500,000**
TOTAL	**$1,942,800**

0.11% of initial capital.

2


Assessment of historical images
• Is the "problem" soil or management related?
• Images over areas already developed into permanent crops can provide an idea

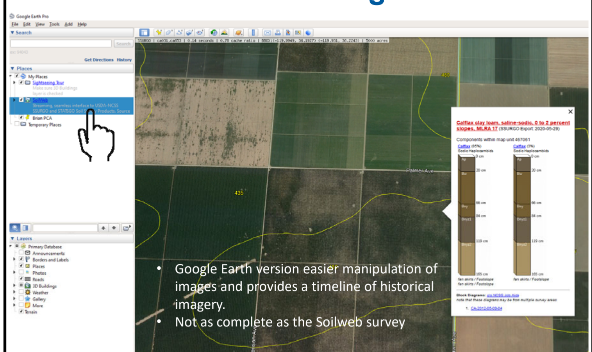

UC DAVIS
CALIFORNIA SOIL RESOURCE LAB
https://casoilresource.lawr.ucdavis.edu/soilweb-apps/
HOME
SOILWEB APPS
PEOPLE
PROJECTS
SOFTWARE
LINKS
BLOG
SoilWeb Apps
SoilWeb
Explore soil survey areas using an interactive Google map. View detailed information about map units and their components. This app runs in your web browser and is compatible with desktop computers, tablets, and smartphones.
SoilWeb Earth
Soil survey data are delivered dynamically in a KML file, allowing you to view mapped areas in a 3-D display. You must have Google Earth or some other means of viewing KML files installed on your desktop computer, tablet, or smartphone.
SEE: Soil Series Extent Explorer
Explore the spatial extent of soil types nationwide.
View regional trends for a variety of soil properties.


SoilWeb
Explore soil survey areas using an interactive Google map. View detailed information about map units and their components. This app runs in your web browser and is compatible with desktop computers, tablets, and smartphones.
SoilWeb Earth
SEE: Soil Series Extent Explorer
Explore the spatial extent of soil types nationwide.
Soil Properties
View regional trends for a variety of soil properties.
Soil Agricultural Groundwater Banking Index (SAGBI)
SoilWeb (3).kmz

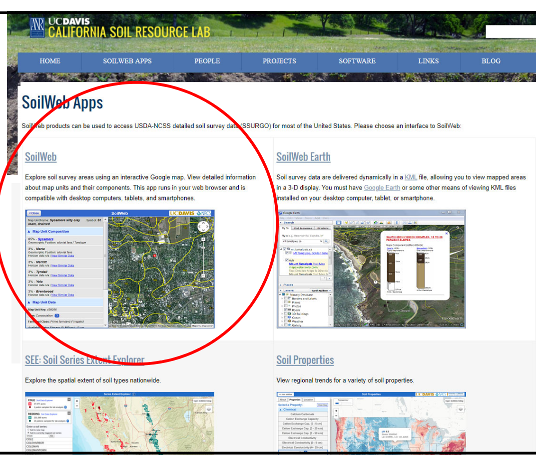
SoilWeb Earth in Google Earth

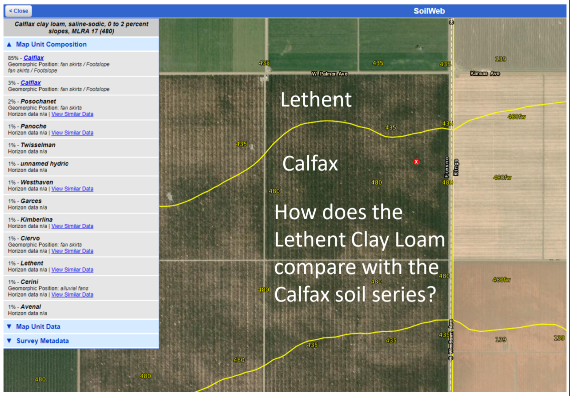
Or another software that can process .kmz files

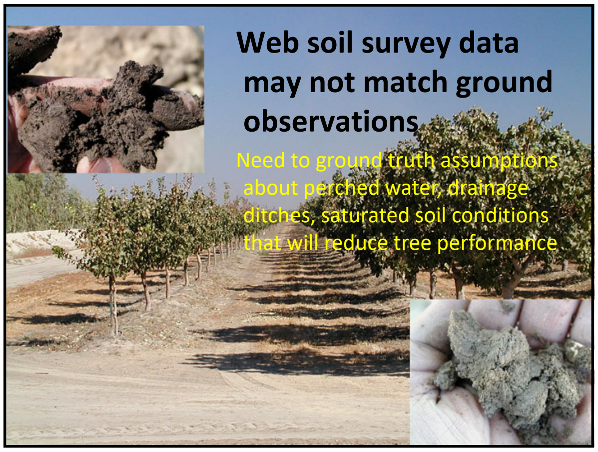
SoilWeb Earth in Google Earth



- Google Earth version easier manipulation of images and provides a timeline of historical imagery.
- Not as complete as the Soilweb survey







Web soil survey data may not match ground observations –

Calfax clay-loam saline-sodic

Depth Range (in)	Horizon Designation	% Clay	%Sand	% Organic Matter	pH by water Extraction	Sat. Hydraulic Conductivity (mm/hr)	EC (dS/m)	SAR (%)	Carbonates (% of < 2 mm)
0 - 2	A	25	22	0.8	7.4	10.8	6.0	10	3
3 - 12	A	30	22	0.5	7.4	10.8	10	18	3
12 - 24	Bw	22	38	0.5	7.4	7.2	12	20	3
24 - 36	Bny	22	30	0.3	7.7	7.2	12	20	3
36 - 60	Bnyz1	20	35	0.2	7.7	7.2	10	20	8

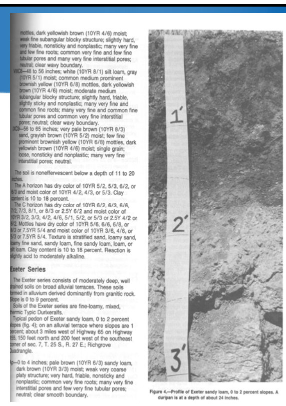
Lethent clay loam

Depth Range (in)	Horizon Designation	% Clay	% Sand	% Organic Matter	pH by water extraction	Sat. Hydraulic Conductivity (mm/hr)	EC (dS/m)	SAR (%)	Carbonates (% of < 2 mm)
0 - 2	Ap	35	36	2.0	7.9	10.5	6.0	0	0
3 - 12	Bt	32	36	1.4	8.4	10.5	8.0	8	0
12 - 24	Bt	30	45	0.3	8.6	2.0	12	15	1
24 - 36	C	23	36	0.3	8.0	5.5	12	15	2.0
36 - 60	C	27	23	0	7.7	3.5	8.0	15	0.5

Soil Profile

- Survey
  - Backhoe pits
  - Augering
  - Push probe

Analysis:	
SP (saturation %)	48
pH	8.2
ECe	6.0 dS/m

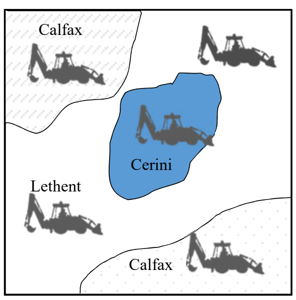


How to do it

SOIL PROFILE

Sampling scheme for variable 160 acres

- **Use soil probe or auger to composite sample 0-1 & 1-2 foot depths from at least 8 holes 50 feet apart for each soil type.**
- **Put at least one backhoe pit to 6 feet in each 40 acres of one soil type. Take deeper samples from pits.**

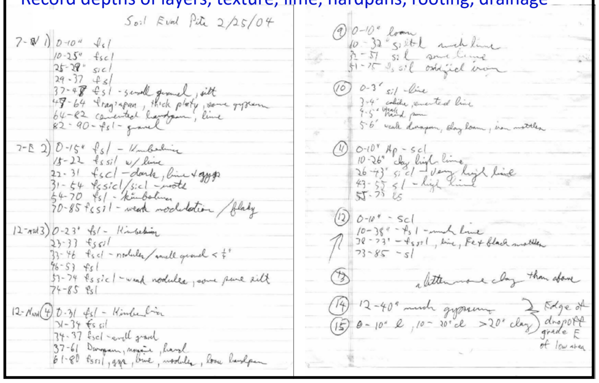



How to do it
SOIL PROFILE
BACKHOE PITS
• SHOVEL
• GEOLOGIST HAMMER/PICK
• MEASURING TAPE
• CLIPBOARD
• BUCKETS/BAGS


How to do it
COLLECTING SAMPLES
@ DEPTH IN SOIL PITS

How to do it

Record depths of layers, texture, lime, hardpans, rooting, drainage



Soil Eval Pits 2/25/04

7-W 1) 0-10" fsl
10-25" fscl
25-29" sicl
29-37 fsl
37-48 fsl - small gravel, silt
48-64 fragipan, thick platy, some gypsum
64-82 cemented hardpan, lime
82-90 - fsl - gravel

7-E 2) 0-15" fsl - Kimberlina
15-22 fssil w/ lime
22-31 fscl - dark, lime + gyps
31-54 fssicl/sicl - roots
54-70 fsl - Kimberlina
70-85 fssil - weak nodulation / flaky

12-mid 3) 0-23" fsl - Kimberlina
23-33 fssil
33-46 fscl - nodules / small gravel < ¼"
46-57 fsl
57-74 fssicl - weak nodules, some pure silt
74-85 fsl

12-Nw 4) 0-31 fsl - Kimberlina
31-34 fs sil
34-37 fscl - small gravel
37-61 Duripan, massive, hard
61-80 fssil, gyp, lime, nodules, loose hardpan

9) 0-10" loam
10-32" siltl much lime
32-51 sil some lime
51-75 fs sil oxidized iron

10) 0-3' sil - lime
3-4' caliche, cemented lime
4-5' weak hard pan
5-6' weak duripan, clay loam, iron mottles

11) 0-10" Ap - scl
10-26" clay high lime
26-43" sicl - very high lime
43-55 sl - high lime
55-75 ls

12) 0-10" - scl
10-38" - fsl - much lime
38-73" - fssil, lime, Fe + black mottles
73-85 - sl

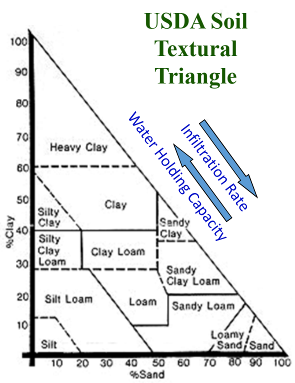
13) a little more clay than above

14) 12-40" much gypsum
15) 0-10" l, 10-20" cl >20" clay
Edge of dropoff grade E of low area

What to evaluate?

SOIL QUALITY

- TEXTURE



How to do it

SOIL TEXTURE

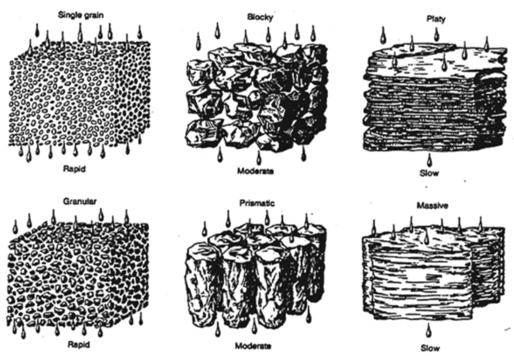
Making a soil "ribbon" test from a moistened ball.

What to evaluate?

SOIL PROFILE

- STRUCTURE

SOIL PROFILE -- STRUCTURE

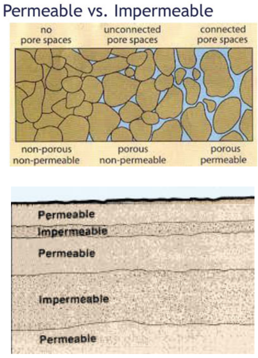


What to evaluate?

SOIL PROFILE

- PERMEABILITY

Permeable vs. Impermeable



PERMEABILITY

- **Measure infiltration**

Double Ring infiltrometer

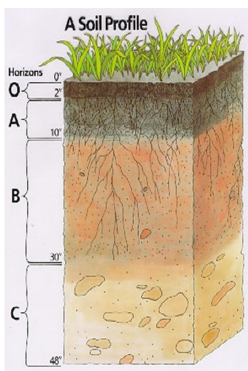
Pick irrigation system that matches soil infiltration!!!
2.5"/week peak season

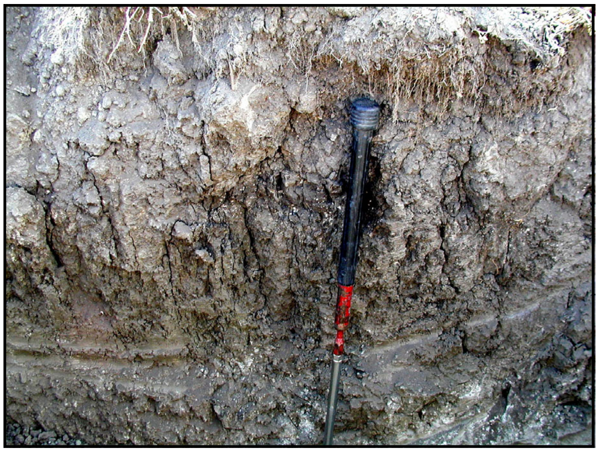
- **Deep rip before planting**
- **Calcium supplying amendments**
- **Organic matter**
- **Cover crops**

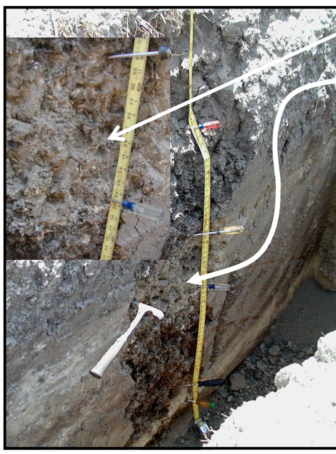
What to evaluate?

SOIL PROFILE

- STRATIFICATION







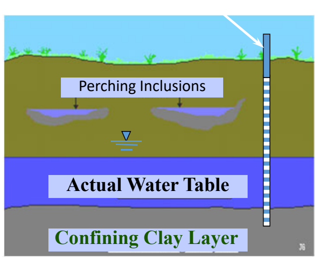
Fine sandy silt layer with high alkalinity and poor structure at the 34 to 44-inch depth may impede root development between 2 layers of clay loam. Slip plowing below this depth is advisable.

What to evaluate?

SOIL PROFILE

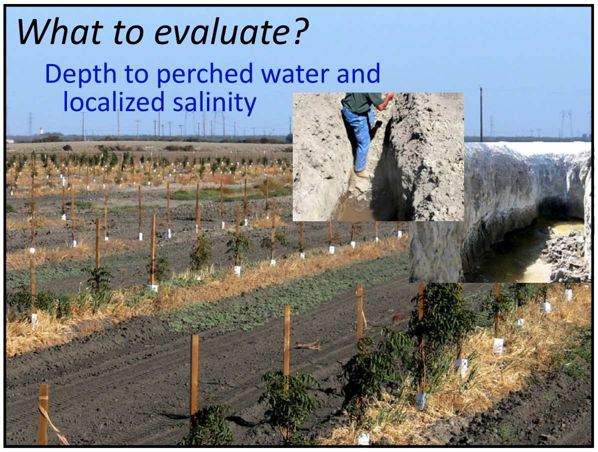
- DRAINAGE

Monitoring well to determine shallow water table depth



What to evaluate?

Depth to perched water and localized salinity

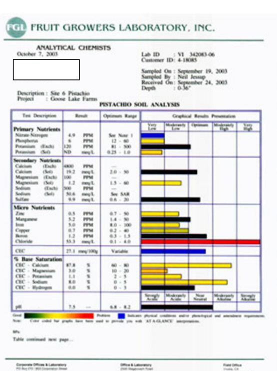


What to evaluate?

SOIL PROFILE

-
-
-
-
-
- SALINITY/FERTILITY

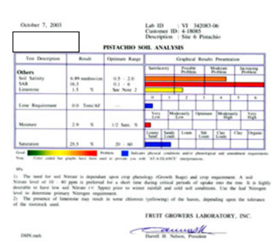
Submit soil and water samples to a CERTIFIED ag lab



FRUIT GROWERS LABORATORY, INC.

ANALYTICAL CHEMISTS

PISTACHIO SOIL ANALYSIS

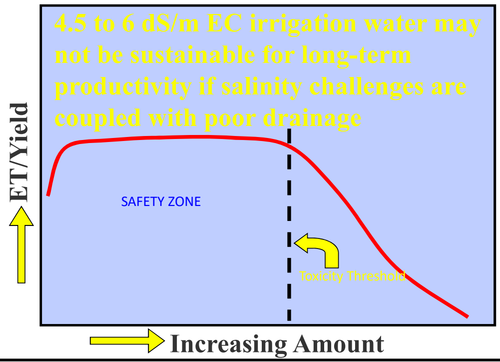


PISTACHIO SOIL ANALYSIS

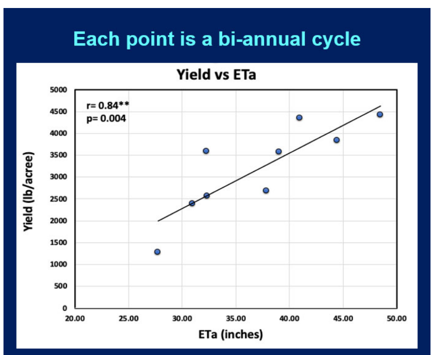
Different labs have different formats. Use one lab with consistent, quality results and a format you understand.

What to evaluate?

SALINITY CONCERNS



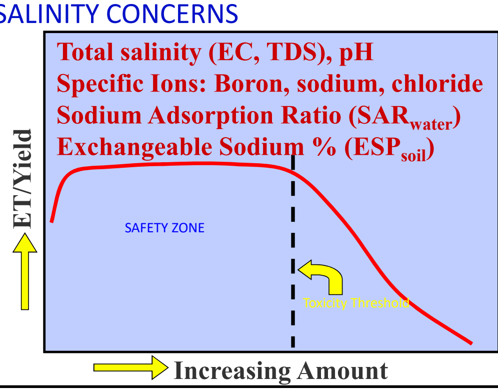
Relationship between ETa and Yield



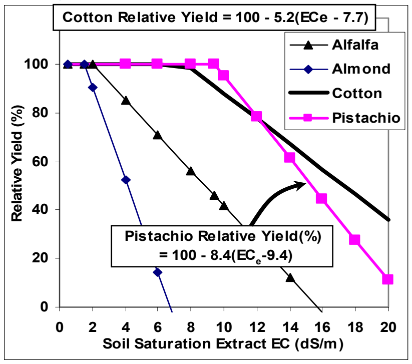
Zaccaria et al. unpublished

What to evaluate?

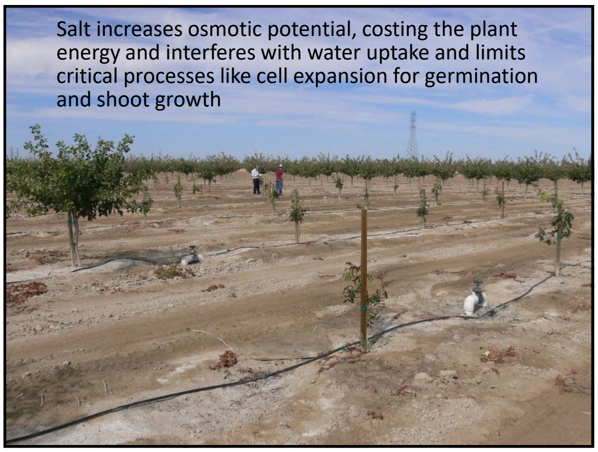
SALINITY CONCERNS



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 664:583-589.



CLASSIC GUIDELINES

UC CE UNIVERSITY OF CALIFORNIA Agriculture and Natural Resources Cooperative Extension

Water Quality for Agriculture. **R.S. Ayers, D.W. Westcot. FAO Drainage Paper 29 Rev. 1,** Reprinted 1989, 1994
http://www.fao.org/DOCREP/003/T0234E/T0234E00.htm

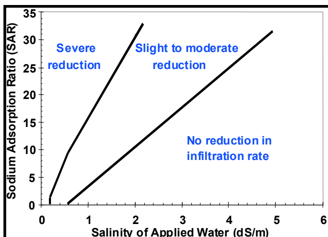
Table 1 GUIDELINES FOR INTERPRETATIONS OF WATER QUALITY FOR IRRIGATION[1]

Potential Irrigation Problem		Units	Degree of Restriction on Use		
			None	**Slight to Moderate**	**Severe**
Salinity *(affects crop water availability)*					
	EC_w	dS/m	< 0.7	0.7 – 3.0	> 3.0
	TDS	mg/l	< 450	450 – 2000	> 2000
Infiltration *(affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together)*					
	Ratio of SAR/EC_w		< 5	5 – 10	> 10
Specific Ion Toxicity *(sensitive trees/vines, surface irrigation limits)*					
	Sodium (Na)[2]	meq/l	< 3	3 – 9	> 9
	Chloride (Cl)[2]	meq/l	< 4	4 – 10	> 10
	Boron (B)	mg/l	< 0.7	0.7 – 3.0	> 3.0

Excess sodium & bicarbonate destroying soil aggregation

Osmotic stress interfering with water uptake

Toxicity, burn, nutrient problems



Infiltration Response to SAR and EC_{irr}

(Ayers, R.S. and D.W. Westcott. 1985. Water quality for agriculture. United Nations FAO Irrig & Drainage Paper No. 29, Rev.1.)

Impact of pH on micronutrient availability and emitter clogging.

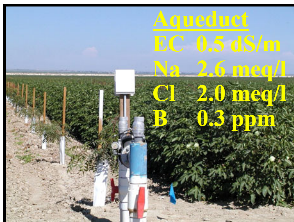
HCO_3

6.5 OPTIMAL pH 7.5

- **Mo deficiency**
- **Low Ca**
- **High Fe, Mn & emitter clogging**

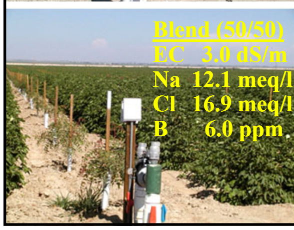
- **Lime precip**
- **Chlorosis**
- **Fe, Zn, Cu, Mn deficiency**

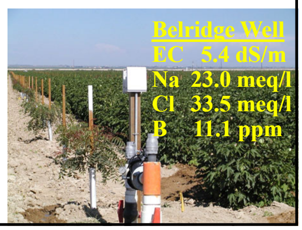
DEVELOPING NEW PISTACHIO PLANTINGS USING SALINE WATER?



Establishing pistachios interplanted in Pima cotton using drip tape and saline water.

(1st leaf, 8/2/05)

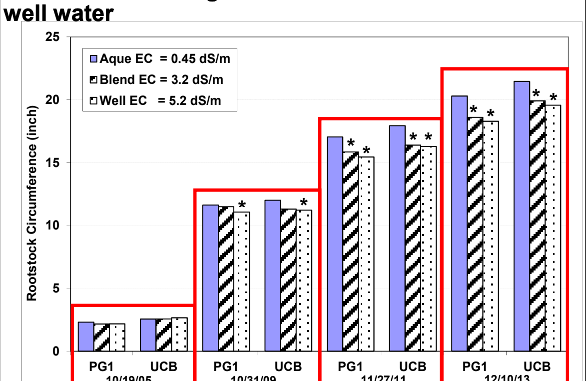




Marginal burn was seen on most leaves

9-1 West Compare

2009-13 rootstock growth decreased 7 to 10% from well water



Trees planted March 5-11, 2005. *Irrigation salinity impact statistically significant

Tree leaf tissue responses

	NO3-N (ppm)	NH4-N (ppm)	PO4-P (ppm)	K (%)	Na (ppm)	Cl (%)	B (ppm)
Rootstock Leaves 9/15/05					**Pistachio 2005**		
Aque	63	160	580	1.02	222	**0.27**	**194**
50/50	55	128	545	1.06	220	**0.27**	****492**
Well	65	148	500	1.08	314	****0.38**	****673**
				K (%)	**Na (ppm)**	**Cl (%)**	**B (ppm)**
				(PG1)		**Pistachio 2009**	
				2.69	100	0.20	378
				2.83	94	0.22	**831
				2.79	90	0.22	**780
				(UCB1)		**Pistachio 2009**	
				2.08	80	0.16	318
				2.17	81	0.17	**616
				2.28	91	0.19	**716
Kerman Leaves 8/28/13 (PG1)						**Pistachio 2013**	
Aque		1.96	0.09	1.97	400	0.20	637
Blend		2.23	0.12	2.49	425	0.33	**1345
Well		1.88	0.10	2.45	400	0.38	**1790
Kerman Leaves 8/28/13 (UCB1)						**Pistachio 2013**	
Aque		1.95	0.10	1.87	450	0.20	537
Blend		2.22	0.12	2.14	475	0.23	**959
Well		2.09	0.11	2.11	450	0.25	**1122

Critical levels of specific ions in leaf tissue
(For August tissue samples prior to harvest.)

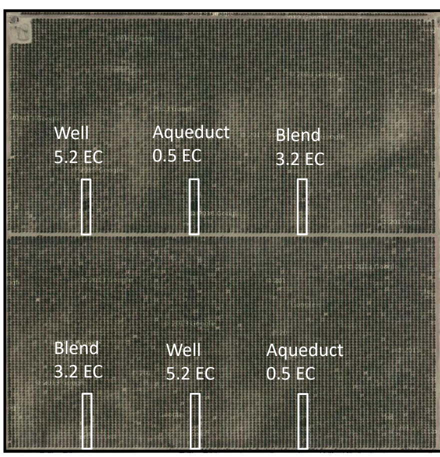
	Degree of toxicity		
	None	Increasing	Severe
Specific ion	Levels in Leaf Tissue		
Chloride (%)	< 0.2	0.2 – 0.3	> 0.3
Boron (mg/l)	< 300	300 - 700	> 800

Salt added to crop rootzone from start of project

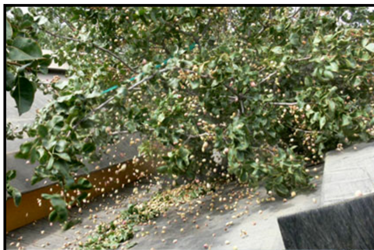
Irrigation Treatment (avg dS/m)	2005 Irrig (in)	Salt [1](lb/ac)	2008 Irrig (in)	Salt (lb/ac)	2011 Irrig (in)	Salt (lb/ac)	2013 Irrig (in)	Salt (lb/ac)	Total Irrig (in)	Total Salt (lb/ac)	[2]EC+ Max (dS/m)
Aque (0.5)	10	1,742	8.8	1,553	33	3,387	33.3	5,686	215.8	32,848	2.6
Blend (3.2)	10	8,570	8.7	8,185	41	40,838	50.5	33,730	247.9	193,172	15.1
Well (5.2)	12	14,782	9.6	13,296	35	48,596	39.0	72,794	225.0	300,395	23.5

[1]Irrigation inches for total tree spacing, salt totals (lb/ac) calculated for a 9.5 foot wide subbing area centered on the tree row. Assumes 640 ppm soluble salt = 1 dS/m and a 5 ac-ft depth of soil = 20 million lbs.

[2]Maximum increase in soil saturated paste EC for a 5 foot rootzone with no precipitation of salts and no leaching past the 5 foot depth.



July 2014 aerial of southern half of trial. White boxes are the 40 tree harvested plots.



1st Harvest 9/23/11
2nd Harvest 9/13/12
3rd Harvest 9/5/13

Yields declined 3.0% PG1 and 1.4% UCB for every additional unit increase in ECe above 5-6 dS/m after a 10-year study of trees planted into saline soil

How to do it   *How to fix it*

Leaching calculations for composite pit samples

FIX: Monitor soil EC, calculate reclamation leaching

Gooselake soils data – composite pits 8, 9, 11, 12, 13

Depth	SP	pH	EC	Ca	Mg	Na	SAR	ESP
0-1'	40	7.9	5.5	34.2	4.6	21.7	4.9	5.7
1-2'	45	8.0	6.7	29.9	4.3	39.6	9.6	11.4
2-3'	45	8.0	7.3	25.1	4	51.8	13.6	15.8

Average salinity = 6.5 dS/m

Guidelines to evaluate orchard soils and water supplies for excess salinity for mature pistachio trees

EC (dS/m) of:	Degree of restriction for pistachios: None	Increasing	Severe
Avg. root zone[1]	< 6	6 - 8	> 8-12
Irrigation water[1]	< 4	4 - 8	> 8-12

[1] Guidelines based on field data where the annual leaching fractions were about 15% for the "No restriction level" and 30% for the "Severe Level".

How to do it *How to fix it*

- WATER QUALITY – Soil structure may suffer with Well 1 quality.

Analysis:

pH	8.4	7.4	7.4	
EC_w	1.0	0.5	5.8	dS/m
Ca	0.5	1.2	26.5	meq/l
Mg	0.1	1.0	15.3	meq/l
Na	9.6	2.5	23.9	meq/l
HCO_3	4.2	1.6	1.5	meq/l
CO_3	1.0	<0.1	<0.1	meq/l
Cl	4.6	2.0	36.9	meq/l
SO_4	0.1	0.9	24.0	meq/l
B	0.7	0.3	11.0	mg/l
NO_3	5.2	0.6	8.0	mg/l
SAR	17.5	2.4	5.4	
SAR_{adj}	16.6			

HCO_3

6.5 OPTIMAL pH 7.5

- Mo deficiency
- Low Ca
- High Fe, Mn & emitter clogging

- Lime precip
- Chlorosis
- Fe, Zn, Cu, Mn deficiency

FIX: Inject acid. 200 - 500 lb/ac-ft H_2SO_4

(Use Excel Program for weights of sulfuric and NpHuric reqd to neutralize HCO3 and release Ca from lime.)

Fine, ball-milled reclaimed sulfur applied @ 1.5 t/ac

2-foot banded appliation: = 15 t/ac to reduce pH in tree row

Incorporated with bent 15" furrowing shovel welded to 30" chisel shank and sunk into slip trench

Incorporation to 28” depth

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Soil analyses from composite sample of Auger & Backhoe treatments prior to planting and end of first season

2005 **Date Sampled: 11/15/05; Grower/Location/Project: Houchin Ripping**

Depth (inches)	SP %	pH	EC dS/m	SAR	Ca meq/l	Mg meq/l	Na meq/l	Cl meq/l	B	HCO3 meq/l	CO3 meq/l	Lime %
0-20"	63	7.6	2.33	7	7.64	1.38	14.6	7.5	0.5	1.9	<0.1	0.4
20-40"	58	7.8	3.36	11	7.73	2.28	25.1	12.5	0.7	1.6	<0.1	13.8
40-60"	48	8.0	3.71	10	9.78	3.28	25.5	17.7	0.7	1.4	<0.1	12.6

2006 **Date Sampled: 11/9/06; Grower/Location/Project: Houchin Ripping**

Depth (inches)	SP %	pH	EC dS/m	SAR	Ca meq/l	Mg meq/l	Na meq/l	Cl meq/l	B	HCO3 meq/l	CO3 meq/l
0-15"	61	7.2	3.15	3	24.5	4.31	10.9	2.4	0.44	3.6	<0.1
15-30	60	7.6	2.32	5	11.8	2.48	12.5	1.3	0.43	2.4	<0.1
30-45	56	7.8	1.87	7	4.9	1.32	12.8	2.2	0.53	2.5	<0.1
45-60	42	7.9	1.88	9	3.7	1.30	13.9	2.6	0.49	2.4	<0.1

Soil Fertility 11/9/06

Depth (inches)	NO3-N (ppm)	Olsen-P (ppm)	AA-K (ppm)	Zn (DTPA)	Mn (DTPA)	Cu (DTPA)	Fe (DTPA)
0-15"	18.9	18.6	375	0.7	4.6	1.5	21.9
15-30	7.2	6.2	230	0.2	0.8	1.5	9.5
30-45	4.8	9.6	185	0.3	0.6	1.1	6.7
45-60	3.1	6.0	126	0.1	0.8	0.6	5.5

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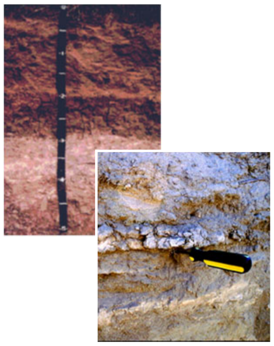
How to do it *How to fix it*

- STRATIFICATION

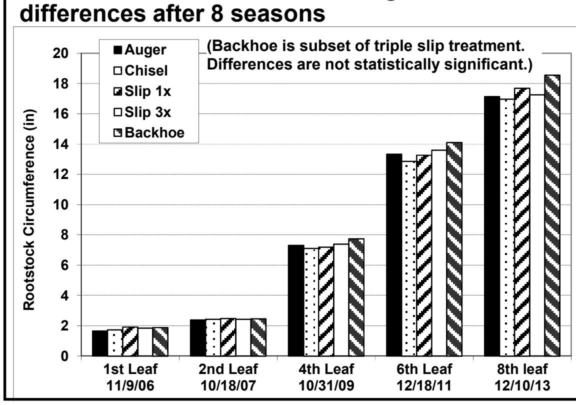


Effect of Pre-plant Tillage on Pistachio Development Under Drip Irrigation (planted 2006)

Treatments:

1. **Auger only:** **no deep tillage. Row marked with furrowing shovel, sulfur applied and incorporated with second pass of same shovel. Standard 3-point hitch auger to be used at planting same as all other treatments**
2. **Slip plow** **(standard tillage for whole project): one slip plow pass down the tree row with a 15-inch shoe penetrating 42 to 50 inches.**
3. **Triple slip:** **slip plow treatment down tree row (as above) with an additional pass 6 foot on either side. A final fourth pass repeated down the center (tree row) pass to achieve a 52-inch penetration and further fracture the profile.**
4. **Backhoe to 7 feet: 3' wide x 7' trench**

Rootstock circumference: No significant differences after 8 seasons



What to evaluate?

Pistachio Crop:

Life cycle, water use, rooting characteristics, spacing, canopy structure, harvest requirements, field traffic

Land:

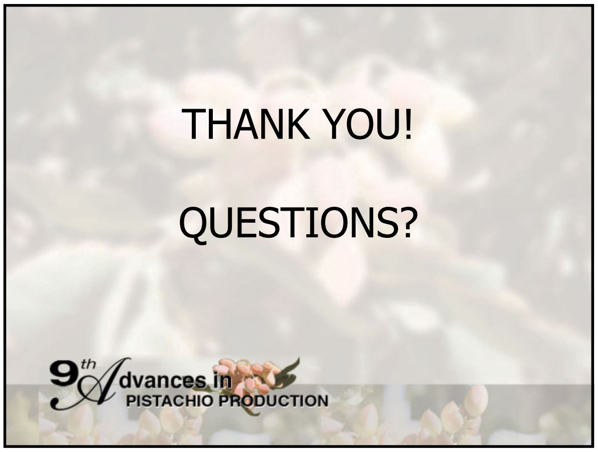
cost, soil texture, drainage chemistry and amendments

Development:

Cost of land leveling, irrigation system, energy

Irrigation method, distribution, frequency, pressure regulation, filtration, durability, monitoring, maintenance/ repairs,

Water supply: reliability, cost, chemistry, amendments


THANK YOU!
QUESTIONS?
9th Advances in PISTACHIO PRODUCTION