Micronutrients and Phosphorus Management in Pistachio

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Nutrients (other than N and K) to care about in pistachio:

- Boron
- Zinc
- Copper
- Phosphorus? (unknown)

Basic plant nutritional physiology

- An essential nutrient is an element needed to complete plant structural components, or it is involved in plant metabolism. Its absence results in
- Cell death
- Severe abnormalities
- Inability to complete its lifecycle
  - aka reproduce
  - aka make what we all care about: pistachios!

The Essential Plant Nutrients

- Macronutrients:
  - Primary
    - Nitrogen
    - Phosphorus
    - Potassium
  - Secondary
    - Calcium
    - Magnesium
    - Sulfur
- Others
  - Carbon
  - Hydrogen
  - Oxygen

- Micronutrients:
  - Iron
  - Manganese
  - Boron
  - Copper
  - Zinc
  - Molybdenum
  - Nickel

Plants are extremely good at getting nutrients from soils

- Plants in unfertilized ecosystems grow just fine!
- We only add elements if they are commonly deficient in an area
- OR if naturally available levels are not great enough to support crop production levels that we want to see
  - Growing plants outside of their native environments plays a role

This spectacular natural environment receives no external nutritional inputs
(Buck Lake in the Emigrant Wilderness)

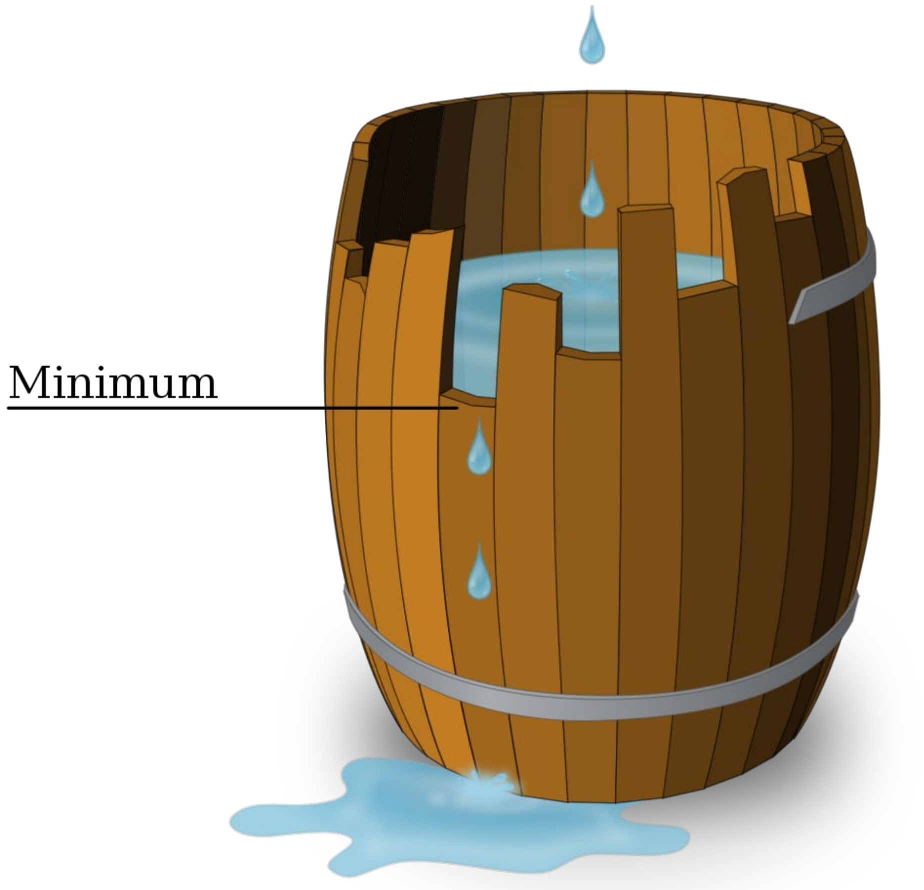
Nutrients perform specific functions in living organisms

- But the research that discovers these functions is often very artificial
- Specific elements are limited or completely limited in greenhouse or climate chamber settings
- Nutrient functions are derived based on how plants are suffering or die

This stock photo is probably closer to the truth than you might think!

Why is this important?

- It is critical to understand that just because a plant function is impaired by a nutrient deficiency
- Does not meant that the function will be enhanced by an overapplication of that element!
- Growth and function are limited by the law of the minimum
- Eventually light interception becomes the minimum!



Boron

- Found in the soil:
  - Adsorbed to clays, metal oxides, and organic matter
  - In the soil solution
- Found in the soil and taken up as $B(OH_3)$
- Used by the plant in:
  - Structural integrity of cell walls
  - Membrane function
  - Pollination

Boron

- Weak growth
- Short internodes
- Misshapen leaves
- Terminal dieback
- Low yields
- *Immobile* in pistachios (deficiency and toxicity symptoms show up in leaves)

Photo: Louise Ferguson

Boron Fertilization

- Soil application (summer timing)
  - Broadcast 50-75 lbs of an 11% boron product can correct deficiencies for several years
  - Fertigation is also a great way to apply B, just reduce the amount by 25-30%
- Foliar application
  - spray a mixture of 2.5 - 5 lbs Solubor per 100 gallons of water per acre
  - Timing can be any time of the year, but best done at bud swell to supply floral tissues with B
    - Spraying during bloom can negatively affect pollen movement and flower health
- Can combine both in cases of severe deficiency
  - Soil applications take time to correct; a spring foliar following a soil application may be needed

Boron Toxicity

- Pistachios can accumulate boron in leaf tissues without apparent reductions in yield
- leaf burn is associated with boron, *not* sodium and chloride in pistachios
- Symptoms of leaf burn will be reduced under higher salinity levels
- Leaching technically works, unknown if it is practical

Zinc

- Found in the soil, availability pH dependent
  - Adsorbed and bound to other compounds (notably $CaCO_3$)
  - In the soil solution (in very low concentrations)
- Taken up as Zn^{2+}
- Used by the plant in:
  - Enzyme catalyst for more than 300 enzymes
  - Involved in auxin biosynthesis

Zinc

Photo: B. Beede

- Immobile in pistachios (including foliar applied zinc!)
    - 6.5% absorbed into plant tissues and translocated
- Deficiency symptoms appear in the spring
- Delayed opening of buds
- Small, chlorotic tufts of leaves, small nuts in severe deficiencies
- Interveinal chlorosis in minor deficiencies
- Wavy leaf margin

Zinc Fertilization

- Foliar applications
  - Mix 1-2 lbs of $ZnSO_4$ or zinc chelate in 100 gallons of water
  - Application rate should be 2-4 lbs Zn/acre
  - Apply during the early spring flush
  - **Leaf absorption decreases rapidly as leaves age**; repeated applications will have limited effects
  - Do not combine with nitrate!
- Soil applications
  - Traditional recommendations are to apply extremely high rates
    - trench 5-10 lbs $ZnSO_4$ per tree
    - Inject 5-20 gallons $ZnSO_4$ sulfate solution (1 lbs $ZnSO_4$ per gallon water) into the root zone
- Foliar applications will work just fine, but will not increase Zn levels in other plant tissues

Copper

- Deficiencies are not uncommon, found in young orchards
- Deficiency symptoms appear in midsummer
  - Zinc: spring
- Tiny, undeveloped leaves at leaf terminals
- Midseason terminal dieback

Photo: Louise Ferguson

Copper fertilization

- Soil applications have been inconsistent and sometimes induced phytotoxicity
- Foliar applications extremely effective
- Apply 1/3 to ½ lbs CuEDTA to 100 gallons of water
- Apply after bloom, once leaves are 50% expanded

Photo: Louise Ferguson

Phosphorus

- Research trials have traditionally shown little or no response to applied phosphorus
  - I found nothing examining pistachios!
- Documented deficiencies in California are so rare they make the news
- *Always* address deficiencies based on leaf tissue analyses
  - High levels of P in soils (traditionally with old corrals) can induce zinc availability
  - Overapplying a nutrient does not improve physiological functions

Phosphorus in soils

- Phosphorus is found in multiple pools in soils
  - P that is available for uptake, in the soil solution
  - P that is mostly available for uptake, bound to the soil
  - P that is somewhat available for uptake, bound to the soil
  - P that is mostly unavailable for uptake, bound to the soil
- Very little P is found in the first pool
  - As soil solution P is depleted, P in the second pool will resupply it
- All applied P will move into various stages of unavailable P

Phosphorus in soils

- Phosphorus isn't very available on the low and high ends of the pH spectrum
- The forms that P is found in differ depending on the pH
  - Binds to Fe, Al at low pH
  - Ca at high pH
- Because of this, different tests are needed to assess P availability in soils
  - Olsen bicarb test in neutral to high pH soils
  - Weak bray in neutral to low pH soils
- Different tests have different sufficiency ranges
  - "Sufficiency" = 10-20 ppm for Olsen bicarb
  - 20-40 ppm for weak bray

WHY?

- Soil tests have been developed to determine *plant response to applied nutrients*
- Especially for phosphorus, this means that the amount you see in a test often *is not what is in the soil*
- Soil tests are to guide fertilizer applications
- And ranges/response curves are calibrated specifically for specific tests

Research on phosphorus

- In general, (worldwide) research that examines the response of tree growth to added P shows no response
  - This could be because P is immobile and application methods in very old research did not actually supply the trees
  - Or because some tree species form mycorrhizal associations, which enhances P uptake
- Or because P deficiency is rare, and there is no need for fertilization research
  - I found only one study in California that documented P deficiency – it is from the 1960s

Phosphorus application to mature trees

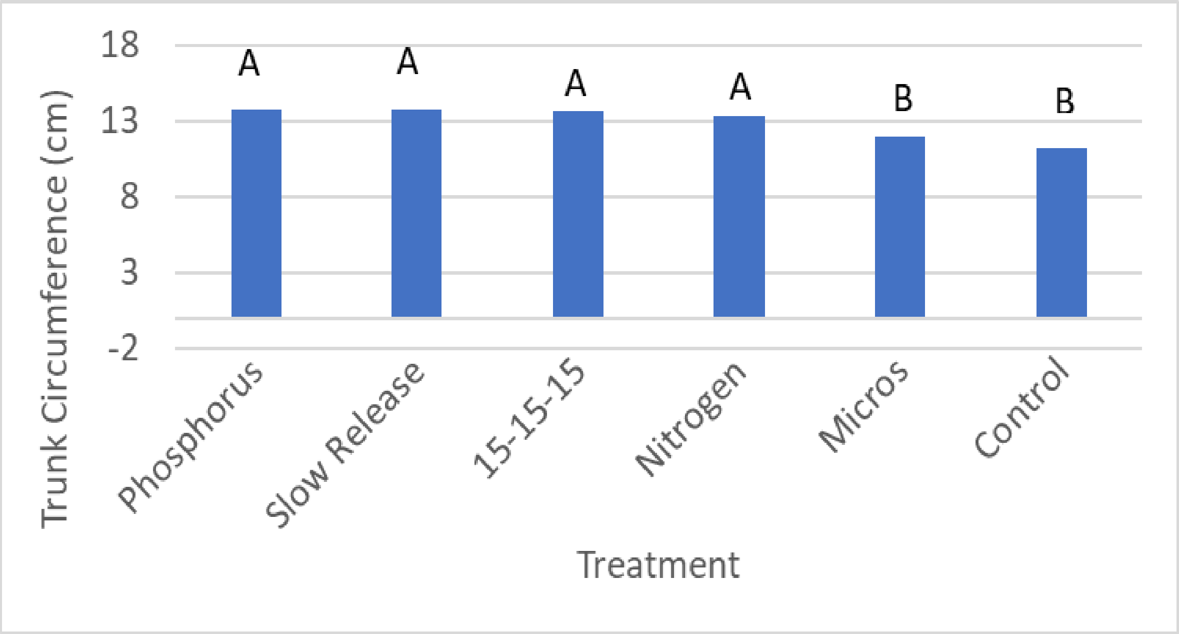
Treatment	1996	1997	1998	1999
No K	2192	2500	2868	2904 d
0.38 kg SOP	2382	2719	2916	3313 bc
0.75 kg SOP	2305	2797	2792	3335 abc
0.38 kg MKP	2251	2862	3067	3727 a
0.38 kg KTS	2345	2867	2824	3015 cd
0.75 kg SOP banded	2275	2978	2585	3534 ab

Adapted from: Edstrom, J.P. and Meyer, R.D., 2006, August. Potassium fertilizer application in drip and micro-jet irrigated almonds. In *V International Symposium on Irrigation of Horticultural Crops 792* (pp. 257-263).

- One study that examined almond responses to applied potassium also included one fertilizer that has phosphorus
- P containing fertilizer performed the best in one out of five years
  - But not significantly the best
- BUT The trial was not set up to examine the response of P
  - You cannot rule out an interaction between K and P

Research – nutrition + ASD (research led by Greg Browne)

- We applied several fertilizer formulations to newly planted almond trees
  - Unfumigated ground
  - In a soil with a **recycled orchard**
  - Soil levels ranged from 7 to 16 ppm (Olsen bicarb)
- Trees receiving only P grew just as well as:
  - Only N
  - Two different complete fertilizer formulations

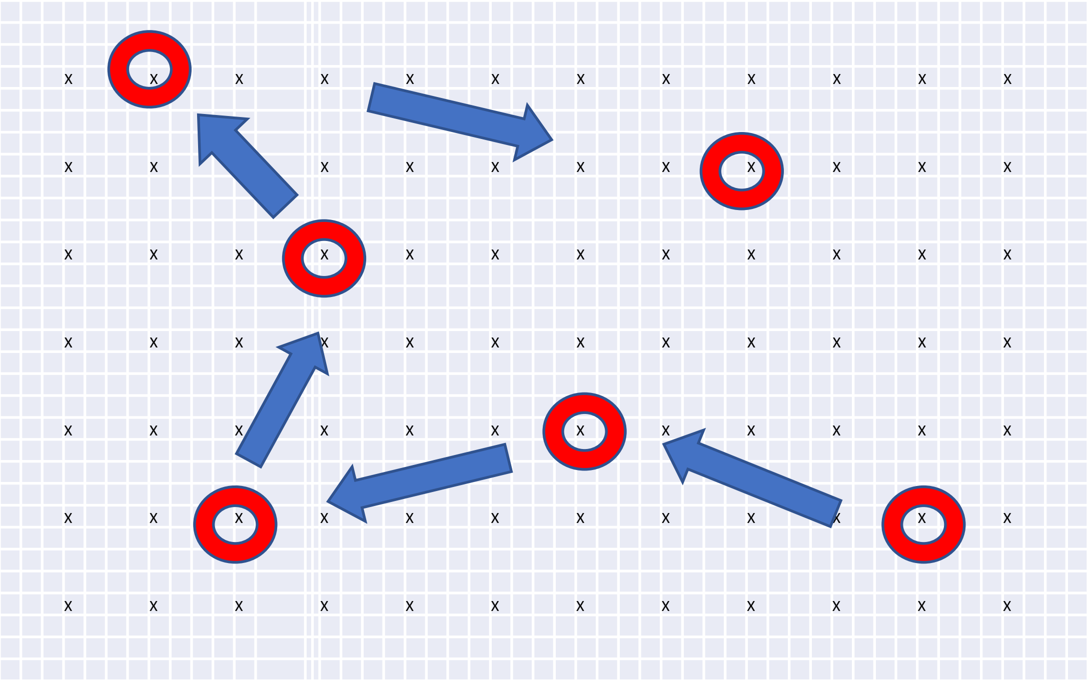


From: Gordon, P., Browne, G., Ott, N., and Khan, A. “Can Fertilizing Overcome Replant Challenges?” Poster at the 2019 Almond Conference

Phosphorus bottom line

- There is no concrete evidence that <u>mature</u> almonds need P
  - No recent evidence to the contrary, however
  - This is being examined in a long term trial by Franz Niederholzer, keep an eye out for results!
- Limited evidence that 1st leaf almonds in sites with incorporated wood chips could use P
  - Greg Browne and I are examining two more sites – data will be published soon
- No evidence one way or another that pistachios need phosphorus

How do you sample for leaf tests?



- Wander at random through the orchard
- Select leaves from all four quadrants of a tree
- Make sure trees are 40+ feet apart
- Don’t combine good and bad
- Don’t combine irrigation blocks
- Split up blocks larger than 40 acres

How to determine if your trees are deficient?

- Sample leaves every July
- Pull <u>subterminal</u> leaflets from several leaves around each sampled tree
- MIX them well, THEN put them in a bag and submit to a testing laboratory

Leaf critical values

Nutrient	Deficient	Sufficient	Excessive
Boron	< 90 ppm	150 – 250 ppm	2000+ ?
Zinc	< 7 ppm	10 – 15 ppm	
Copper	< 4 ppm	6 – 10 ppm	
Phosphorus	< 0.14%	0.14 – 0.17%	

Thank you!

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www.growingthevalleypodcast.com

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