NUTRITION

Terms used to describe levels of nutrient elements in plants

Deficient: when an essential element is at low concentration that severely limits yield and produces more or less distinct deficiency symptoms. Extreme deficiencies will lead to death of the plant.

Insufficient: when the level of an essential plant nutrient is below that required for optimum yields or when there is an imbalance with another nutrient. Symptoms of that condition are seldom evident.

Toxic: **when the concentration of either essential or other elements is sufficiently high to reduce plant growth severely. Severe toxicity will result in death of plants.**

Excessive: when the concentration of essential plant nutrient is sufficiently high to result in a corresponding shortage of another nutrient.

An element could be considered essential if :

1. **its deficiency prevents the plant from completing its life cycle,**
2. **its deficiency is specific to the element and can be corrected or prevented only by supplying that element, and**
3. **the element has a nutritional role apart from correcting any unfavorable microbial or chemical condition of the soil.**

Arnon and Stout (1939)

Essential nutrient elements for citrus

- **Elements supplied atmosphere: Carbon and oxygen**
- **Elements supplied by soil:**
  - **macronutrients: H, N, P, K, Ca, Mg, and S**
  - **micronutrients: Fe, Zn, Mn, Cu, B, Mo**

D.J. Nicholas: Cl, Si, Na, and Vanadium

C HOPK(I)NS CaFe Mg Mn Cu Zn Mo Cl B

C hopkins café managed by my cousin MoCl

Availability of nutrients

- **Mobile: N, P, K, Na, Mg, Cl, S**
- **Immobile: Ca, Fe, and B**
- **Intermediate: Zn, Mn, Cu, and Mo**

8 **Amount of nutrients removed by orange**

9 ## KEY TO MINERAL DEFICIENCY

A1. Symptoms only in new growth

B1. Leaves uniform in color, growth reduced.

C1. Leaves usually large and dark green

- **Ammoniation**
- **gum pockets in twigs and fruit**
- **brownish eruption on the peel surface called exanthema**

Role: Catalyst for respiration and enzyme constituent

Copper

10 ## Soils high in Copper

- **Soil and foliar application (fungicide) has resulted in accumulation of Cu.**
- **Results in Fe chlorosis**
- **Lower limit is 50 lb/acre**

Remedies:

- **Lime the soil to attain pH of 6.5**
- **Maintain adequate P levels**
- **Avoid using Swingle citrumelo**

11 **A1. Symptoms only in new growth**

B1. Leaves uniform in color, growth reduced.

C2. New leaves pale green

- **later turn yellow green as they enlarge**
- **reduced growth**
- **poor vegetative growth**
- **reduced yield if leaf values below 2.3%**

Role: Constituent of proteins, chlorophyll, coenzymes and nucleic acids.

Nitrogen

12 ## Nitrogen effects contd.

- **High rates reduce quality (Undesirable)**
  - **amount of green color in the rind of Valencia oranges**
  - **small fruit size**
  - **rind-staining of navel orange**
  - **thick peel**
  - **% juice decreased**
- **Benefits from high Nitrogen**
  - **reduce creasing in orange (but enhance regreening)**
  - **reduce amount of B and S in leaves**

13 **Citrus is a component in the nitrogen cycle**

- **600 box of oranges per acre removes 75 lb of N from the grove**
- **mature grove requires 200lb of N**
- **Fate of 125 lb of N is not understood**
  - **volatilization or denitrification**
  - **leaching**
  - **mineralization**
  - **immobilization**

14 Nitrogen Fixation

Aminization (Heterotropic bacteria):

Protein $R\text{-}NH_2 + CO_2 + energy$

15 **Ammonification (Mineralization)**

$R\text{-}NH_2 + HOH \rightarrow NH_3 + R\text{-}OH + energy$

$NH_4^+ + OH$

16 **Nitrification**

Nitrosomonas

$2\ NH_4^+ + 3O_2 \rightarrow 2\ NO_2^- + 2\ H_2O + 4\ H^+$

Nitrobacter

$2NO_2^- + O_2 \rightarrow 2NO_3$

(Obligate autotropic bacteria)

17 **Nitrogen Contd.**

- **What to apply:**
  - **Urea: 45-46% N**

- Ammonium nitrate: 33.5% N
- Calcium nitrate: 15.5 % N
- Ammonium sulfate: 20-21% (do not use if soil pH >6)
- Ammonium phosphate 11% N and 21% P

• When to apply (Soil / Foliar spray)

- 50-70 lbs N/ Acre to soil in January
- Biuret: one spray before bloom and one before June drop
- Maximum safe conc. of urea: 10 lbs/100 gal not exceed 35lb

18 ## Nitrates in groundwater

• Nitrate-N in ground water above the MCL.
• Maximum contamination limit-10 ppm

Reduction in ground water

- lower rates
- precise placement
- split applications
- control release formulations
- better irrigation management
- foliar sprays

19 ## A1. Symptoms only in new growth

B1. Leaves uniform in color, growth reduced.

C3. New growth dark green lusterless

• leaves thick, brittle, curl downward, veins enlarge and become corky
• misshapen leaves
• Fruit with gum deposits in the albedo
• fruit drop

Role: sugar translocation and CHO metabolism

Boron

20 ## Boron Contd.

• Deficiency is rare in California
• Toxicity is common
• Corrective action-Deficiency
  - apply Borax to soil 1-2 oz/tree
  - caution: deficiency may convert into excess
• Corrective action-toxicity
  - switch to low boron water source

- add lime- if from soil
- don't grow citrus

21 **A1. Symptoms only in new growth**

B2. Leaves with chlorosis patterns

C1. Leaves reduced in size

- pointed and narrow
- yellow mottling on green background
- Fruit small and pale
- irregular and chlorotic leaf spots
- reduced yield

Role: regulate metabolic activities

Zinc

22 **Zinc Contd.**

- most widespread and damaging in CA.
- Commonly called "mottle leaf" or "little-leaf"
- Causes:
  - Low Zn content in acid soils
  - low Zn solubility in alkaline soils
  - induced or aggravated by phosphate fertilization.
  - caution: deficiency may convert into excess

23 **Zinc Contd.**

- Corrective action:
  - Acid soil: 5lbs banded around the tree
  - soil application: alkaline soils do not correct deficiency
  - foliar spray
    - standard spray: 0.5 lb Zinc sulfate/100 gallons - apply 8-10 gallons /tree
    - another spray: 2-3 lb zinc oxide/100 gallons water
- Time:
  - TX: end of bloom and if symptoms persists one more spray at the end of summer.

24 **A1. Symptoms only in new growth**

B2. Leaves with chlorosis patterns

C1. Leaves normal in size and shape.

D1. Pale green mottle over entire leaf

- **Mottle-horse shaped with open end toward midrib**
- **mottle-marbled pattern**

Role: controls oxidation-reduction systems and formation of O_2 in photosynthesis

Manganese

25 **A1. Symptoms only in new growth**

B2. Leaves with chlorosis patterns

C2. Leaves normal in size and shape.

D2. Feather-like straight green veins on light green background

- **leaves yellow-severe**
- **die back**

Role: Chlorophyll synthesis and in enzymes for electron transfer

Iron

26 **Iron Contd.**

- **Difficult to correct the the problem:**
  - **Acid soils: high Cu makes Fe chlorosis**
  - **Calcarious soils: Fe unavailable**
    - **effect of bicarbonate ion (HCO_3^-)**
    - **Use tolerant rootstocks**
- **Corrective measures:**
  - **Soil application of Chelates**
    - **EDTA- Ethylene Diamine Tetra Acetic Acid**
    - **Fe-EDDHA -Ethylene Diamine Di (o-hydroxy phenyl) Acetic acid**

27 **A2. Symptoms originating on mature leaves**

B1. Fading chlorophyll in localized areas

C1. Fading starts in basal parts of leaf between mid rib and lateral leaf margin

- **Spread is outward leaving a green wedge pattern at the base of the leaf.**
- **Spread may be inward**
- **Abscise prematurely**

Magnesium

28 **Magnesium Contd.**

- Poor management of potassium fertilization (soil application) created the Mg deficiency
  - K displaced Mg… it was then leached out of the soil
- Corrective measures:
  - Soil application
    - not effective on soils with pH higher than 7.0
    - if pH is suitable, apply Mg Sulfate or Mg oxide
  - Foliar: Mg nitrate 10 lbs/100 gallon or
  - (8 gal/mature tree)

29 **A2. Symptoms originating on mature leaves**

B1. Fading chlorophyll in localized areas

C2. Fading starts along lateral leaf margins and moves inward about half way to the midrib

- Tree growth stunted-root system

Role: Cell wall component. Plays role in structure permeability of membranes.

Calcium

30 **Calcium Contd.**

- Calcium deficiency is rare-apply lime to increase pH.
- Corrective measures:
  - Soil application : Apply limestone (calcium carbonate) or superphosphate [$CaH_4(PO_4)_2$]
  - Foliar:spray 2% calcium hydroxide

31 **A2. Symptoms originating on mature leaves**

B1. Fading chlorophyll in localized areas

C3. Fading starts as blotches in distal portion of leaf

- fruit size is reduced but good quality
- old leaves persistent (Ca)

Role: Regulatory mechanism of photosynthesis and protein synthesis.

Potassium

32

- Excess K (orange and grapefruit)

- increased regreening
- thicker feels
- coarser peels
- delayed color break
- decreased % juice (a peel effect)
- decreased solids
- increased acid

• Excess K-lemons

- delayed loss of green color--- delayed harvest
- increased acid in juice---higher returns for processing

33

- High K decreases lemon peel thickness but high K gives thicker orange rinds
- high K increases lemon % juice (good) but high K gives lower % juice in oranges

34 **Potassium Contd.**

• Soil application

- Apply before winter rains-5-10 lbs of sulfate of potash (K_2SO_4- 47% K)

• Foliar application

- KNO_3 up t o 40 lbs/100 gallons… 25o lbs /acre
- Once reach 40 lbs of KNO_3/100 gal. DO NOT include other salts (Zn + KNO_3 + Mn Sulfate)-
  - » Cause gumming of orange fruit… damage is from Zn

• DO NOT apply KNO_3 and Magnesium nitrate

35 **A2. Symptoms originating on mature leaves**

B1. Fading chlorophyll in localized areas

C4. Fading in randomly distributed spots on the leaf blade

• spots develop brown centers with yellow or orange halos

• spots may unite

Role: In nitrogenase needed for nitrogen fixation

Molybdenum

36 **Molybdenum Contd.**

- **Not a problem in California but problem in some acid soils of Florida**
- **Corrective measures:**
  - **Foliar spray: 1 oz of sodium ammonium molybdate in 100 gallon water**

37 **A2. Symptoms originating on mature leaves**

B2. Fading of chlorophyll not localized.

C1. Fading of leaf to dull green and to orange yellow

- **burned tips (extreme cases)**
- **fruits coarse or spongy**
- **peel thick**
- **hollow centered**

Role: Energy transfer as part of ATP, constituent of many proteins, coenzymes, nucleic acids and metabolic substrates.

Phosphorus

38

- **Excess P effect on fruit quality**
  - **Some reduction in size and peel thickness**
  - **reduction in peel coarseness in peel texture**
  - **Increase in % juice**
  - **increase in ratio of solids/acid**
- **Apply to soil**
  - **moves slowly into root zone, so apply before winter rains**
  - **2 lbs P/ tree for two years**
  - **10 lbs superphosphate CaH_4 (PO4) $_2$**
  - **10 lbs of ammonium phosphate $(NH_4)_4 PO_4$**

39 **A2. Symptoms originating on mature leaves**

B2. Fading of chlorophyll not localized.

C2. General pale green or yellow foliage with whitish veins

- **fewer number of fruits**
- **pale internal and external color**
- **quality good**

Nitrogen