RANGES OF ELEMENTS IN AVOCADO LEAVES

Ranges for mature trees*

Elements		Unit	Deficient: Less than	Adequate	Excess: More than
Nitrogen	(N)	%	1.6	1.6 -2.0	2.0†
Phosphorus	(P)	%	0.05	0.08-0.25	0.3
Potassium	(K)	%	0.35	0.75-2.0	3.0
Calcium	(Ca)	%	0.5	1.0 -3.0	4.0
Magnesium	(Mg)	%	0.15	0.25-0.80	1.0
Sulfur	(S)	%	0.05	0.20-0.60	1.0
Boron	(B)	ppm‡	10-20	50-100	100-250
Iron	(Fe)	ppm	20-40	50-100	-
Manganese	(Mn)	ppm	10-15	30-500	1,000
Zinc	(Zn)	ppm	10-20	30-150	300
Copper	(Cu)	ppm	2-3	5-15	25
Molybdenum	(Mo)	ppm	0.01	0.05-1.0	-
Chloride	(Cl)	%	-	-	0.25-0.50
Sodium	(Na)	%	-	-	0.25-0.50
Lithium	(Li)	ppm	-	-	50-75

Causes of Trace Metal Deficiencies in Avocado

Soil	Plant
Low total zinc	Root growth
Alkaline soil pH	Phytophthora
Bicarbonate	Rootstock
Salinity	Translocation

Correction of Trace Metal Deficiencies in Avocado

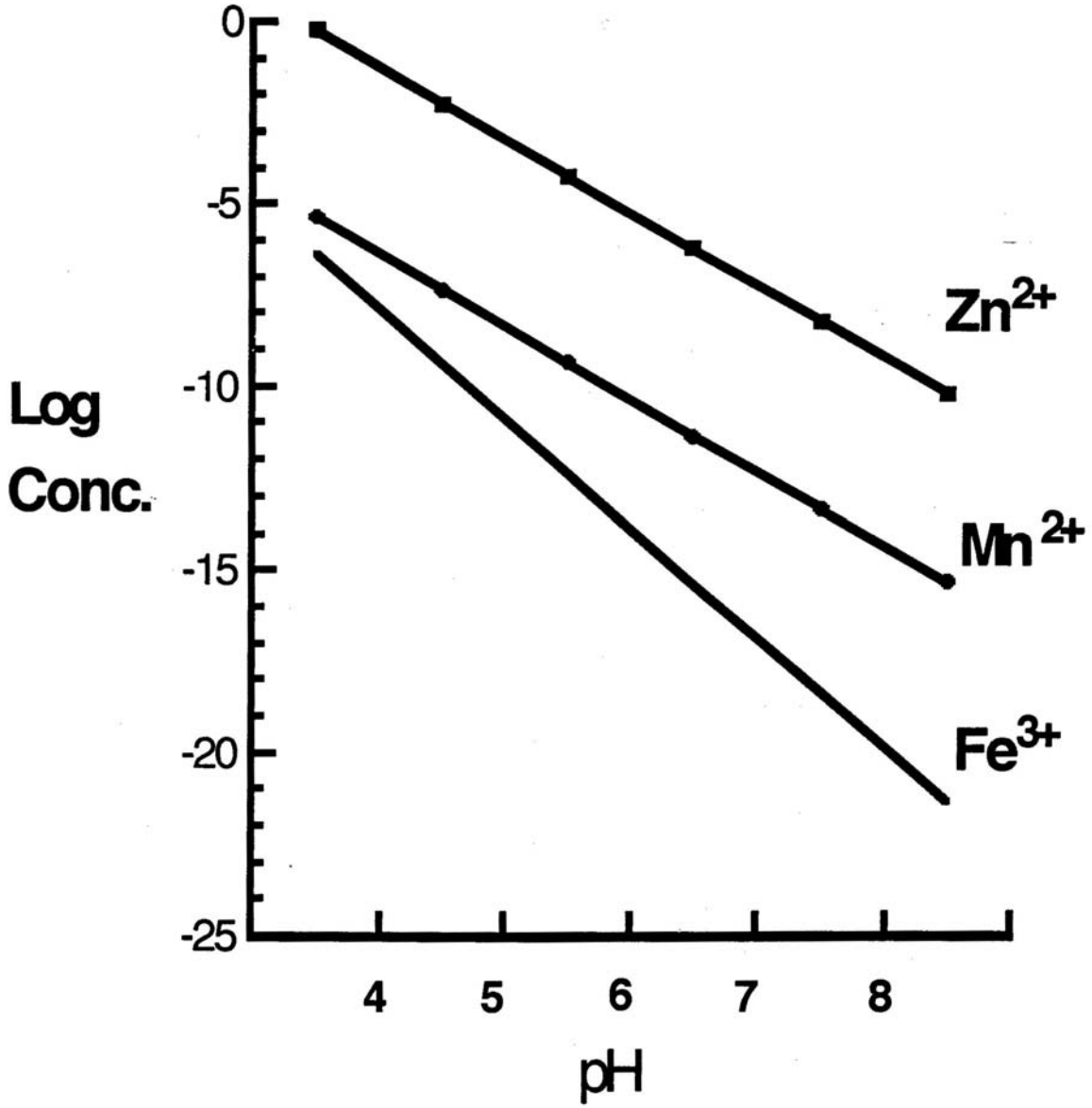
Soil Treatments

- Acidification: N-furic, elemental sulfur
- Application of zinc sulfate
- Applications of chelated metals (iron and zinc)

Foliar Applications

- Canopy applications of metal salts
- Canopy applications of metal chelates

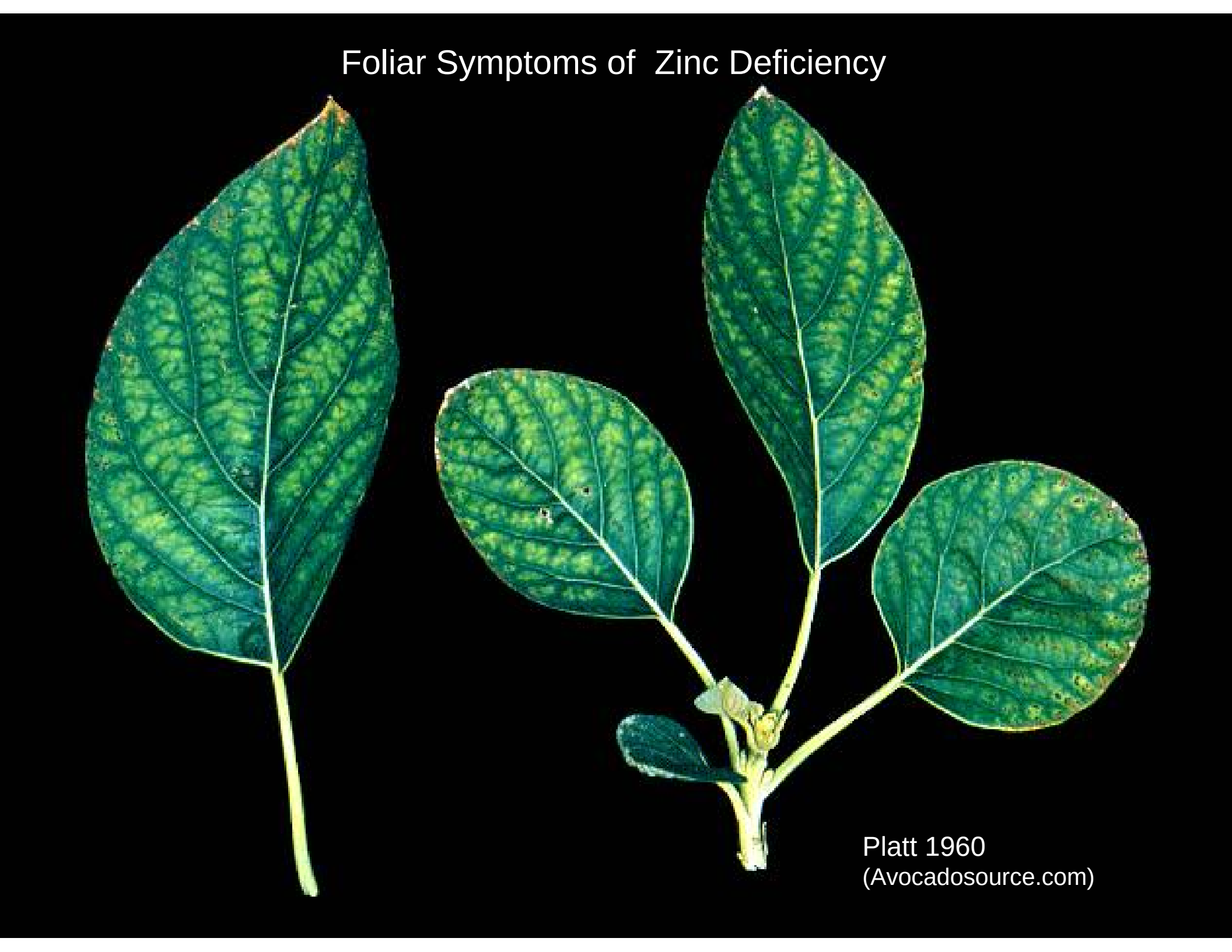
Soil pH effects on metal solubility



Zinc Deficiency in Reed Avocado

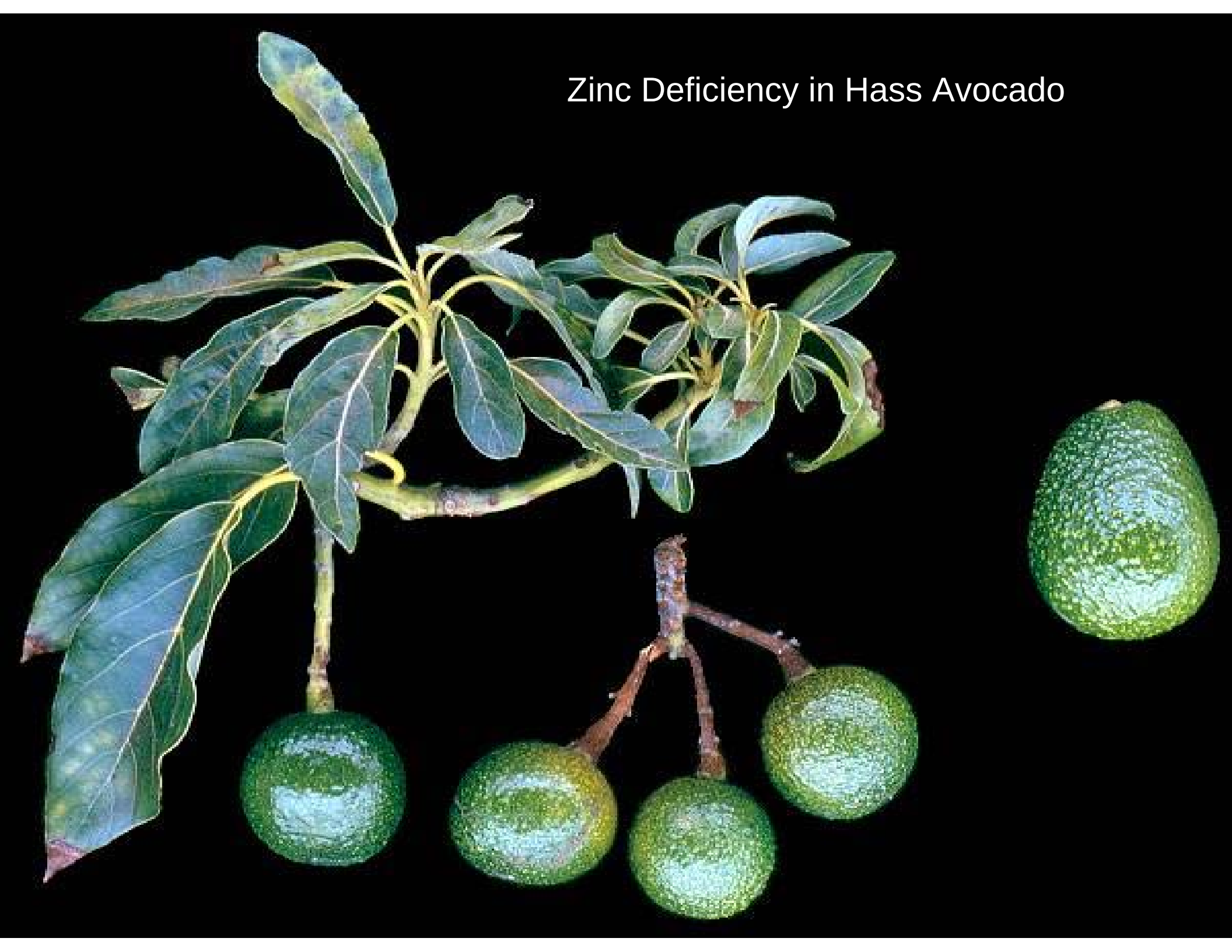
Platt 1976
(Avocadosource.com)

Foliar Symptoms of Zinc Deficiency



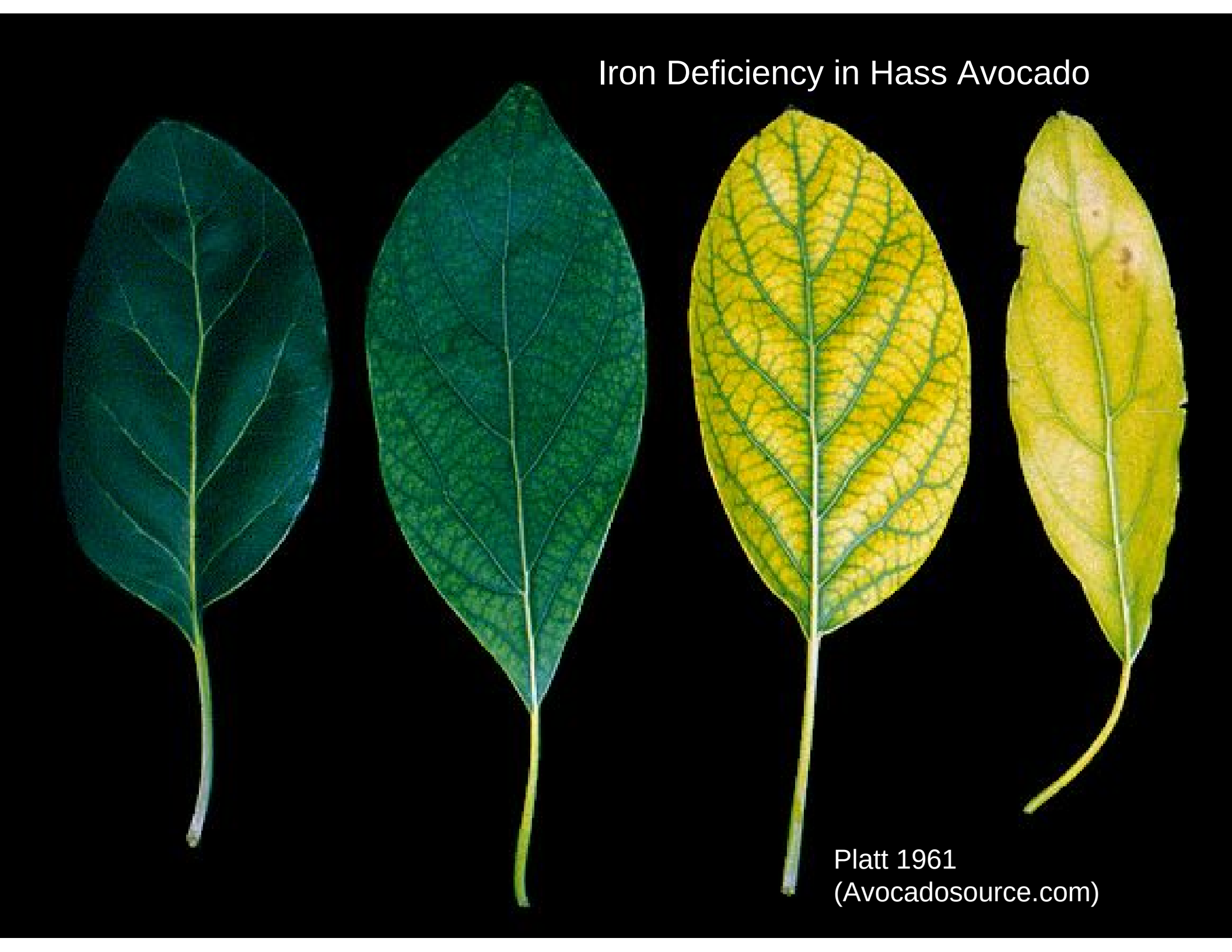
Platt 1960
(Avocadosource.com)

Zinc Deficiency in Hass Avocado



Iron Deficiency in Hass Avocado

Iron Deficiency in Hass Avocado



Platt 1961
(Avocadosource.com)

Field Trial for Evaluation of Methods to Correct Trace Metal Deficiencies

Application Method	Zinc Material	Application Rate	Application Timing
Control	N/A	N/A	
Foliar	Zinc sulfate Zinc Metallosate Zintrac 8	15 gram / liter 11.7 ml / liter 2.3 ml / liter	Once per year; 6/11/93
Simulated Irrigation	Zinc sulfate Zinc chelate	1.75 lb / tree 1.5 oz / tree	Quarterly;
Soil Banding	Zinc sulfate	7 lb / tree	Once per year; 10/19/92, 2/94

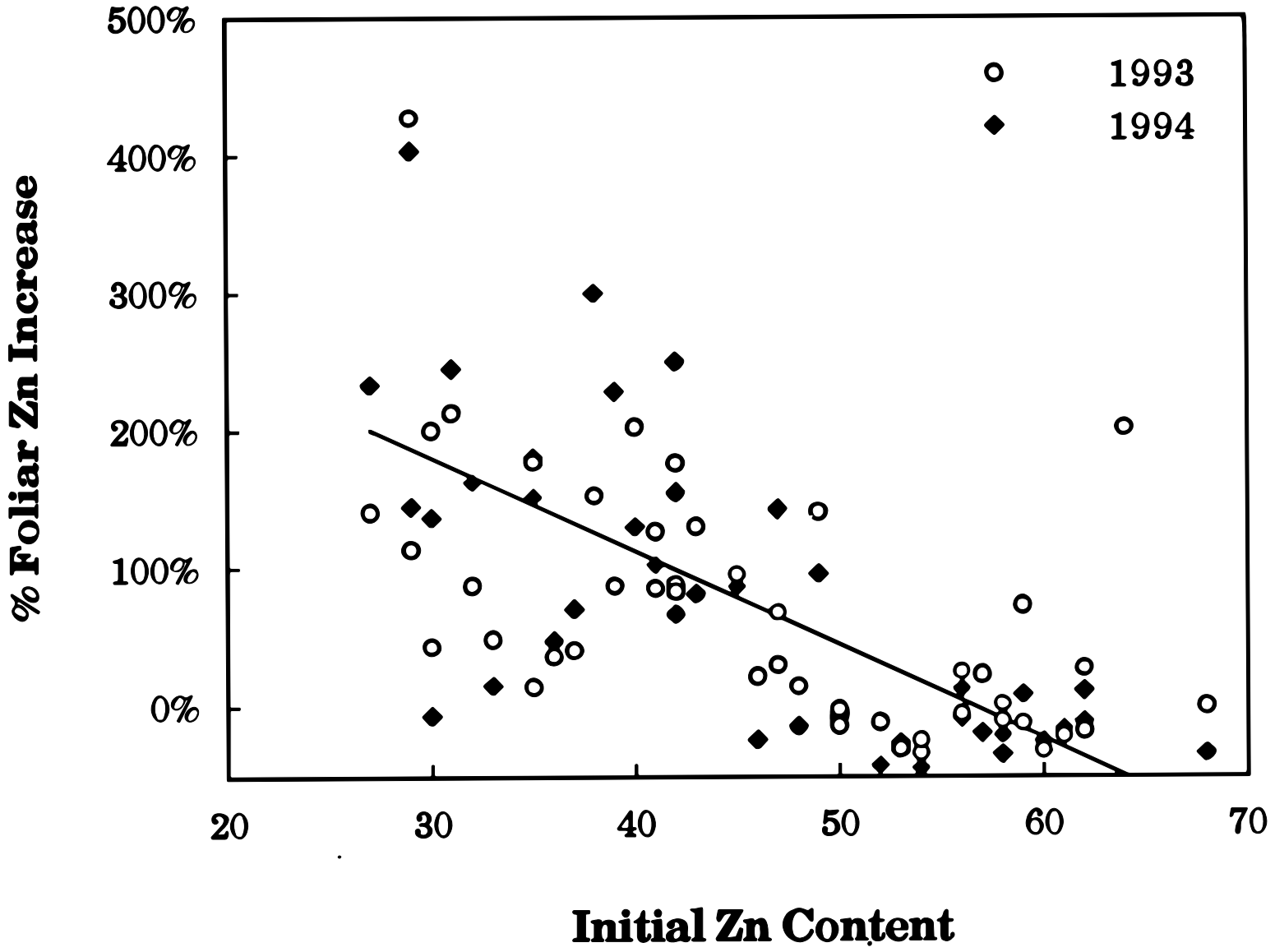
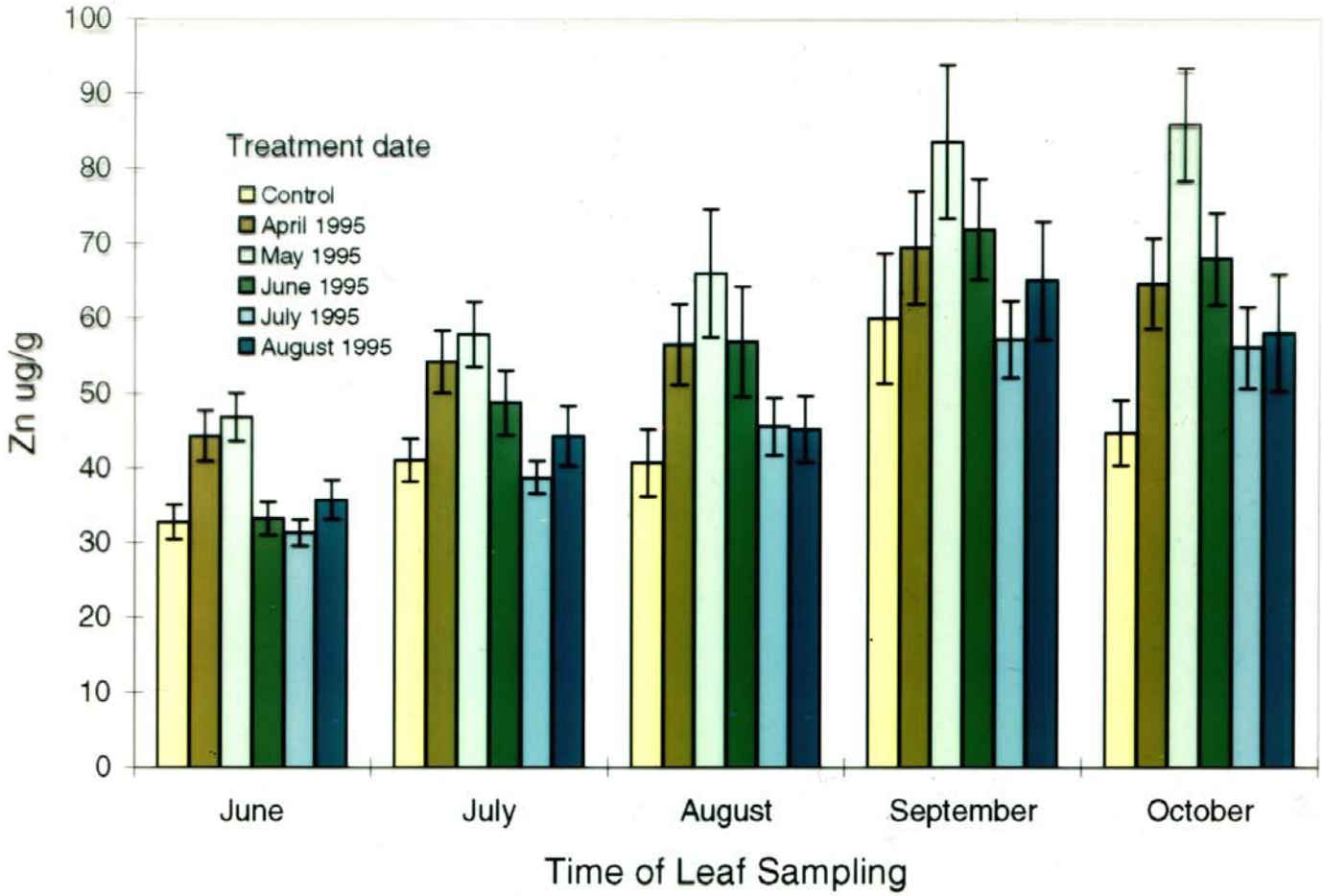


Fig. 2. 'Hass' avocado responses to soil applications of Zn fertilizers as affected by their initial Zn status. Line was fit to data points by regression analysis (r = 0.704).

Table 3. Foliar concentrations of zinc for trees with low and high zinc contents prior to fertilization with soil and irrigation applied zinc fertilizers in 1992 and after fertilization in 1993 and 1994.

Treatment	Initial tree status (N)[y]	Foliar Zn $\mu g \cdot g^{-1}$	Foliar Zn Concentration ($\mu g \cdot g^{-1}$) 1992[z]	1993	1994
Control unfertilized	8	< 50	38 (1.9)	40 (2.8)	37 (3.0)
	10	≥ 50	57 (1.9)	54 (6.7)	43** (2.1)
Zn-EDTA irrigation	6	< 50	41 (3.3)	73* (14.1)	57 (14.1)
	10	≥ 50	58 (1.6)	50 (3.9)	44 (3.1)
$ZnSO_4$ irrigation	9	< 50	37 (2.0)	75** (5.4)	86** (7.6)
	5	≥ 50	57 (2.1)	56 (5.8)	55 (4.7)
$ZnSO_4$ soil banded	12	< 50	38 (1.8)	86** (8.9)	99** (9.4)
	4	≥ 50	58 (2.5)	103 (32.2)	61 (21.4)



Changes in foliar zinc concentrations for 'Hass' avocado trees on a calcareous soil after fertilization with 7 lb zinc sulfate per tree. Fertilizer was applied once to individual sets of 15 trees with timing indicated by treatment date in the figure legend. Vertical bars indicate 1 standard error of the mean.

Chelated Metals

Zinc – Metalosate, HEDTA, EDTA

Iron: EDDHA (Sequestrene 138) > HEDTA, EDTA
Organic Chelates: citric acid, fulvic acid

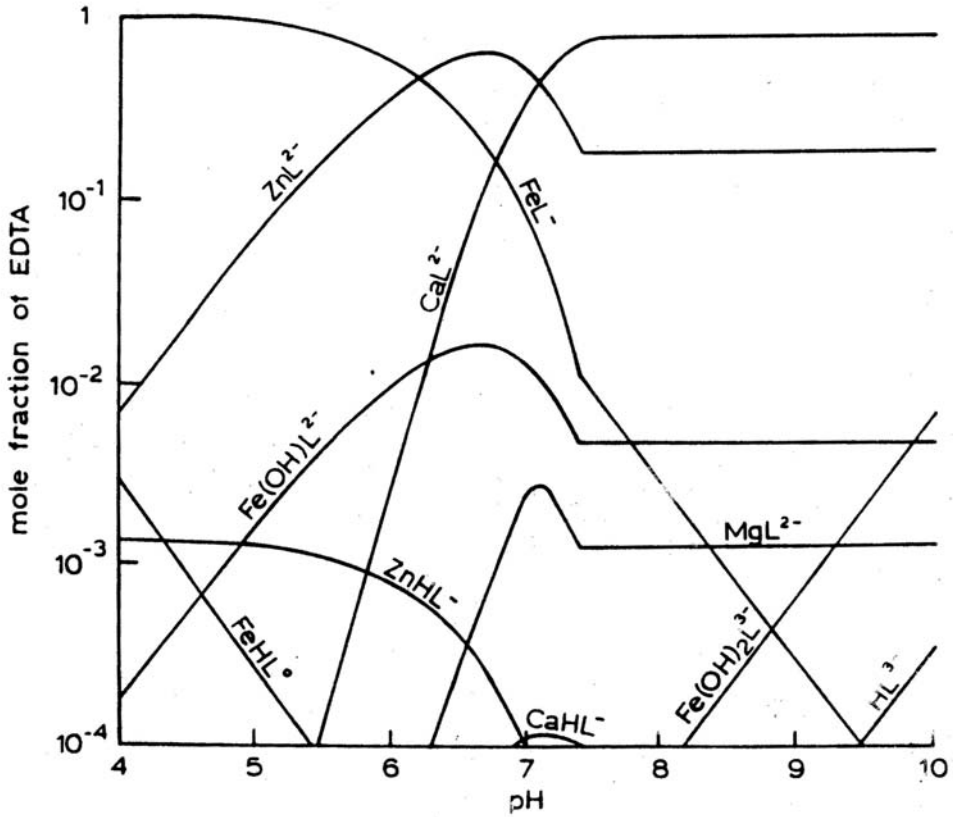
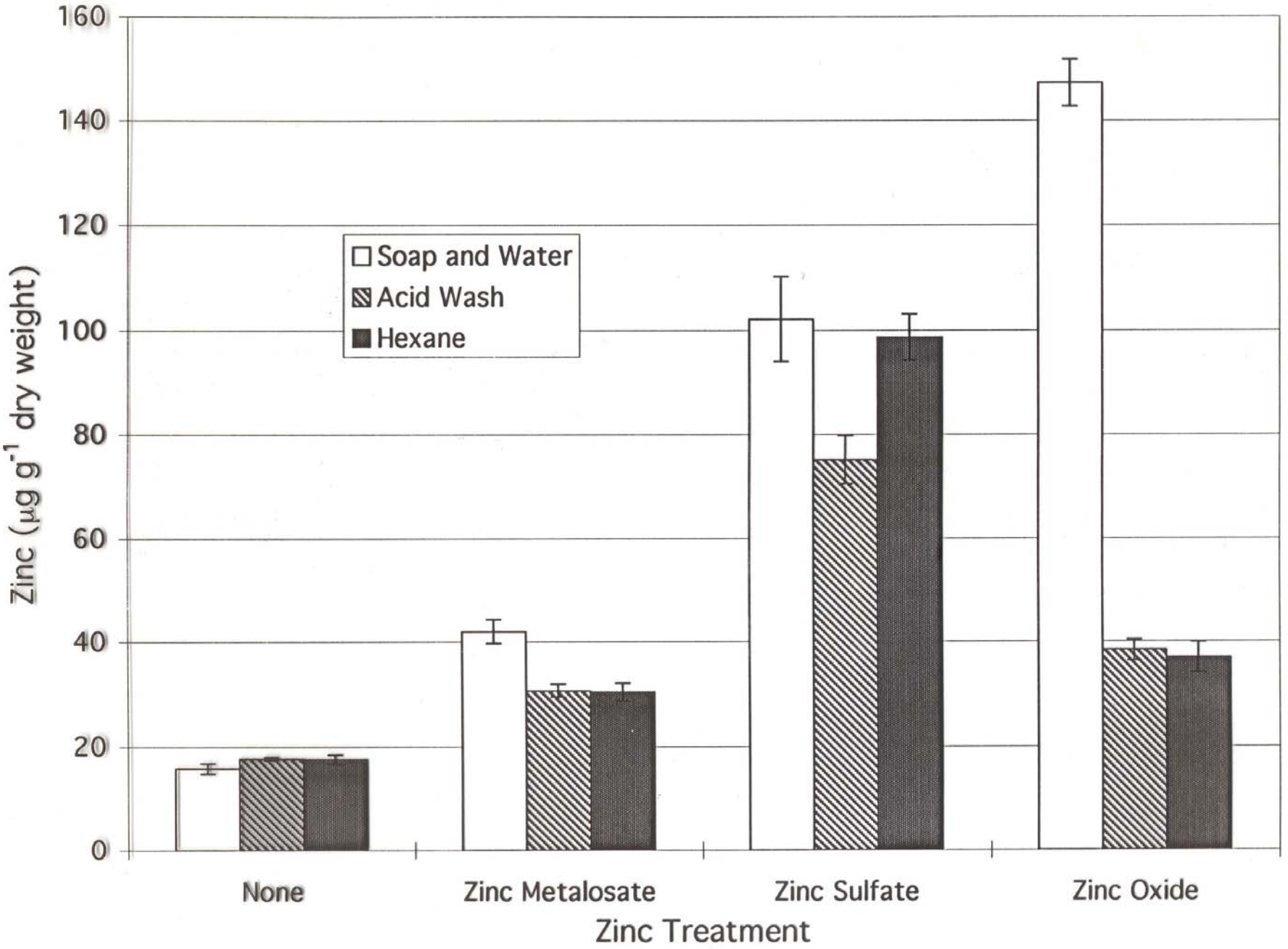


Fig. 15.4 The mole fraction diagram for EDTA in soils when Zn^{2+}, Fe^{3+}, Ca^{2+}, Mg^{2+} and H^{+} are competing metal ions at 0.003 atm of $CO_2(g)$.

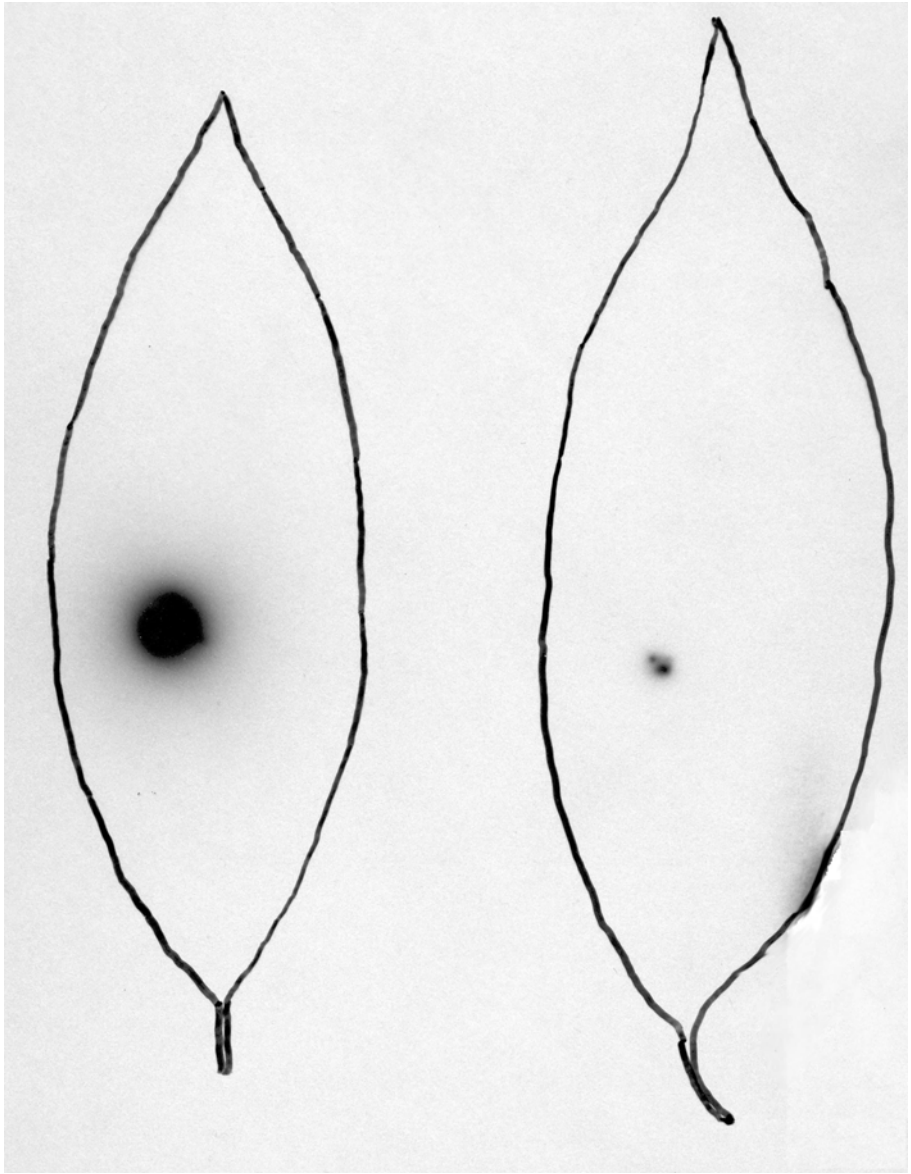
Foliar Applications of Zinc

Materials:

- Chelates (EDTA, Metalosate..)
- Zinc Oxide
- Zinc Sulfate
- Complexes with calcium, phosphorus


160
140
120
100
80
60
40
20
0
Zinc (µg g-1 dry weight)
Soap and Water
Acid Wash
Hexane
None
Zinc Metalosate
Zinc Sulfate
Zinc Oxide
Zinc Treatment

Application and Absorption of Radioactive Zn65 to Hass Avocado Leaves



Zinc Metalosate Zn Sulfate

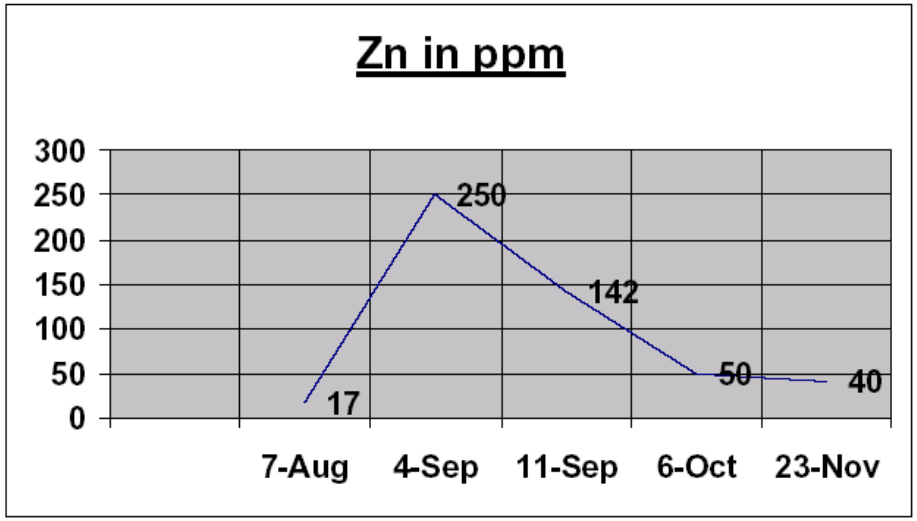
Foliar Applications of Zinc

An application of NUTRIENT TECHNOLOGIES Zinc products was made by helicopter in 40 gallons per acre spray solution in tests designed to disprove existing statements that Zinc is not absorbed from foliar applications to avocado. NUTRIENT TECHNOLOGIES Zinc formulations are reacted and micronized to an average 1 micron particle size to increase foliage absorption and penetration. Materials used were:

2 quarts TECH-FLO ZETA (22% Zinc)
3 quarts TECH-FLO ALPHA (0-10-0, 8% calcium, 2½% Sulfur, 5% Zinc)
1 quart TECH-SPRAY IZP (0-8-0, 2% Sulfur, 1% Zinc, 3% Iron).

Tissue Analysis: Agri Service, Vista, CA
Aerial Application: Pacific Rotors, Bonsall, CA

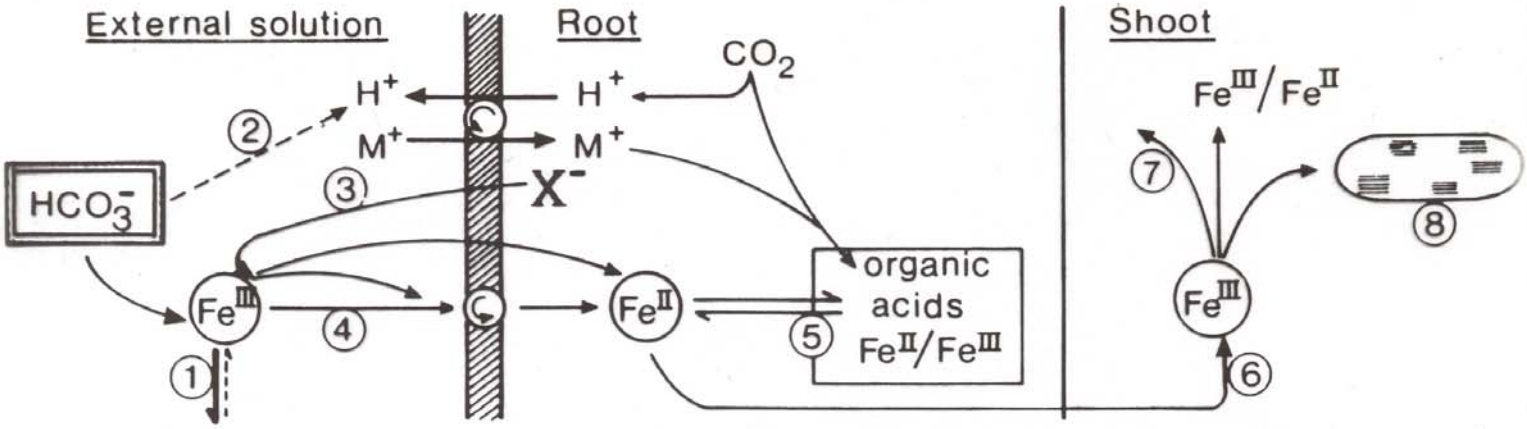
RESEARCH & PHOTOGRAPHY
Ken Gemmill, Agronomist
NUTRIENT TECHNOLOGIES, INC.



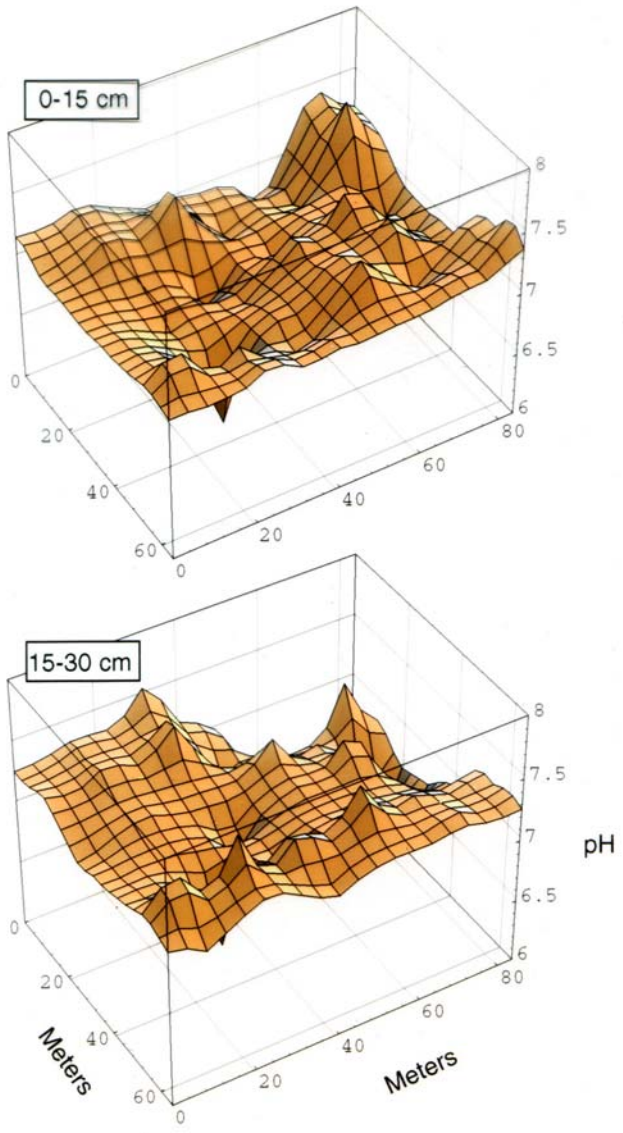
Sample Date 1998	Sampling Data	Zinc Tissue Value
Aug 7	Pre treatment sample	17
Aug 27	Date of aerial application	
Sept 4	Post application, sample washed	250
Sept 11	Post application, sample washed	142
Oct 6	New hardened flush, No residue	50
Nov 23	New hardened flush, no residue	40
Nov 23	New no-hardened flush, no residue	32

Soil and Water Factors Associated with Metal Deficiencies

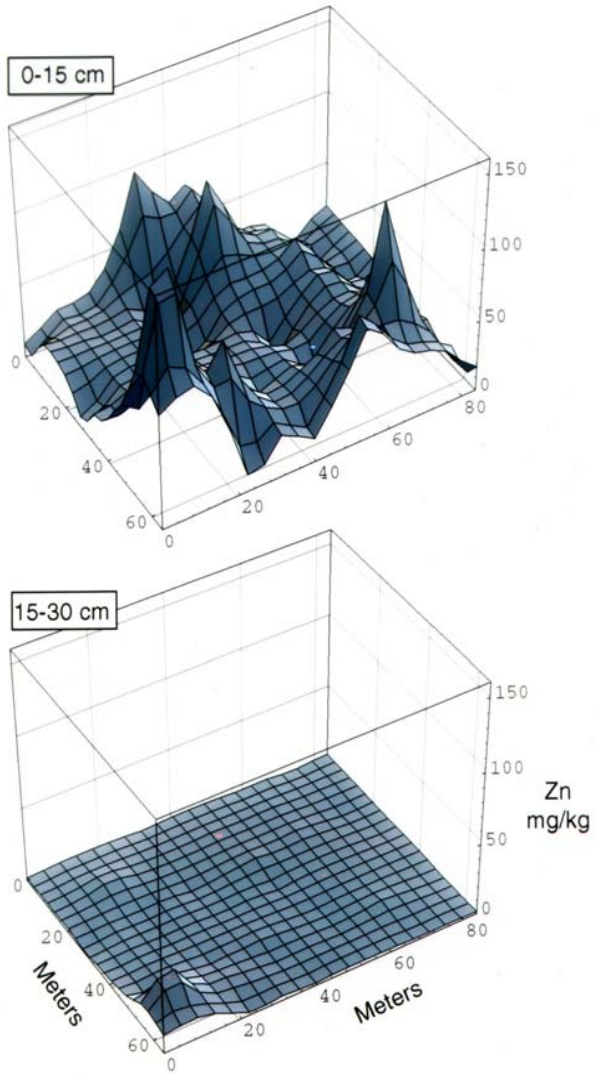
Bicarbonate Effects on Plant Growth



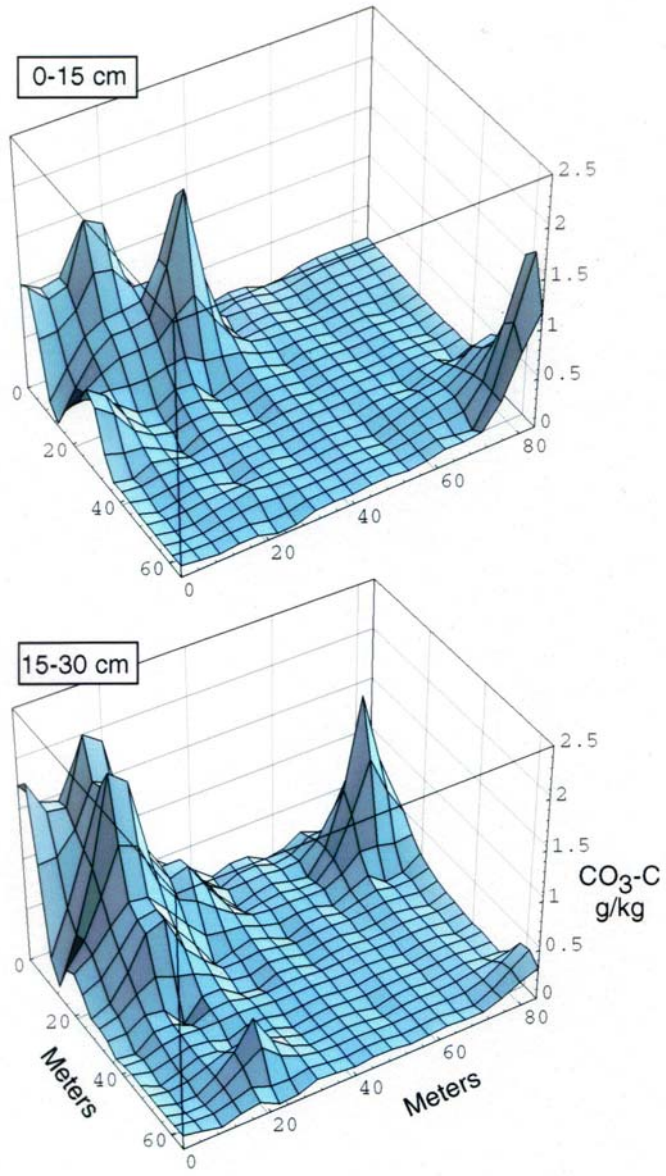
1. Raises and buffers pH
2. Impairs rhizosphere acidification -
3. Lowered release of phenolics
4. Decreased reduction / solubilization of Fe
5. Sequesters trace metals with organic acids
6. Inhibits Fe transport to the shoot
7. Impairs utilization of Fe in expanding leaves
8. Inhibits root growth / cytokinin production



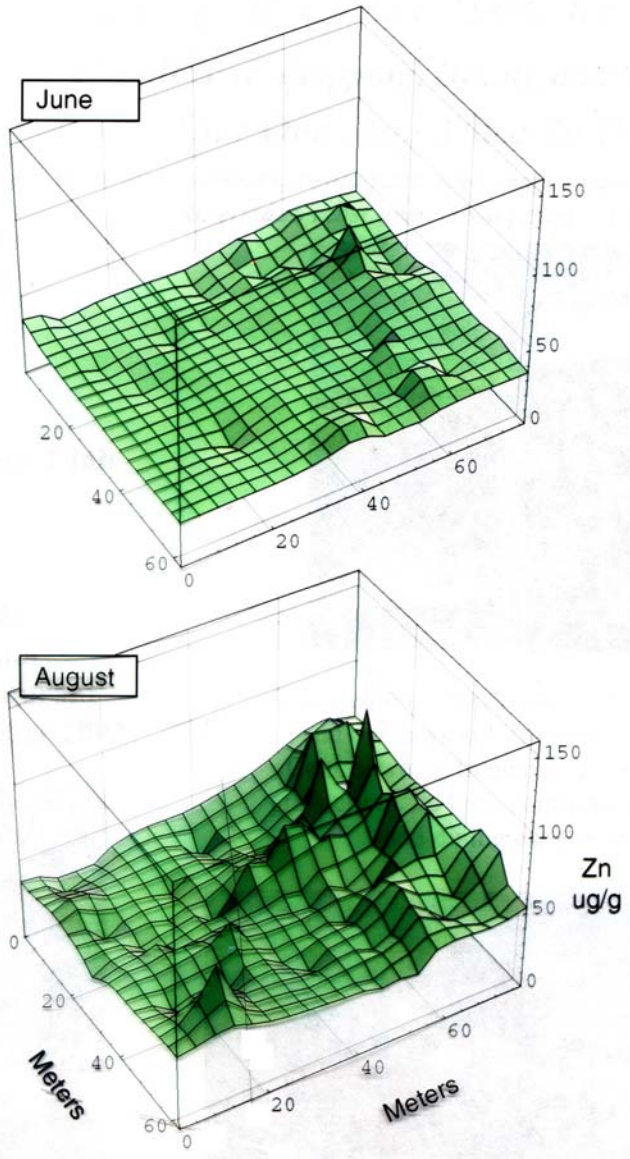
Spatial variability in soil pH for a calcareous soil planted with 'Hass' avocado located in Ventura County, California. Soil sampled at two depths.



Spatial variability in DTPA-TEA extractable (plant available) zinc concentrations in a calcareous soil planted with 'Hass' avocado in Ventura County, California. Soil was sampled at 10 x 15 meter intervals for a total of 42 sampling points, each at two depths. Top 0-15 cm; Bottom 15-30 cm.



Spatial variability in soil carbonate content in a calcareous soil planted with 'Hass' avocado in Ventura County, California. Soil sampled at two depths.

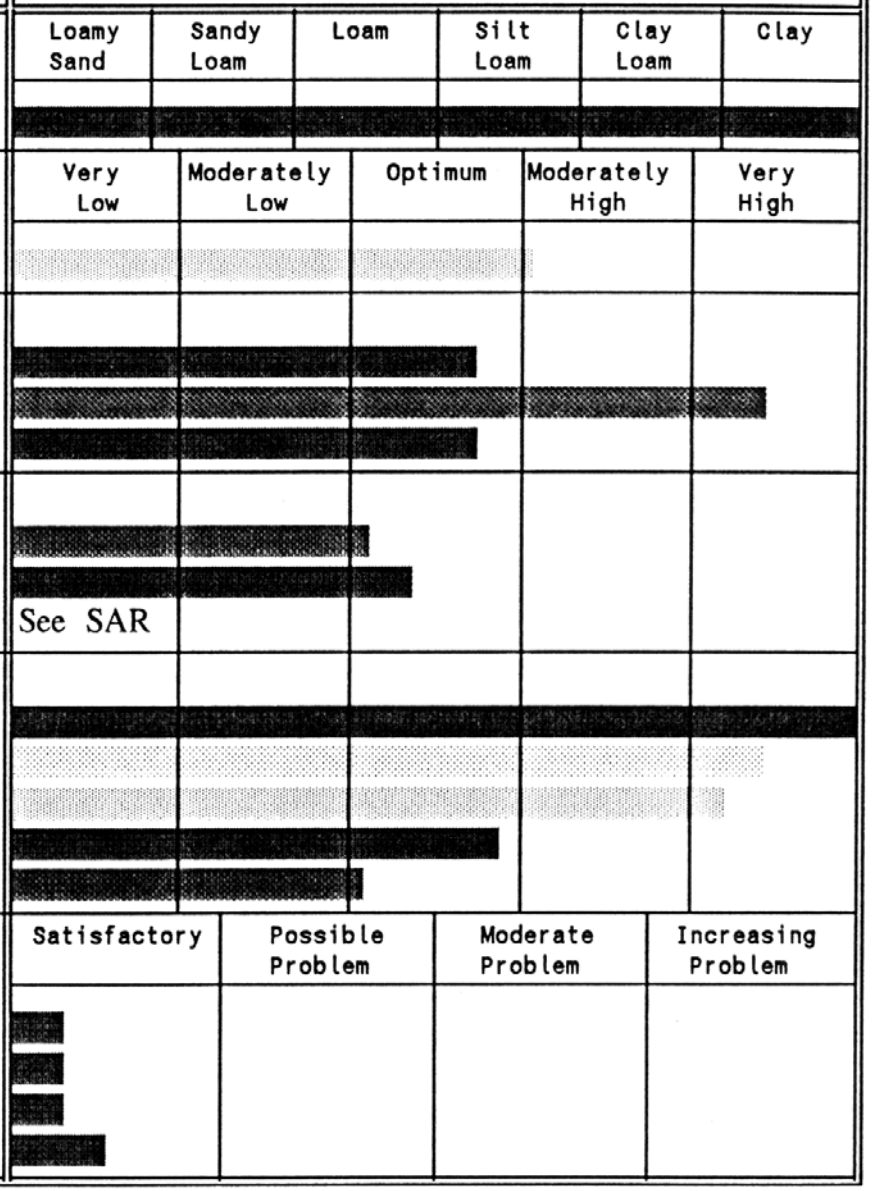


Spatial variability in foliar zinc concentrations for 'Hass' avocado planted on a calcareous soil in Ventura County, California. Top figure: before fertilization with zinc sulfate. Bottom figure: after fertilization with 7 lb zinc sulfate per tree.

RE: SOIL ANALYSIS - AVOCADO

Test Description	Result	Units	Optimum Range
Saturation	110	%	20 - 60
Moisture	64	%	1/2 Satn. %
Primary Nutrients			
Nitrate-Nitrogen	32	PPM	10 - 40
Phosphorus	86	PPM	12 - 60
Potassium	390	PPM	81 - 500
Secondary Nutrients			
Calcium	4.1	meq/L	2.0 - 20
Magnesium	2.6	meq/L	1.5 - 4.5
Sodium	6.3	meq/L	See SAR
Micro Nutrients			
Zinc	530	PPM	0.7 - 20
Manganese	72	PPM	1.4 - 30
Iron	160	PPM	8.0 - 60
Copper	4.4	PPM	0.2 - 5.0
Boron	0.20	PPM	0.02 - 2.1
Toxic Elements			
Boron	0.20	PPM	0.02 - 2.1
Chloride	4.7	meq/L	1 - 150
Sulfate-Sulfur	3.5	meq/L	10 - 500
Soil Salinity	1.2	mmhos/cm2	0.5 - 2.0

Graphical Results Presentation



Good: :Problem

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

The above analysis was performed by Fruit Growers Laboratory, Inc.

Recommendations

1. Diagnose deficiency carefully: Zinc or Iron, or Phytophthora root rot?

2. Soil acidification: increases metal solubility and availability

3. Apply metals to soils during peak root growth

4. Zinc: soil application 1 lb per tree in canopy drip zone.
   Avoid overapplication and zinc toxicity

5. Foliar application: during new leaf flush, may not be effective since little zinc is absorbed or translocated.

6. Iron: use metal chelates;
   pH 8.0 EDDHA Sequestrene 138 1 lb tree
   pH 6-7 HEDTA
   pH < 6 EDTA (iron should not be limiting in most soils at this pH)