Avocado Fertilization
The Macro Elements

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Plant Nutrition

The Essential Elements

- Primary Elements Required for Growth
  - Carbon, Hydrogen and Oxygen
    - Supplied from carbon dioxide and water, essential for photosynthesis
  - Nitrogen
  - Phosphorous
  - Potassium

The Essential Elements

- Secondary Nutrients
  - Calcium
  - Magnesium
  - Sulfur

Functions of Essential Elements

- Nitrogen (N)
  - Nitrogen is utilized by plants to make amino acids, which in turn form proteins, found in protoplasm of all living cells. Also, N is required for chlorophyll, nucleic acids and enzymes

Functions of Essential Elements

- Phosphorus (P)
  - Phosphorus is used to form nucleic acids (RNA and DNA), it is used in storage and transfer of energy (ATP and ADP)
  - P fertilizer stimulates early growth and root formation. Best used by plants in cold weather and with fast top growth (lettuce)
  - Least response by plants in summer with extensive root systems (tree crops) and mycorrhizae

Functions of Essential Elements

- Potassium (K)
  - Potassium is required by plants for translocation of sugars, starch formation, opening and closing of guard cells around stomata (needed for efficient water use)
  - Increases plant resistance to disease
  - Increases size and quality of fruit
  - Increases winter hardiness

Functions of Essential Elements

- Calcium
  - Essential part of cell walls and membranes, must be present for formation of new cells
  - Has been shown to make avocado root tips less leaky, therefore less attractive to Phytophthora zoospores

Functions of Essential Elements

- Magnesium
  - Essential part of the chlorophyll molecule
  - Activator for many plant enzymes
  - Mobile in the plant to younger tissue

Functions of Essential Elements

- Sulfur
  - Constituent of three amino acids, therefore important for synthesis of proteins
  - Essential for nodule formation in legumes (in case you have legume cover crops)

Deficiency

- Nitrogen
  - Slow growth, stunting, reduced yields
  - Yellow-green color to leaves (a general yellowing)
  - More pronounced in older leaves since N is a mobile element that will move to younger leaves
  - Don’t confuse with root rot and gopher damage

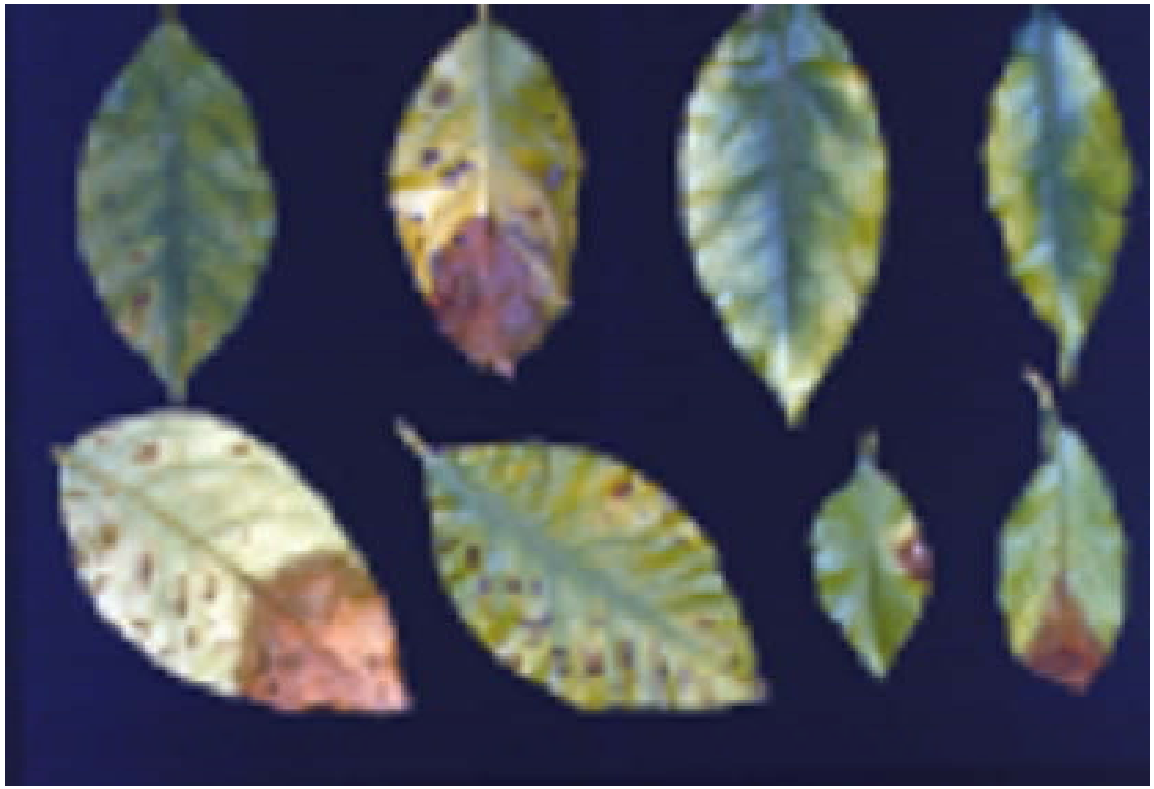

N
no N

Nitrogen Deficiency

Deficiency

- Phosphorus
  - Slow growth, stunting
  - Small leaves without chlorosis between veins
  - Randomly distributed necrotic areas in leaves with severe deficiency

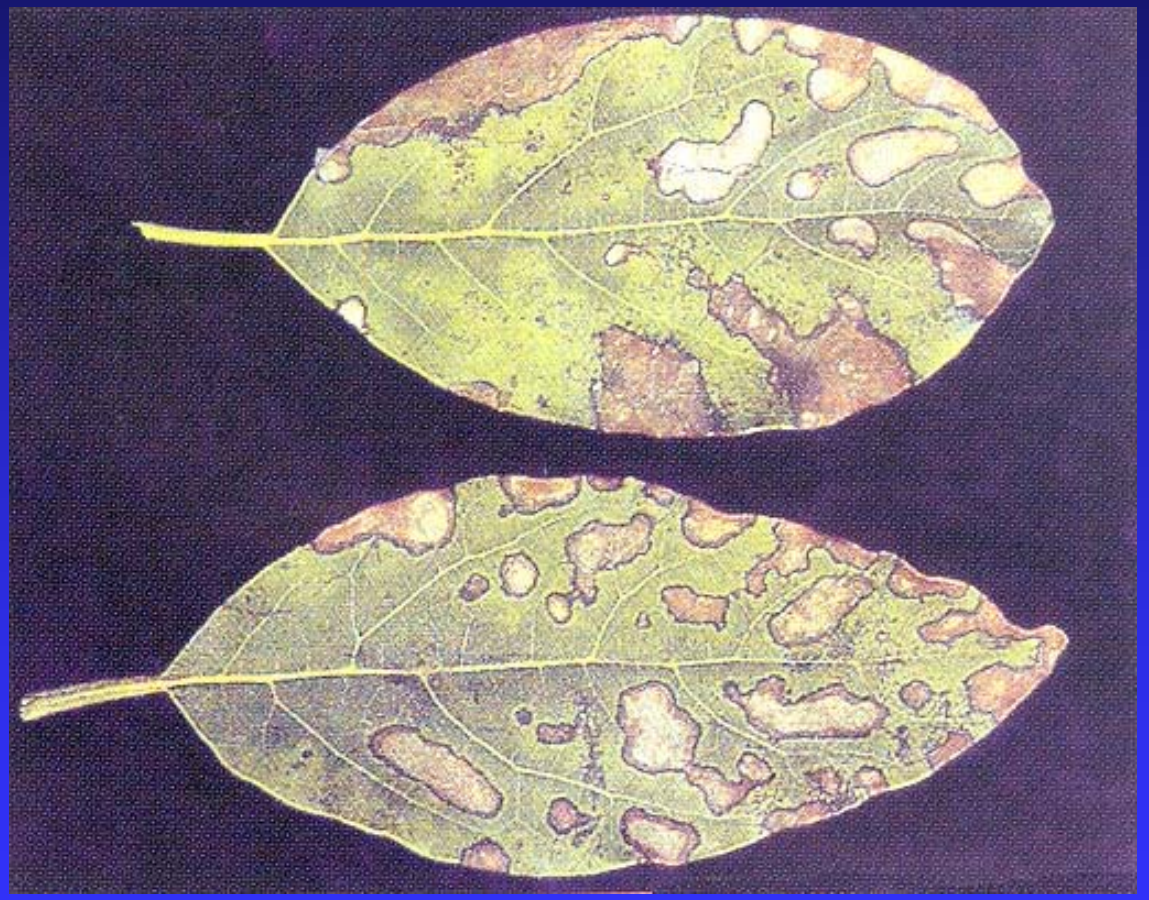
Phosphorus , lemon, San Diego 1950



Deficiency

- Potassium
  - Leaf tip and marginal burn, starting on mature leaves
  - Small fruit, shriveled seeds
  - Slow growth
  - Thin twigs, dieback
  - Confused with chloride tip-burn which is much more common

Potassium deficiency



Deficiency

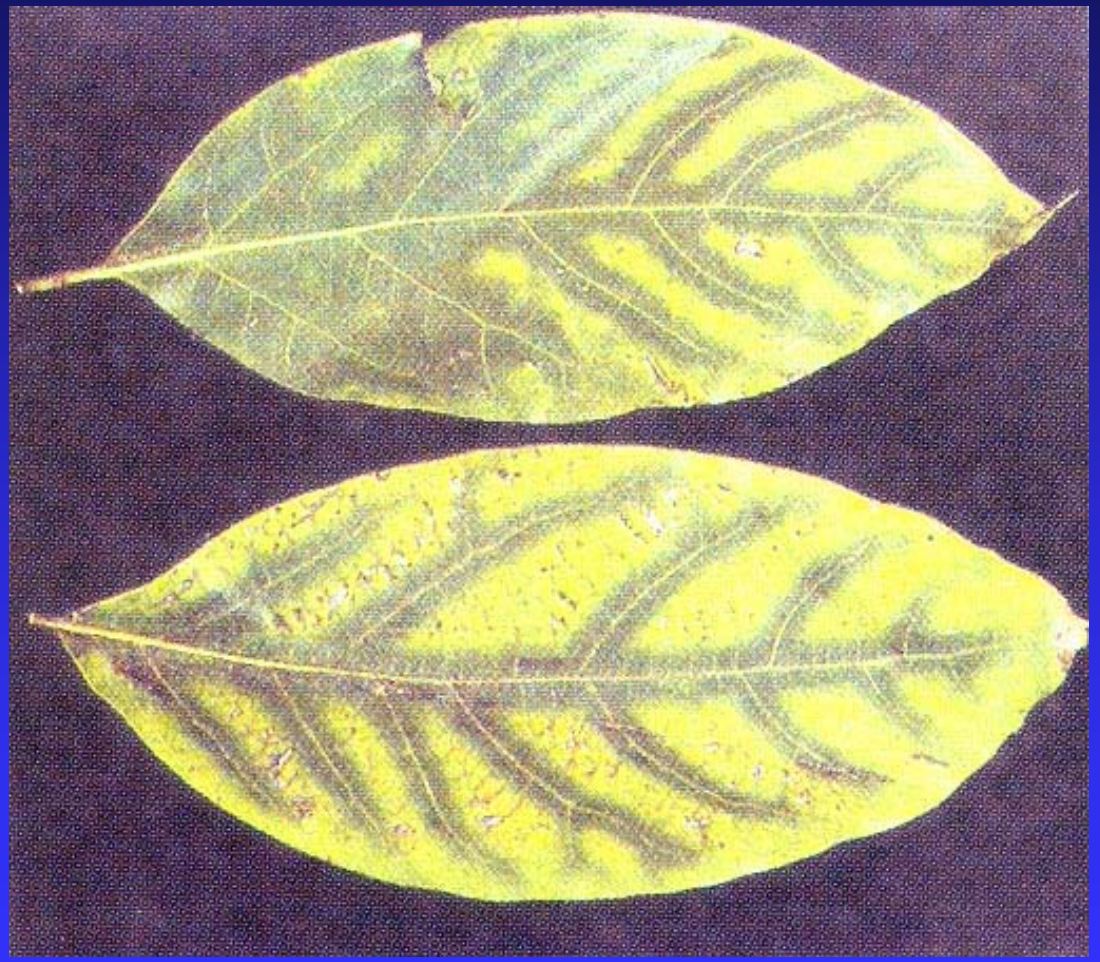
- Calcium
  - Tip burn of young leaves
  - Death of growing points (including root tips)
  - Abnormal dark green appearance of leaves
  - Premature shedding of flowers and buds
  - Weak stems
  - Water soaked discolored areas on fruits (apples)
  - Usually not a problem in California

Deficiency

- Magnesium
  - Interveinal chlorosis in older leaves
  - Curling of leaves upward along margins
  - Marginal yellowing with green "Christmas tree" area along midrib of leaf (seen in citrus)
  - Not a problem in California

Magnesium, lemon

Magnesium deficiency



Deficiency

- Sulfur
  - Young leaves light green to yellowish in color
  - Retarded growth
  - Not a problem in California, Colorado River water and local supplies have enough sulfate

Deficiency in Avocado (Lahav and Whiley, 2002)

- N – Pale green, small leaves, shedding, short internodes and dieback in branches
- P – Brownish green in old leaves, small rounded leaves, shedding, dieback in branches
- K – Interveinal chlorosis in older leaves with small brownish-red spots, small narrow leaves, thin branches with dieback

Nutrient Availability and Uptake

- Most of N is taken up as nitrate (NO_3^-)
- Some may be taken up as ammonium (NH_4^+)
- Nitrate is highly mobile in soil and moves to the roots quickly (and is leached out readily)
- Ammonium binds to soil particles and is converted to nitrate by bacteria

Nutrient Availability and Uptake

- Ammonium to nitrate takes 1-2 weeks at 75F
- Ammonium to nitrate takes 12 weeks or more at 50F
- Ammonium to nitrate is optimum at pH between 5.5 and 7.8
- Under anaerobic conditions, nitrate is lost from the soil as nitrous oxide, nitric oxide and N_2 gases

Nutrient Availability and Uptake

- The atmosphere contains 78% N_2 gas
- Some soil organisms and root nodules on legumes convert N_2 to NO_2
- Lightning also converts N_2 to NO_3
- Fertilizer companies use natural gas to convert N_2 to NH_3 (under high temperature and pressure)
- Organic manures are slowly converted to NH_4 and NO_3 for plant uptake

Nutrient Availability and Uptake

- Phosphorus (P)
  - Most P in soil is tied up chemically, less than 1% may be available for uptake into plant
  - P taken up as phosphate ions: $H_2PO_4^-$, HPO_4^{--}, or PO_4^{---}
  - Note: phosphorous acid is a phosphonate, not readily used as a nutrient

Nutrient Availability and Uptake

- P maximum availability is from pH 6.5 to 7.5
- P uptake is increased when there is some nitrogen in the phosphate fertilizer

Nutrient Availability and Uptake

- Potassium (K)
  - Taken up as K^+ ions and remains in ionic form in the plant
  - 90-98% of K occurs in primary materials and is unavailable to the plants
  - 1-10% is trapped in expanding lattice clays and is slowly available
  - 1-2 % is in soil solution and readily available

Nutrient Interactions

- Excess K+ may compete with Mg and Ca uptake
- Excess P interferes with Zn uptake
- Excess Fe can induce Mn deficiency
- Increasing K fertilization can reduce B in the leaf analysis

Fertilizers

- N-P-K ratio is the “grade” and is required to be on all bags of fertilizer
- 21-7-14 means that in 100 lbs of fertilizer you will get 21 lbs of N, 7 lbs of phosphate (P_2O_5) and 14 lbs of potash (K_2O)

Formulations-Nitrogen

- Ammonium nitrate (34-0-0)
- Ammonium sulfate (21-0-0-24S)
- Calcium nitrate (15.5-0-0)
- Urea (46-0-0)
- Solutions
  - Ammonium nitrate 20% N
  - Calcium ammonium nitrate 17% N
  - Urea ammonium nitrate 32 % N

Formulations - Phosphate

- Starts with phosphate rock from mines in N. Africa, and Montana, Wyoming, Idaho and Utah
- Finely ground phosphate rock used in organic production (best on acid soils)
- Phosphoric acid (0-52-0)
- Superphosphate (0-20-0-12S)
- Ammonium phosphate (11-52-0)
- Liquid ammonium phosphate (8-24-0)

Formulations-Potassium

- Potassium chloride (cheapest, but not recommended for avocados)
- Potassium sulfate
- Potassium nitrate
- Solubility in water (%K_2O) at 20C
  - KCl 16.1
  - KSO_4 5.4
  - KNO_3 11.2

Application Methods

- Foliar – Not very effective on avocado due to thick waxy cuticle on leaf surface
- Soil - Should be applied only in area wetted by the sprinkler, high cost for labor
- Fertigation – Many advantages, including precise location of fertilizer where roots grow, low cost of application, difficulty applying P unless phosphoric acid is used

Application Timing

- N fertilizers should be applied frequently, especially where soil is light and lacking fertility; usually at least once a month for 9 months during growing season.
- P and K fertilizers do not leach readily and can be applied less frequently
- Heavy soils can be fertilized less frequently

Application Amounts

- Use leaf analysis to determine N, P and K
- N should be around 2.2%
- Generally, 1.5 – 2.0 lbs actual N per tree per year is about right
- If P is higher than 0.14%, do not apply P
- K is applied at 200-300 lbs/acre (K2O), but do not apply if K is higher than 1.2%

Chloride Toxicity