

Using Soil & Water Analyses in Orchard Management Decisions

Mae Culumber UCCE Advisor- Fresno County

NSJV Almond Day

cmculumber@ucanr.edu



University of California
Agriculture and Natural Resources  Cooperative Extension

What can soil and water reports be used for?

- Preplant evaluations
 - select crop, ground prep approach, and reclamation needs
 - Detect possible sources of macro and micro-nutrient deficiency
- Select appropriate salinity reclamation approach established orchards
- Nutrient management plans
 - Nitrogen credits from water, soil, and amendments

Preplant evaluation: Soil Surveys

- Soil type and distribution
- Drainage issues and flood potential
- Soil salinity levels (Na^+ , Cl^- , and B)
- Nematode analyses

Site Evaluation Soil Sampling

Soil Analysis

- Objective: Determine suitability for planting
- Sample equal depths down to 5 feet (12" or 18" increments)
- labs generally analyze water soluble and extractable nutrients

Plant Parasitic Nematodes

- Objective: Determine the presence of plant parasitic nematodes
- Assists in rootstock selection and fumigation requirements
- Sample the top profile of the soil, usually between 6"-12" from multiple sites

Water Sampling

- Water should be sampled to determine suitability for almonds
 - Well and surface water
- Water sampling should occur at various times of the year
 - Wells should run 30 minutes prior to sampling
 - Install an EC meter, and resubmit when salinity changes by 20%



HOME » SOILWEB APPS

SoilWeb Apps

SoilWeb products can be used to access USDA-NCSS detailed soil survey data (SSURGO) for most of the United States. Please choose an interface to SoilWeb:

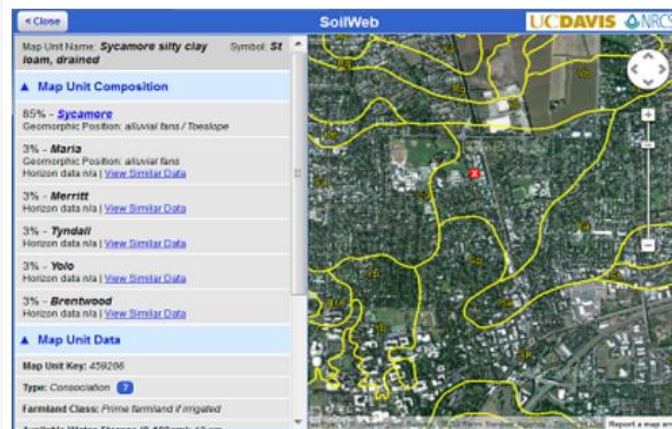
Soil Properties App



This app allows users to explore a variety of soil properties in map form.

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.

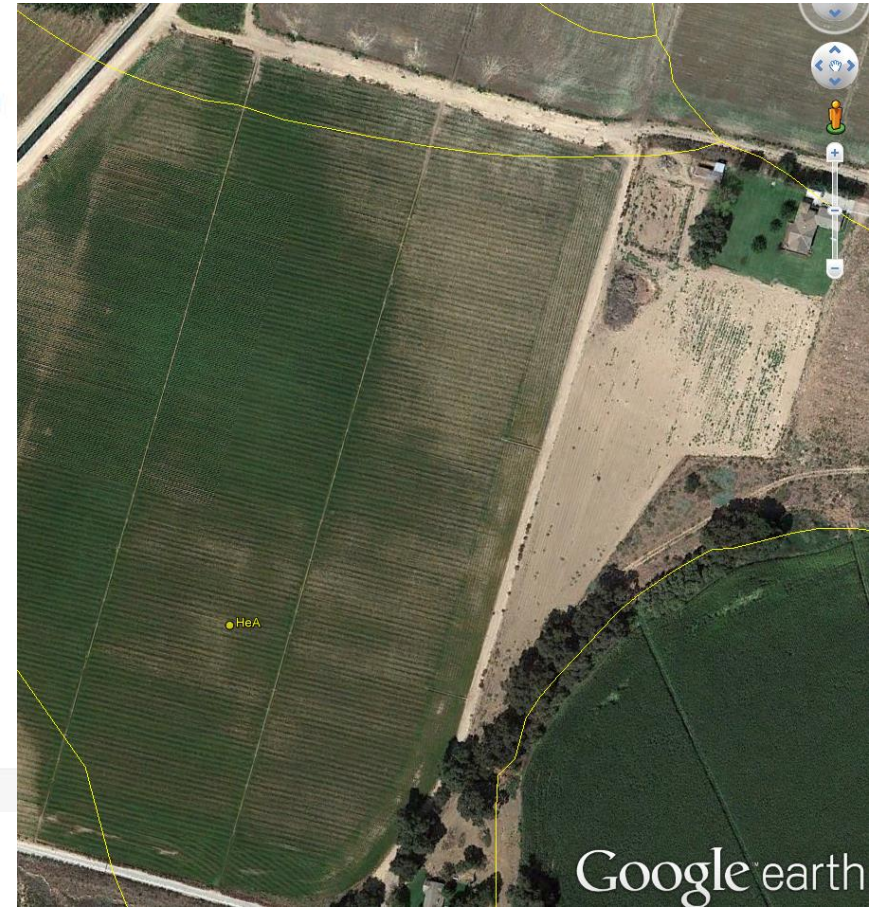
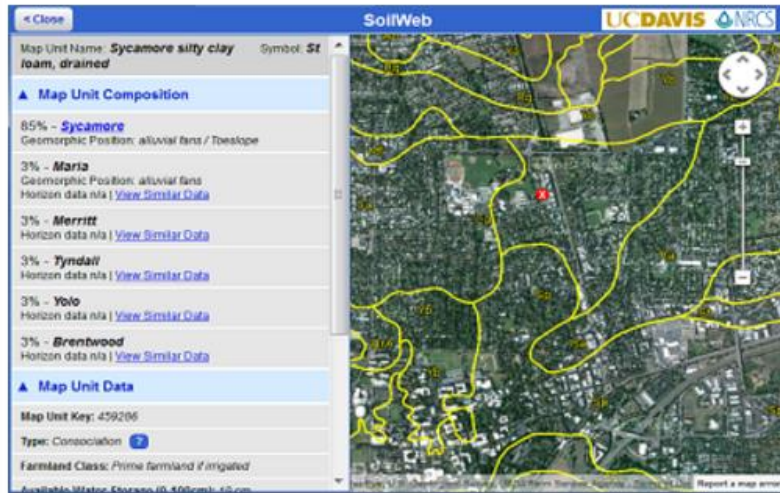


<https://casoilresource.lawr.ucdavis.edu/soilweb-apps/>

Site Evaluation: soil types and distribution

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.



Soil Map: NRCS, Google Earth, etc.

Site Evaluation: drainage issues and flood potential

Check with a Backhoe

Start with soil survey

- Dig holes (5'-6' deep) where maps show differences
- Look for:
 - stratified and compacted layers
 - pull soil samples for analysis and nematodes



Interpreting a Soil Sample - Nematodes

Extraction Method	Plant Parasitic Nematodes						*Soil Ecology	
	Root Knot	Stubby Root	Dagger Xiphenema americanum	Dagger Xiph. index	Ring	Pin	BF + FF	MI
SF	109	5	9		1,067	85	73	0.06
	188		15	3	1,041	134	129	0.10

Plant Parasitic Nematodes:

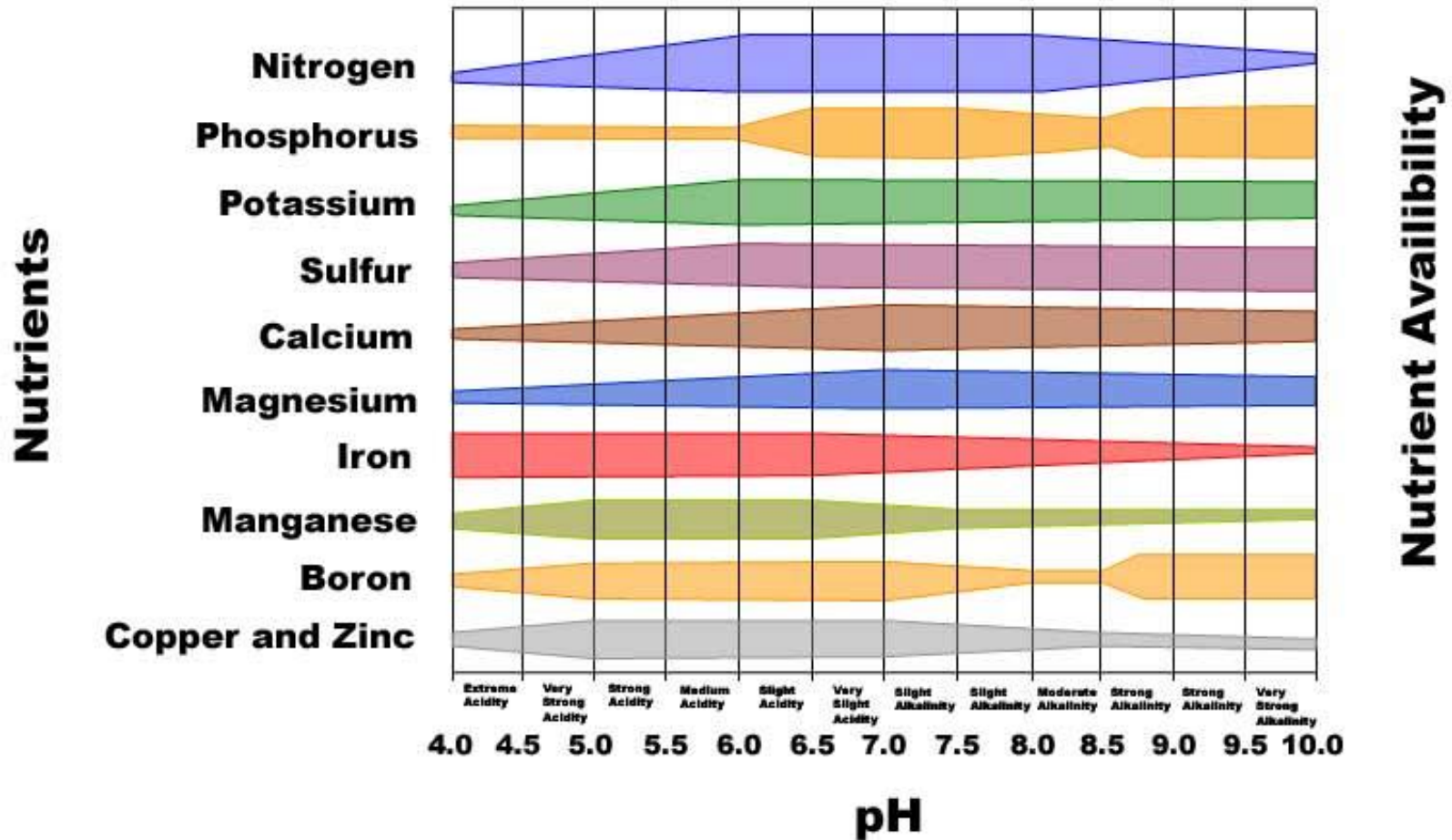
- Ring, Lesion, and Rootknot nematodes are of primary concern
- Should be considered when determining soil fumigation needs
- If not listed, the nematode is not found

Key things to look for in water and soil analyses:

Analysis	Threshold for caution
pH	> 7.5 nutrient limitations, acidifying amendments likely necessary
EC (dS/m)	> 1.5 (potential reduced vigor and production)
Saturation % (soil water content at saturation indicates soil texture)	<20% sand, 20-35% sandy loam, >35% silt, clay, clay loam
Na ⁺ and Cl ⁻ (meq/L)	> 5 soil and water osmotic stress, reduced vigor, ion toxicity
Boron (mg/L)	> 1.0 soil and water
SAR water	> 5x EC _w likely infiltration problems
Exchangeable sodium % soil	> 4% likely infiltration problems
Bicarbonates (HCO ₃ ⁻) water (meq/L)	> 2.5, acid forming amendments recommended
% Lime (CaCO ₃ ⁻) soil	<1% add Ca amendments, >1% use acid forming amendments

pH index

Influence of pH on Availability of Plant Nutrients



ECw water analysis: interpretation

Sample	pH	Ecw (dS/m)	Ca (meq/L)	Mg	Na	HCO ₃ (meq/L)	SO ₄	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!

Salinity of:	<u>Degree of Growth/Yield Reduction</u>			
	Unit	None	Increasing	Severe
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 a 15 percent leaching fraction.

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

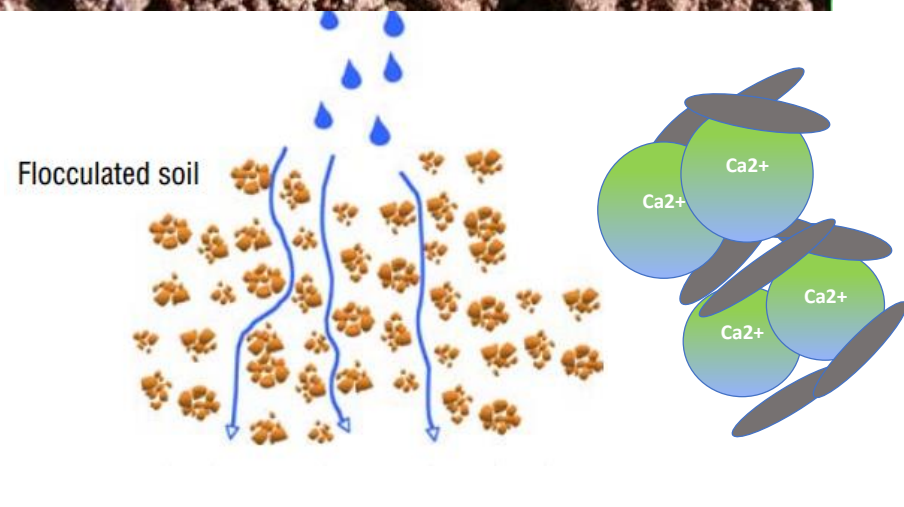
Interpretive Guidelines – Slow Water Infiltration

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

Saline-sodic or sodic soil with SAR water $>5 \times EC_w$ = soil crusting/infiltration issues

Normal or saline soil with SAR water $< 5 \times EC_w$ = little to no infiltration problem



Choose appropriate reclamation approach in saline conditions

Amendment types:

Calcium supplying	Acid-forming
<ul style="list-style-type: none">• low levels of lime <1%, pH < 7.8, <2.5 HCO₃⁻ in water<ul style="list-style-type: none">• Calcium nitrate• Calcium chloride• Gypsum (dihydrate)	<ul style="list-style-type: none">• naturally occurring lime >1%, pH > 8.2, > 2.5 meq/L HCO₃⁻ in water<ul style="list-style-type: none">• Sulfur• Nitro-sulfur• Thio-sul• N-phuric• Sulfuric acid• Sulfurous acid (sulfur burner)

Calcium and acid supplying

- Ca-Thiosulfates
- Lime-sulfur

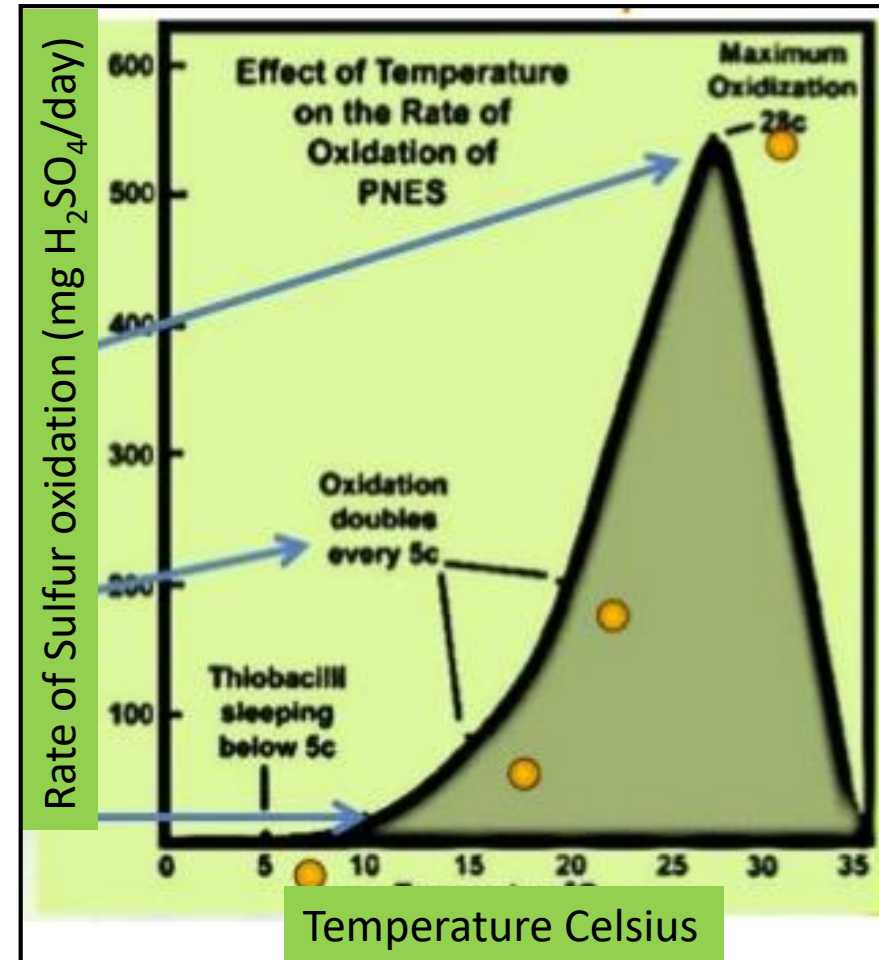
**Broadcasting or
injecting gypsum into
the water is only
necessary if:
Sodium > 5*Calcium**

**Gypsum is a salt
adds to osmotic
pressure that limits
water uptake
through the roots**



Acid forming amendments:

- Elemental sulfur, Nitro-sulfur (20% N 40% S as sulfide), Thio-Sul (12% N 26% S as sulfide)
- Biochemical oxidation of sulfides (S_2) by the bacteria genus *Thiobacillus* to form sulfuric acid
- Sulfuric acid reacts with soil lime to form gypsum
- Climate determines efficiency
 - Requires soil temps > 55F (13C) for 2-4 weeks
 - Field capacity soil moisture conditions most efficient



Acid forming amendments:

- **Sulfuric acid:** efficient for the dissolution of carbonates in highly sodic soil and irrigation water
- not recommended to go below pH 5.0 water or 7.0 for soil
- Do not use in neutral soils, there is no lime to buffer the acidifying effects and you can drastically reduce the pH and damage soil and trees
- Typical soil amendment rates $\frac{1}{2}$ - 2 T/ac
- Water amendment 400 – 500 lbs



Photo credit Florent Trouillas

Nutrient Management Planning

- Methods do not generally measure the quantity of nutrients available to a crop, but determine more or less what portion of the pool of nutrients is plant-available
 - pools of residual nutrients levels vary, changing the amount nutrients available to the plant.
- Important to use a combination of both soil, tissue, and water analyses to estimate fertility needs

14 Essential Elements for tree crops

Macronutrients

- Nitrogen
- Potassium
- Phosphorous
- Magnesium
- Calcium
- Sulfur

Micronutrients

- Zinc
- Boron
- Iron
- Manganese
- Copper
- Chloride
- Nickel
- Molybdenum

Soil fertility guidelines for Nitrate-nitrogen (NO₃⁻N)

Fertility Level	ppm	lbs/acre ¹
Low	<10	<36
Medium	10-20	36-72
High	20-30	72-108
Excessive	>30	>108

- Nitrate is unstable easily leached with irrigation or precipitation
- Analyses may not provide a reliable estimate of soil N
 - still useful of preplant evaluations and annual NMP planning

Soil fertility guidelines for phosphate (PO_4^-)

Fertility Level	Bray P1 method PO_4 Concentration (ppm) Soil pH <7.0	Olsen method PO_4 Concentration (ppm) Soil pH > 6.5
Low	<20	<10
Medium	20-40	10-20
High	40-100	20-40
Excessive	>100	>40

- Both provide an index of availability but not absolute values of available P levels
- P deficiencies are thought to be rare in Almond in Central Valley, low levels should be confirmed with tissue analysis

Soil fertility guidelines for potassium (K⁺)

Fertility Level	Extractable K (ppm)
Very Low	< 75
Low	75 -150
Medium	150 – 250
High	250 -800
Very High	> 800

- K can undergo exchange reactions with other nutrients, be fixed to clay minerals, or leached with irrigation water
- Ammonium acetate test considered best indication of available K⁺
- Levels below 150 ppm are considered low and trees are likely to respond to fertilization

Right Rate: Soil and Water Testing Reports

N is supplied from soil, water, and other sources including manures, composts, nitrogen fixing cover crops, etc.



Testing provides more accurate accounting of N sources

Improves N Efficiency, reduces production costs and environmental impact



Fertilizing Young Almond Orchards: Other Considerations?

Nitrate-nitrogen ($\text{NO}^3\text{-N}$) in the soil:

$\text{NO}^3\text{-N}$ concentration (ppm) * 2 * soil sample thickness (in.)

N (lbs/acre) = $\frac{\text{NO}^3\text{-N concentration (ppm)} * 2 * \text{soil sample thickness (in.)}}{6 \text{ inches}}$

Depth	5 PPM	10PPM	15 PPM	20 PPM
0-6"	10	20	30	40
0-12"	20	40	60	80

ESTIMATING SOIL N CREDIT: The lab reports an average 10 ppm $\text{NO}_{3-\text{N}}$ down to a 4 foot depth for your fanjet irrigated almonds. How much available $\text{NO}_{3-\text{N}}$ is in the profile?

At roughly 4 million lbs soil/ac-ft, and going down to 4 feet:

$$\text{Total } \text{NO}_{3-\text{N}} = 10.0 \text{ parts/million} * 4 \text{ million lb/ac-ft} * 4 \text{ ft} = 160 \text{ lb/ac}$$

**BUT ONLY IN THE WETTED
AREA OF THE ROOTZONE**

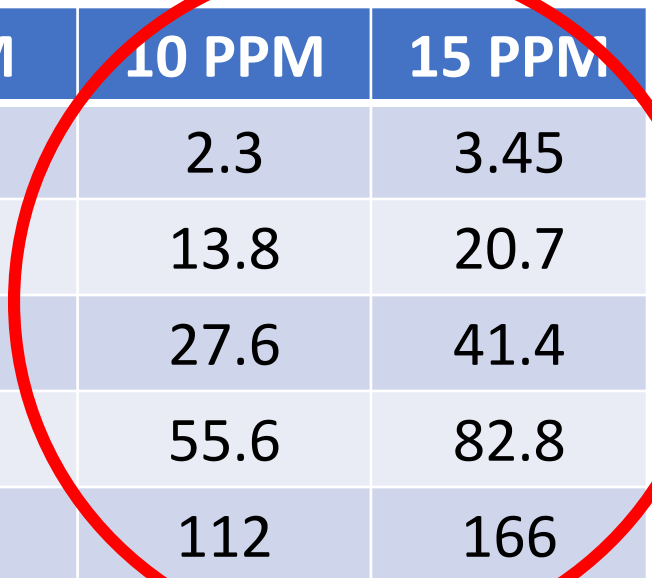
$$\text{FINAL N CREDIT} = 160 \text{ LB/AC} * 60\% \text{ WETTED} \\ \text{ROOTZONE VOLUME} * 70\% \text{ NUE} = 67 \text{ LB/AC}$$

Source of N in irrigation water

Nitrate-nitrogen (NO³-N) in the water:

$$N \text{ (lbs/acre inch)} = \text{NO}^3\text{-N concentration (ppm)} * 0.23$$

Acre inches applied	3 PPM	5 PPM	10 PPM	15 PPM
1	0.7	1.15	2.3	3.45
6	4.1	6.9	13.8	20.7
12	8.3	13.8	27.6	41.4
24	16.6	27.6	55.6	82.8
48	33.2	55.2	112	166



Summary

- Soil and water analyses useful for preplant surveys, salinity reclamation planning, and nutrient management planning
- Water analyses should be conducted at least annually, more frequently with groundwater if water table fluctuates
- Soil analyses and not a substitute for tissue analysis to detect deficiencies
- Water and soil can contribute a significant source of annual N needs, account for this in your NMPs

Thank You!

Mae Culumber

UCCE Fresno

cmculumber@ucanr.edu

559-241-7526

https://ucanr.edu/sites/Nut_Crops/