Welcome to the

2011 INDEX FRESH

Seminar Series

A Comprehensive Guide to Soil and Leaf Analysis

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Sampling Techniques

- **Predictive Sampling**
  - Used to make routine fertilizer and amendment recommendations
  - Soil samples in conjunction with tissue samples are preferable

- **Diagnostic Sampling**
  - Used to characterize and improve problem areas
  - Samples taken from poor growth areas and compared to vigorous growth areas
  - Soil samples will give more insight than tissue

Sampling Methods

- **Soil Sampling**
  - Within uniformly managed blocks
  - Where the feeder roots and the water meet
  - At least 25-30 random cores per block
  - Sample when the soil is dry
  - Try to sample at least 1 month before making major nutrient management decisions
  - With a few exceptions soil chemistry changes very little throughout the year

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Sampling Methods

- **Tissue Sampling**
  - Timing is Important!
    - Phenologically
    - Hold time from sampling to analysis
  - Within uniformly managed blocks
  - The most recently matured leaf
  - Necessary leaf quantity differs among crops but a good rule of thumb for every crop is…

Actually a rule of hand

Capturing the Elusive Recently Matured Leaf

- **Why?**

Sample Area	% Nitrogen	% Phosphorus	% Potassium
SA-121Y	2.64	0.344	1.74
SA-121RM	2.25	0.158	1.08
SA-121O	1.66	0.128	1.17
Optimum Range - Average	2.20 - 2.40	0.0800 - 0.440	1.00 - 3.00

% Calcium	% Magnesium	ppm Zinc	ppm Manganese
0.412	0.177	43.4	20
1.49	0.441	22.8	32
2.07	0.527	16.0	41
1.00 - 4.50	0.250 - 1.00	30.0 - 250	30 - 700

Plant Tissue Analysis

- **Constituents**
  - **Most commonly deficient plant essential nutrients**
    - **Nitrogen**
    - **Phosphorus**
    - **Potassium**
    - **Calcium**
    - **Magnesium**
    - **Zinc**
    - **Manganese**
    - **Iron**
    - **Copper**
    - **Boron**
    - **Sulfur**
  - **Uncommonly deficient plant essential nutrients**
    - **Molybdenum**
    - **Nickel**
    - **Cobalt**
    - **Chloride (regularly analyzed to monitor toxicities)**

Nutrients and Avocados

Element	Role	Deficiency Symptom
Nitrogen	Vegetative Growth	Chlorotic older leaves

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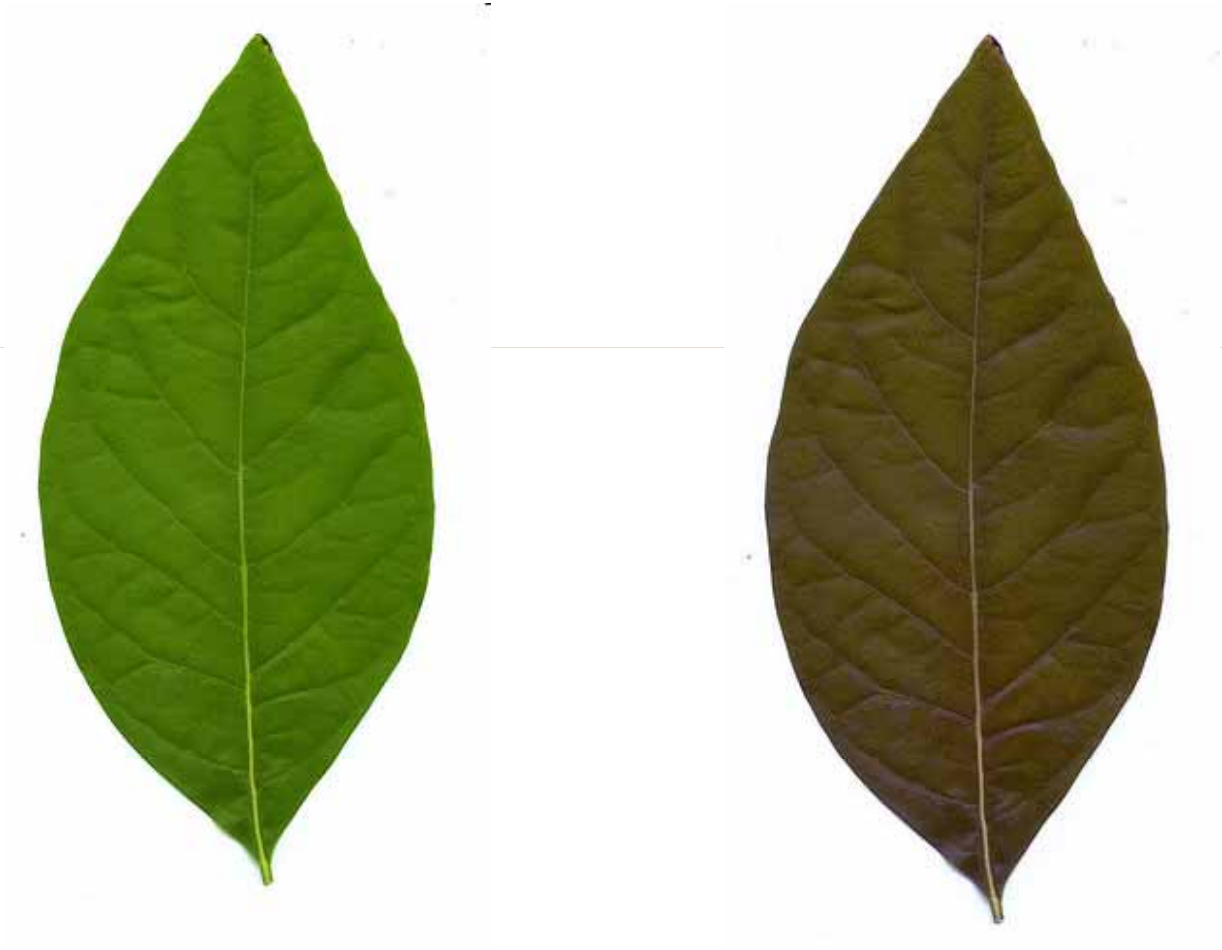
Nutrients and Avocados

Element	Role	Deficiency Symptom
Nitrogen	Vegetative Growth	Chlorotic older leaves
Phosphorus	Energy transfer / Root growth	Purple tint to leaf / Difficult to see



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Nutrients and Avocados

Element	Roles	Leaf Deficiency Symptoms
Nitrogen	Vegetative Growth	Chlorotic older leaves
Phosphorus	Energy transfer / Root growth	Purple tint to leaf / Difficult to see
Potassium	Regulates water / Fruit quality	Intraveinal and marginal chlorotic older leaves

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Nutrients and Avocados

Element	Role	Deficiency Symptom
Nitrogen	**Vegetative Growth**	**Chlorotic older leaves**
Phosphorus	**Energy transfer / Root growth**	**Purple tint to leaf / Difficult to see**
Potassium	**Regulate water / Fruit quality**	**Intraveinal and marginal chlorotic older leaves**
Calcium	**Cell structure / Fruit set**	**Spotted Necrotic younger leaves**


None Here
MEXICO
MEXICO ½ MILE
Sonora
Chihuahua
Coahuila
Baja California Sur
Durango
Nuevo León
Sinaloa
Zacatecas
Tamaulipas
Querétaro
San Luis Potosí
Nayarit
Distrito Federal
Guanajuato
Aguascalientes
Jalisco
Hidalgo
Tlaxcala
México
Yucatán
Campeche
Quintana Roo
Colima
Michoacán
Puebla
Veracruz
Tabasco
Guerrero
Oaxaca
Chiapas
Morelos
Pacific Ocean

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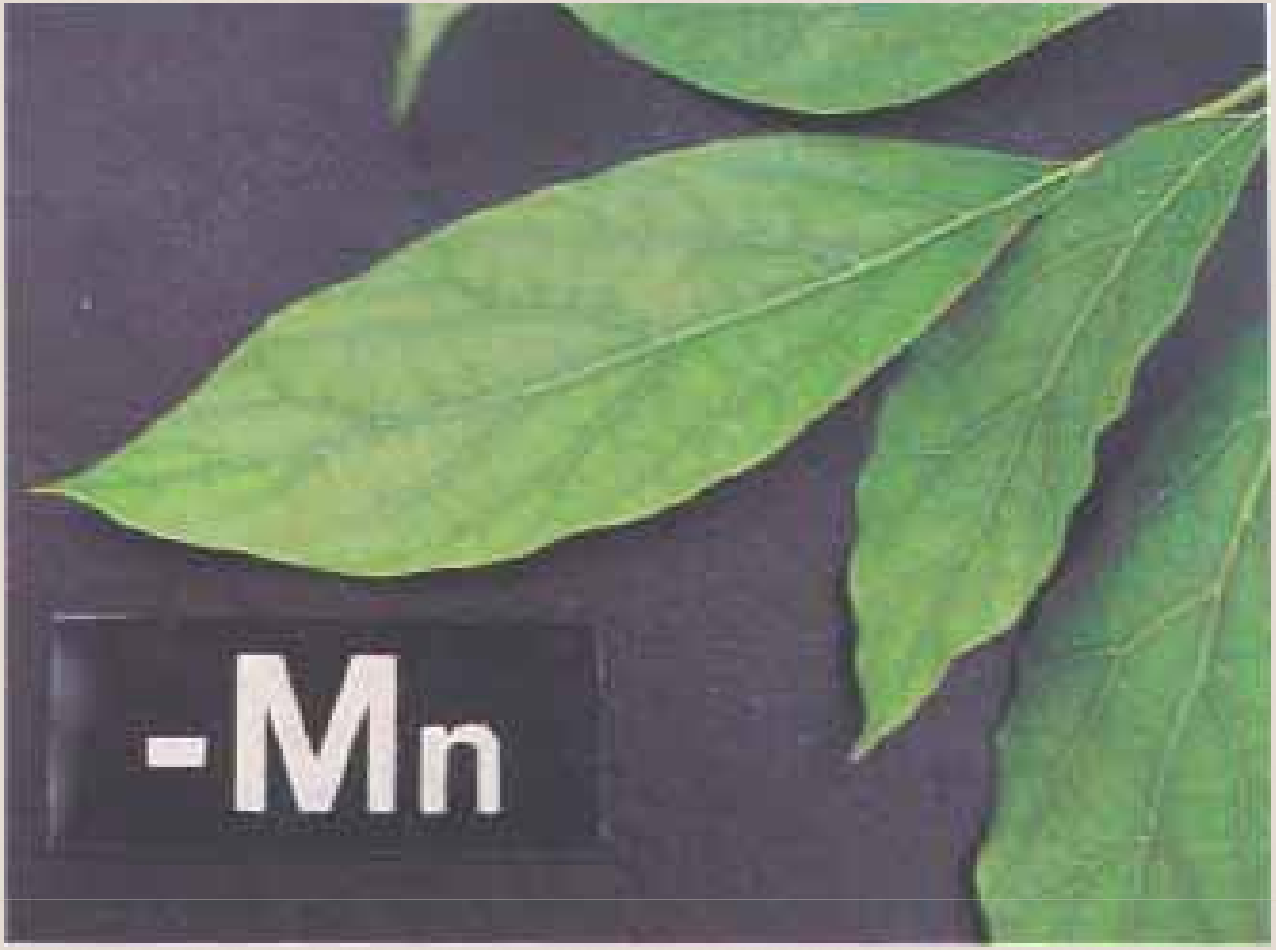
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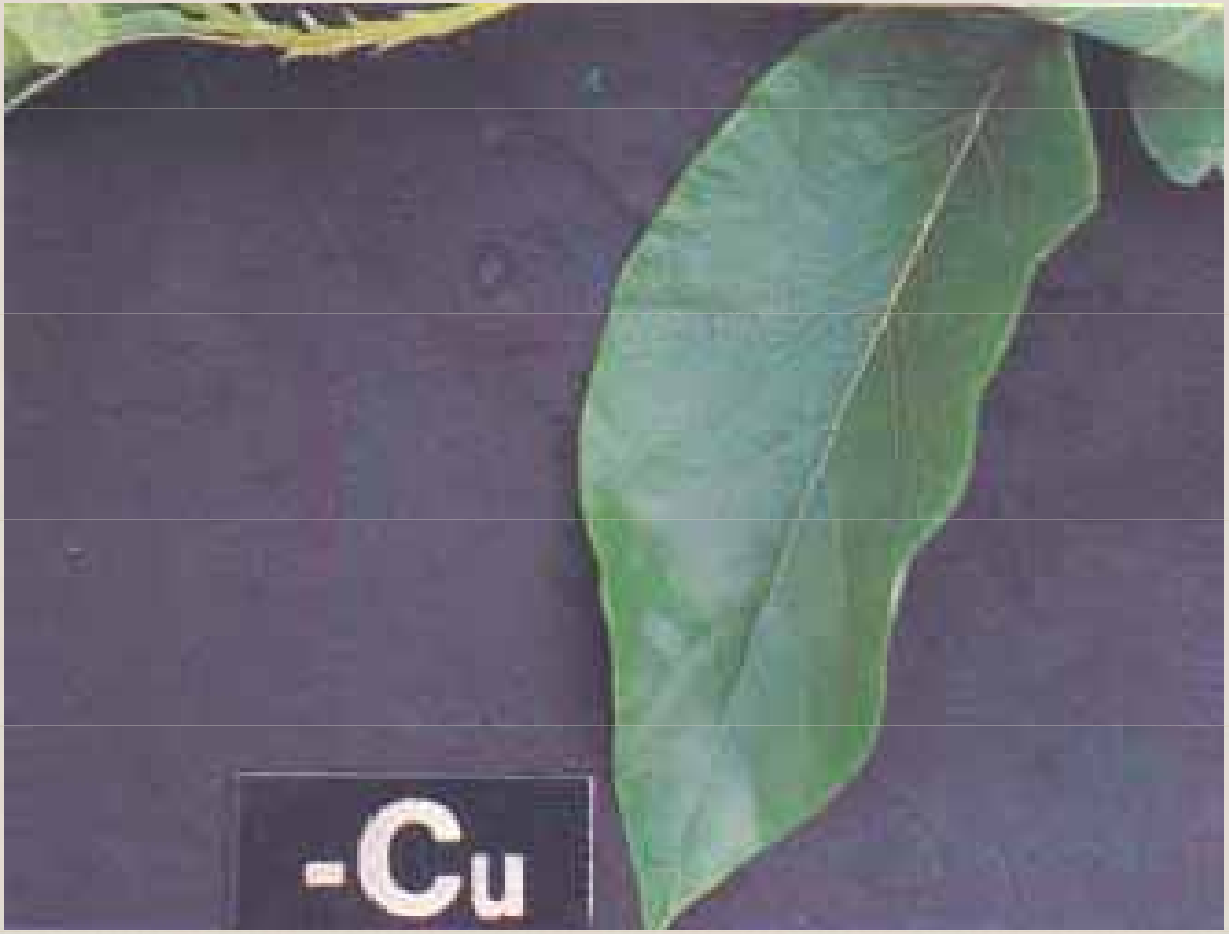
Copper	Unique enzyme production	Varies with crop but typical die-back of terminal growth



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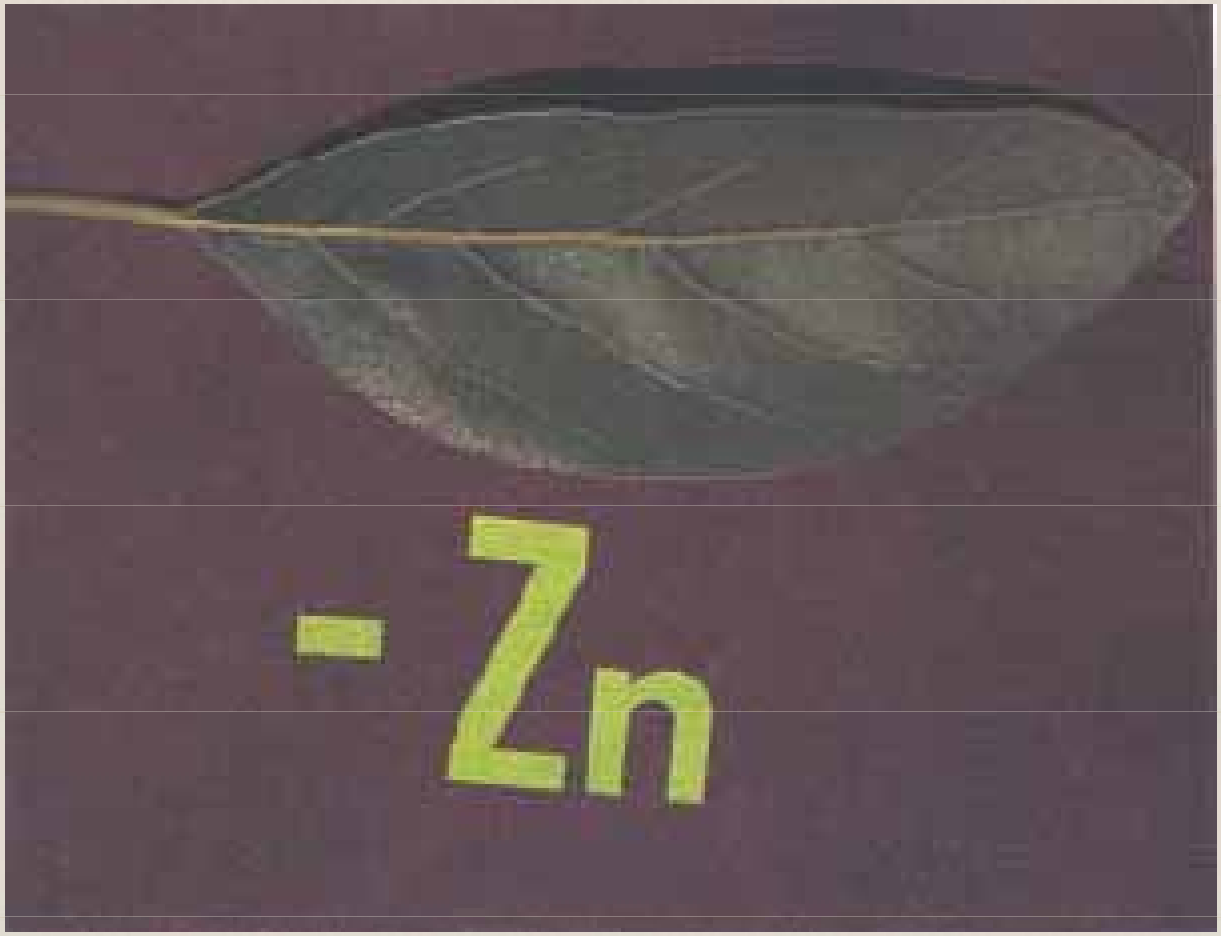
Zinc	Production of growth hormones	Mottled young leaves / bushy rosetted leaves



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Chloride	Reducing your avocado yields	Tip Burn

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Soil Analysis

- **Constituents**
  - Primary Nutrients and Macronutrients
    - N, P, K, Ca, Mg, S
  - Exchangeable and Soluble portions of cations
  - Secondary Nutrients and Micronutrients
    - Fe, Zn, Mn, Cu, B, Cl, and sometimes Mo
  - Other chemical properties
    - pH, cation exchange capacity, soil salinity, limestone and sodium

HASS SOIL ANALYSIS

Test Description	Result	Units	Optimum Range	Graphical Results Presentation
				Very Low / Moderately Low / Optimum / Moderately High / Very High
Primary Nutrients				
Nitrate-Nitrogen	20.8	Lbs/AF	76 - 120	
Phosphorus-P_2O_5	55	Lbs/AF	180 - 310	
Potassium-K_2O (Exch)	879	Lbs/AF	570 - 3800	
Potassium-K_2O (Sol)	27.3	Lbs/AF	140 - 520	1%
Secondary Nutrients				
Calcium (Exch)	21900	Lbs/AF	16000 - 22000	
Calcium (Sol)	458	Lbs/AF	260 - 740	54%
Magnesium (Exch)	2740	Lbs/AF	1600 - 3300	
Magnesium (Sol)	124	Lbs/AF	120 - 260	24%
Sodium (Exch)	270	Lbs/AF	0.0 - 1600	
Sodium (Sol)	194	Lbs/AF	0.0 - 1200	20%
Sulfate	227	Lbs/AF	230 - 4000	
Micro Nutrients				
Zinc	21.6	Lbs/AF	6.8 - 180	
Manganese	28.8	Lbs/AF	11 - 260	
Iron	22.4	Lbs/AF	68 - 240	
Copper	3.20	Lbs/AF	2.0 - 45	
Boron	0.760	Lbs/AF	1.6 - 8.8	
Chloride	56.7	Lbs/AF	27 - 670	
CEC	33.7	meq/100g	14 - 35	
% Base Saturation				
CEC - Calcium	81.0	%	60 - 80	
CEC - Magnesium	16.7	%	10 - 20	
CEC - Potassium	1.39	%	0.90 - 6.0	
CEC - Sodium	0.858	%	0.0 - 5.0	
CEC - Hydrogen	0.00	%	0.0 - 3.0	
				Strongly Acidic / Moderately Acidic / Near Neutral / Moderately Alkaline / Strongly Alkaline
pH	7.82	---	6.0 - 7.5	

HASS SOIL ANALYSIS

Test Description	Result	Units	Optimum Range	Graphical Results Presentation				
				Very Low	Moderately Low	Optimum	Moderately High	Very High
Primary Nutrients								
Nitrate-Nitrogen	11.6	Lbs/AF	40 - 80					
Phosphorus-P_2O_5	64	Lbs/AF	140 - 280					
Potassium-K_2O (Exch)	685	Lbs/AF	700 - 4700					
Potassium-K_2O (Sol)	11.2	Lbs/AF	94 - 470	0%				

Common Nitrogen Questions

Q. Why is nitrate-nitrogen only analyzed in the soil and not ammonium and/or total nitrogen?

A. Under conditions favoring plant growth, most forms of soil nitrogen are rapidly converted to nitrate.

$$2\ NH4^+ + 3\ O2 \rightarrow 2\ NO3^- + 2\ H20 + 4H^+$$

Q. Why is the nitrate bar blue?

A. The blue bar indicates there really is no “optimum range.” Soil nitrate requirements are primarily dependant on the growth stage of your crop and soil temperature.

Nitrogen Management

- **Nitrogen uptake efficiency during critical stages**
  - **25% when applied to the soil in a single annual application**
  - **50 – 60% when applied to the soil in 3 to 4 increments**
  - **90% when applied to citrus foliage in increments**
    - **However, the total nitrogen requirements of citrus can not be met without leaf damage**
    - **Only about half of the total nitrogen requirements can be met foliarly**
    - **None of the nitrogen requirements for avocados may be met foliarly**

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Common Phosphorus Questions

Q. Why is phosphorus reported as P2O5?

A. Phosphorus fertilizer is sold as P2O5 equivalent
To convert from P2O5 to P multiply by 0.44

Q. Why are there two different methods for soil P analysis?

A. Depending on the pH, phosphorus exists as two different ions so there are two different extraction solutions to mimic actual P available to your crop.

Phosphorus Management

- **Different precipitates of P**
  - **Important to monitor pH for P**

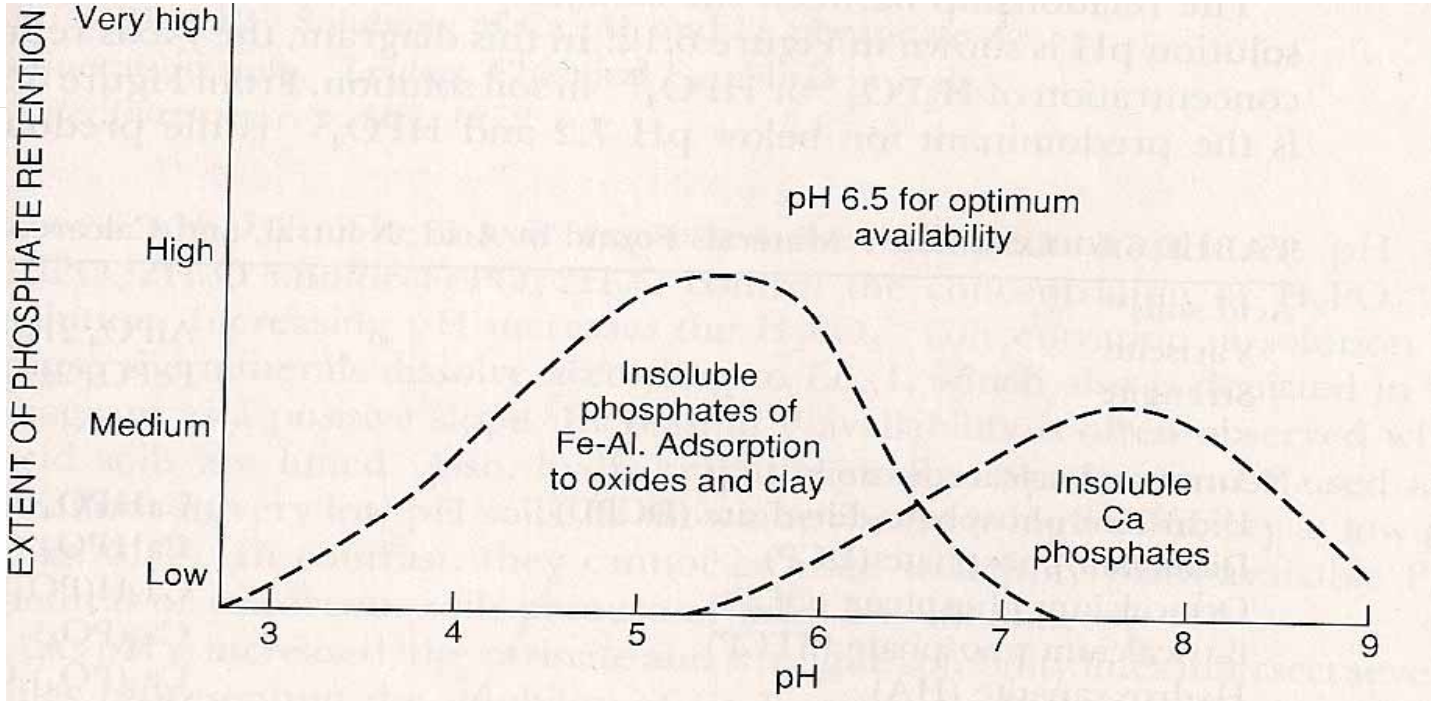

FIGURE 6.11 Soil pH effect on P adsorption and precipitation. *Adapted from*

Phosphorus Management

- **Fertilization management**
  - **High soluble Ca, Fe, and Al form insoluble phosphorus precipitates**
    - **So don't apply P with these types of fertilizers**
  - **High carbon to phosphorus ratio can immobilize P**
  - **Phosphorus is not very mobile in the soil**
    - **Use water soluble forms of P fertilizer and an acid mix to help keep the P in solution**

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Common Potassium Questions

Q. Why are there two different potassium results?

A. Potassium is measured in two ways.

1. Exchangeable (Exch)

The exchangeable portion is the potassium available as a reserve in your soil. This moves into solution as the soluble K is taken up.

2. Soluble (Sol)

The soluble portion is the potassium most readily available.

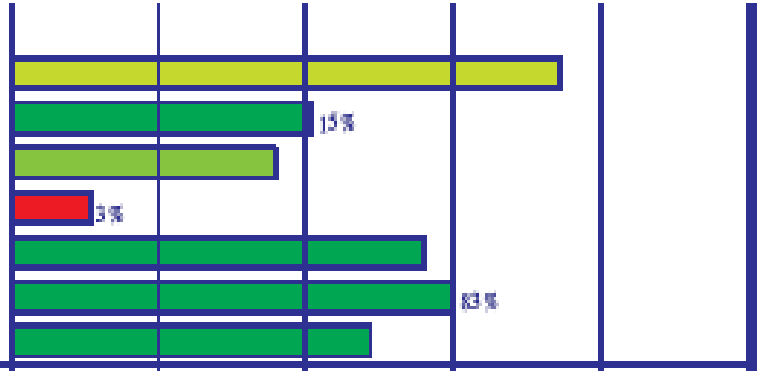
Potassium Management

- Potassium in the soil is mostly available by mass flow…so…
  - Leaching is possible
    - Coarse, sandy, and soils in areas of high rainfall
  - Citrus can use soil or foliar applied K
    - If foliar application use KNO_3
  - Avocados can't absorb foliar applications thus, water soluble forms of K should be applied to the soil
    - Potassium thiosulfate appears to be the most available source

Potassium Management

- **Potassium and crop yields**
  - Most directly related nutrient to high crop yield
  - High N and P increases yields but also increases the total demand for K to support that yield
  - K released from the exchangeable sites in the soil is often too slow to supply ample amounts in a high yield system

Secondary Nutrients			
Calcium (Exch)	15200	Lbs/AF	10400 - 13900
Calcium (Sol)	176	Lbs/AF	160 - 641
Magnesium (Exch)	870	Lbs/AF	1050 - 2110
Magnesium (Sol)	19	Lbs/AF	73 - 219
Sodium (Exch)	750	Lbs/AF	0 - 1000
Sodium (Sol)	1150	Lbs/AF	0 - 628
Sulfate	1840	Lbs/AF	190 - 4030



Calcium, Magnesium Sodium & Sulfur

Q. Why are these nutrients considered secondary?

A. This just means they are not needed in as large of of quantities as the primary nutrients

-Although, secondary nutrient deficiencies can depress plant growth just as much as primary nutrient deficiencies.

-At times some plants can even require more S and Ca than P. Avocado crop removal rates show this to be true.

Calcium Management

- **Calcium is rarely deficient in our soils**

  Low rainfall = high calcium = rare deficiencies

  - In our area calcium toxicity is more likely than calcium deficiency:
    - Limestone induced chlorosis
    - High pH due to lime and deficiencies in phosphorus and some micronutrients
    - Managing high calcium soils
      - » pH change is extremely difficult
      - » Plant selection (avoid limestone sensitive rootstocks)

Magnesium Management

- **Magnesium uptake is greatly influenced by potassium and calcium so watch ratios to prevent deficiencies**
  - –Base saturation is a good indicator of correct nutrient ratios in the soil
  - –K to Mg ratio
    - •For field crops: anything less than 5:1
    - •For vegetables: about 3:1
    - •For fruit trees: about 2:1
  - –Ca to Mg ratio
    - •Should not exceed 15:1 for any crop
    - •Apply foliar magnesium nitrate to citrus for deficiencies
      - –For avocados use magnesium sulfate applied to the soil

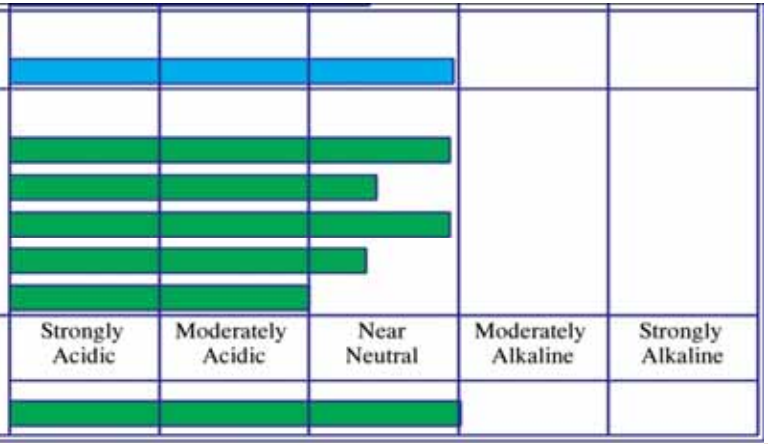
Sodium Management

- **Sodium is not generally a plant essential nutrient but is still reported…why?**
  - It's necessary to calculate the cation exchange capacity (CEC)
  - Most importantly, high sodium can cause soil structural problems
    - Na has a large hydrated radius…larger than K, Ca and Mg
      - This causes dispersion in the soil
      - Breaks up soil aggregation
      - Causes a massive structure
      - Poor water infiltration

Sodium Management

- **What can I do about my high sodium soil?**
  - If you have sufficient calcium in the soil
    - Leach with plenty of low sodium water at an acidic pH (sulfuric acid) to flush the sodium and let calcium replace it on the CEC
  - If no high soil calcium ***then*** Gypsum, Gypsum, Gypsum
    - Leach with plenty of low sodium water

CEC	34.0	meq/100g	8.0 - 35
% Base Saturation			
CEC - Calcium	78.8	%	60 - 80
CEC - Magnesium	14.5	%	10 - 20
CEC - Potassium	4.82	%	2.0 - 5.0
CEC - Sodium	1.90	%	0.0 - 5.0
CEC - Hydrogen	0.00	%	0.0 - 3.0
pH	7.51	---	6.0 - 7.5



Cation Exchange Capacity, pH, % Base Saturation, and the Lyotropic Series

The "Easy" Definitions:

- **Cation Exchange Capacity –** The total amount of cations a soil can hold on its negatively charged particles (the clay and humus).
- **pH –** A measurement estimating the "active" hydrogen ions
- **Percent Base Saturation –** The percent of a certain cation that is held on the CEC in comparison to others
- **Lyotropic Series –** The order in which cations will bond with the negative charges in your soil $Al^{3+} > Ca^{2+} > Mg^{2+} > K^{+} = NH_4^{+} > Na^{+}$

How to use your tissue analysis report with your soils report

A frequently asked question:

Q. Why does my soil report show ample nutrient levels and my leaf tissue report shows deficiencies?

A. Because plants are not always capable of taking up the necessary amounts of nutrients to support their rate of growth and yield.

Avocado and Citrus Crop Removal

Nutrient Removal in lbs/acre	800 boxes Of Oranges	1000 boxes of Lemons	7000 lbs/acre of Avocados
Nitrogen	64	75	23
Phosphorus	8	9	2
Potassium	66	80	35
Sulfur	1.6	3.2	3.6
Calcium	20	30	1
Magnesium	4.2	5	1.5
Zinc	0.03	0.12	0.02
Manganese	0.02	0.05	0.01
Iron	0.13	0.12	0.4
Copper	0.02	0.05	0.01
Boron	0.1	0.14	0.05
Chloride	0.02	0.02	0.01

**Generally crop removal x 1.5 = fertilizer requirements*

Questions?

For more info:

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Fruit Growers Laboratory, Inc.