Pistachio nutrient management during drought

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First:

- Research on water shortages in pistachio in California on deficit irrigation
  - Targeted, and short term (assumption is that water supplies will resume?)
- Quite a lot of research on drought in agriculture
  - Not much in pistachios, and none of it from California
- This presentation addresses things that are known about:
  - How plants in general respond to drought stress
  - Research on nutrient availability under drought stress
  - Again: scientific literature typically examines drought in the context of no water

What can we expect to happen to orchards under long term drought?

Groundwater available

- Increased salinity
- Reduced soil moisture at the start of the season?
- Theoretically full irrigation amounts available
  - Possibly poor irrigation water quality

Groundwater limited or unavailable

- Increased salinity
- Reduced soil moisture at the start of the season
- Periods of time where water is reduced or unavailable
  - Ideally this can be strategically deployed

What does drought do to plants?

- Reduce growth
  - Less carbon fixed and directed toward growth
- Reduce yields
  - Less carbon fixed and directed toward fruit
  - Less vegetative growth
- Weakens trees (more likely for long term, “true” drought)
  - Unclear if this would affect pistachios
  - Typically makes trees more susceptible to pests/diseases

When would we expect reduced water availability to most affect pistachio yields?

- Kernel fill
  - Affects kernel yields
  - Also time period when buds abscise…
- Hull/shell expansion
  - Higher splits vs smaller fruit
- Shoot expansion
  - Long term reduction in fruiting wood

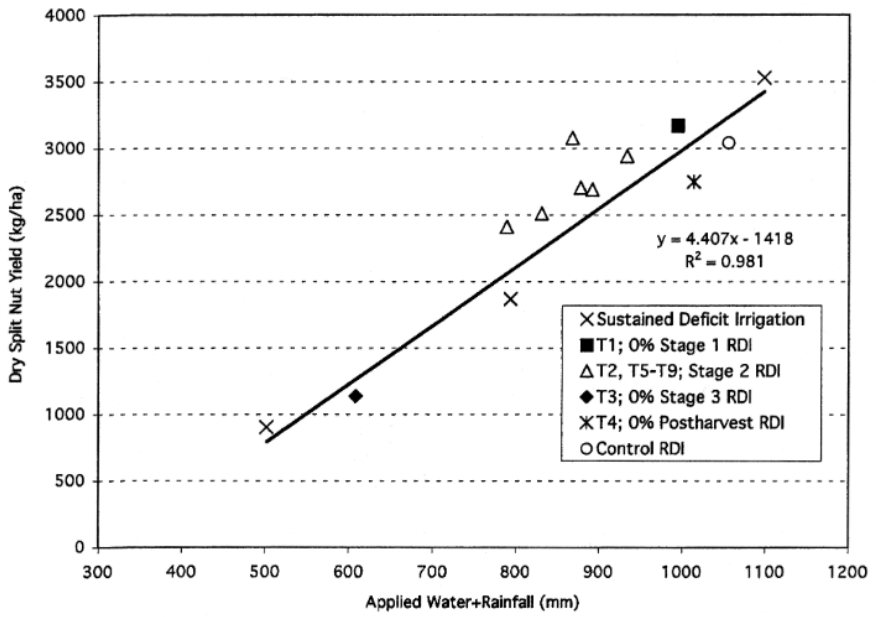
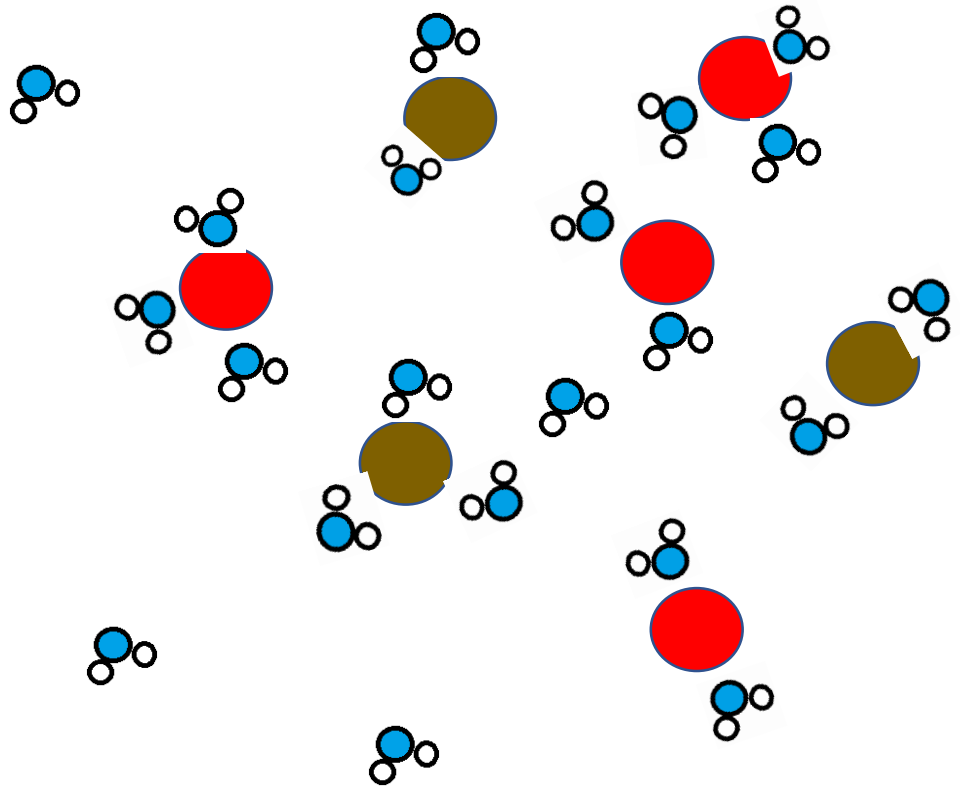


FIG. 3
Mean (1991–92) yield of dry split nuts versus mean (1991–92) applied water and rainfall for the current RDI experiment and previous work with sustained water deficits over the season (Goldhamer *et al.*, 1987). Equation and correlation coefficient are the first-order best fit for the sustained deficit irrigation data.

From: Goldhamer and Beede (2004)

Connection between salinity and drought

- Irrigated agriculture adds salts to soil (yes, even canal water contributes!)
- Lack of sufficient rain results in insufficient leaching
  - Chlorides, sodium if there is a cation to replace Na from the CEC
  - Some areas do not receive enough rainfall for leaching
- Osmotic (salt) stress imposes some of the same issues on plants as drought
  - Reduces available water



How important is a full soil profile in the winter?

- Leaching is best done when soil profile is completely full
  - Best done as a winter activity
  - Probably best if the rain happens earlier in the dormancy period
- In soils with poor infiltration rates, lack of stored soil water presumably contributes to later season water stress
- In soils with good infiltration and lots of available water, if 100% ET can be applied, everything is theoretically
  - As long as water management practices are good!

How does dry soil affect nutrient availability?

Nutrient	Mass Flow	Diffusion	Root interception
Nitrogen	X		
Phosphorus		X	
Potassium	X	X	
Calcium	X		X
Magnesium	X		X
Sulfur	X	X	
Boron	X		
Copper	X		
Iron	X	X	X
Manganese	X		X
Zinc	X	X	X

Adapted from: https://nrcca.cals.cornell.edu/nutrient/CA2/CA0209.php

Potassium Fixation: a special concern in Vermiculite or mica rich soils

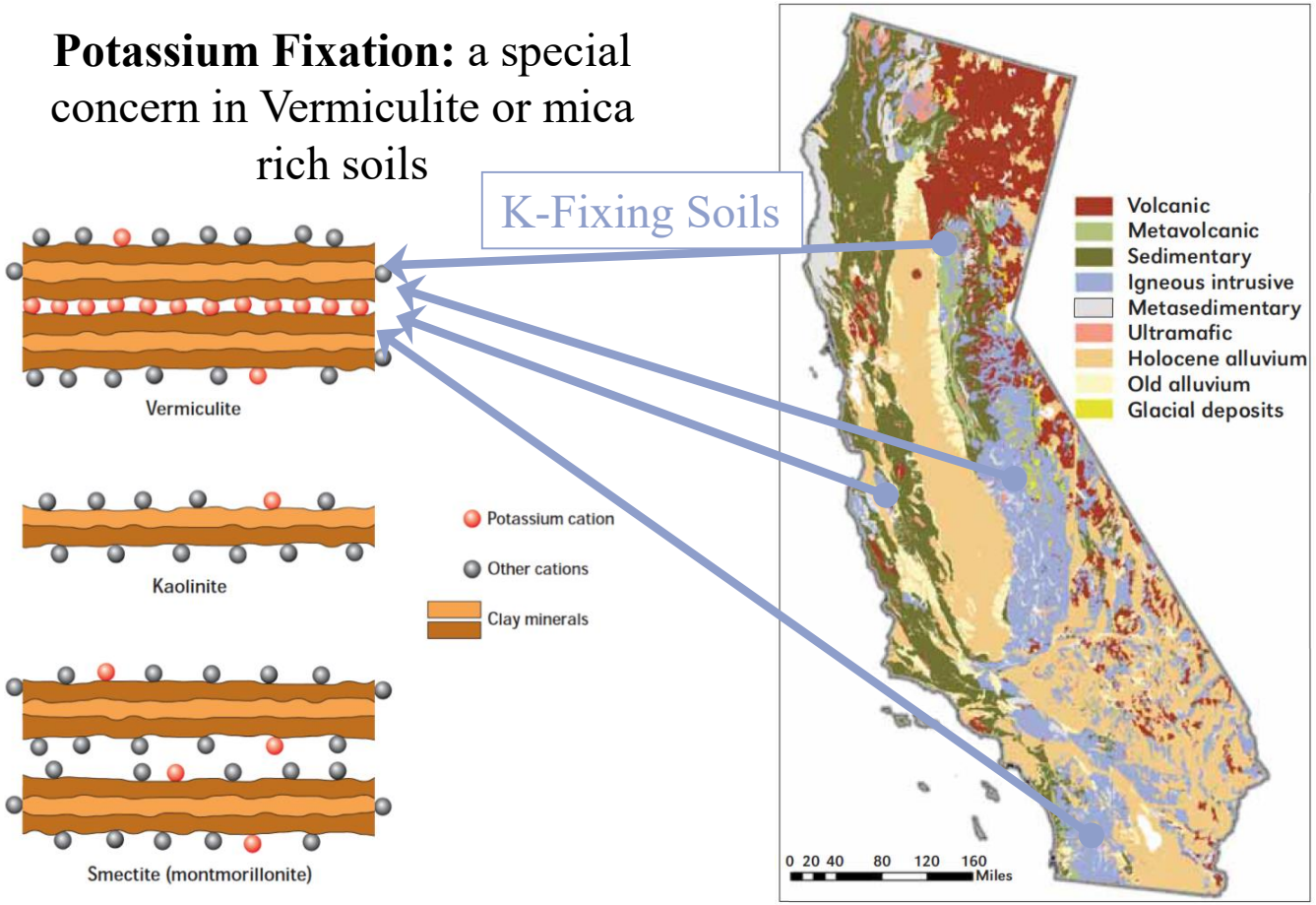


Figure 3. The soils of the Central Valley of California are primarily derived from granitic material from the East and sedimentary material from the West. Potassium-fixing soils are typically associated with granitic (igneous intrusive) parent material.

Slide credit: J. Caprile

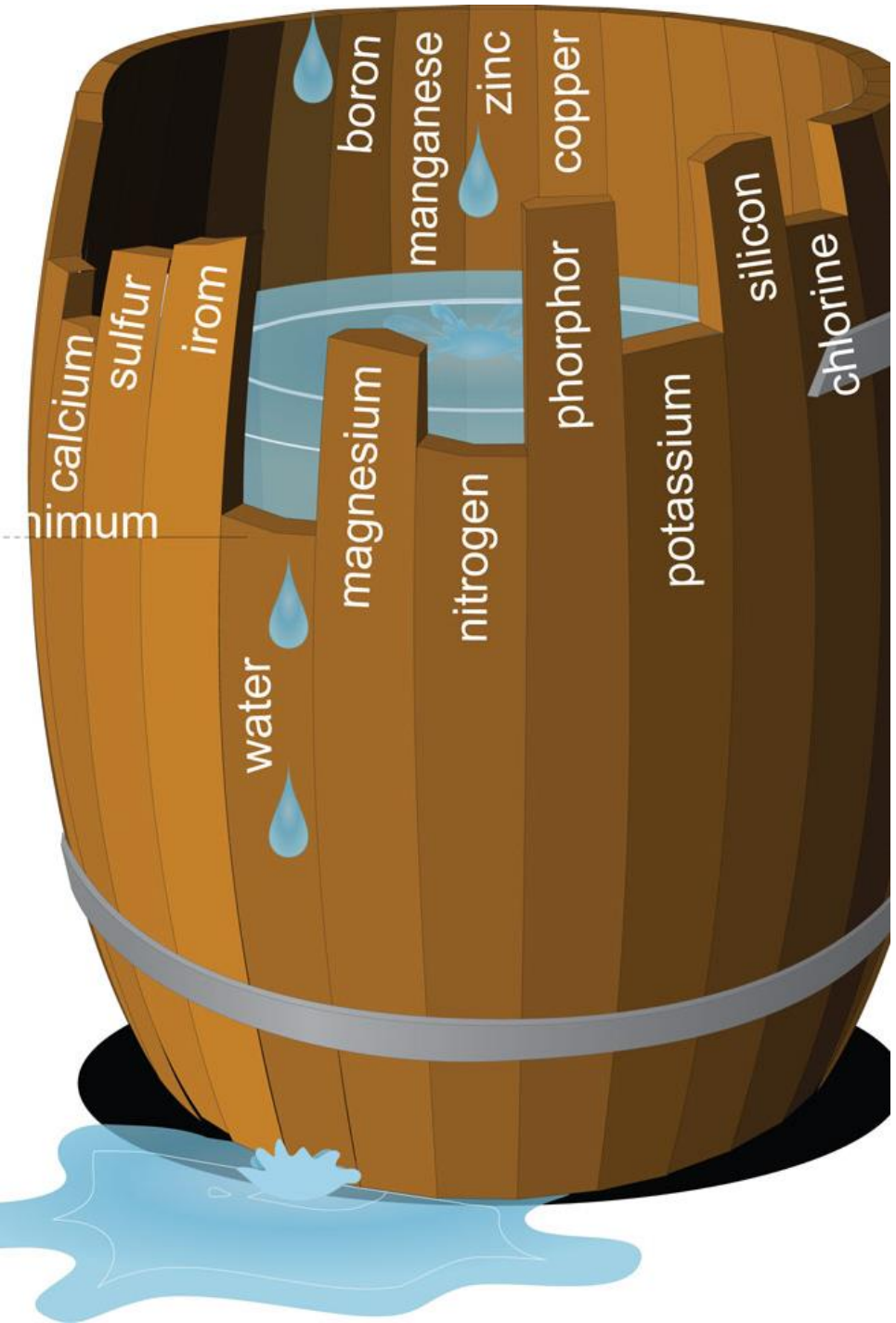
Pettygrove et al, Better Crops 2012

How does dry soil affect nutrient availability?

- In general, nutrient availability will decline
- Worst for nutrients needed in larger quantities
  - Micronutrients are needed in such small quantities that it probably isn't an issue
  - And, we already have mechanisms in place for dealing with low availability of Zn
- Less transpiration = less translocation of nutrients
- But…

How does dry soil affect nutrient availability?

- Root growth is typically less affected by drought than shoot growth
- Demand for nutrients decreases
- Some processes that make nutrients available may still occur when soils dry
  - More available nutrients when the soil is rewetted
- Possibly less growth dilution of nutrients in plant tissues



Ok, cool, what does all of that mean?

- Liebig's law of the minimum still applies!
- Hot areas with high transpiraitonal demand means that water will limit growth
- California is a high input system
- Primary concern is adjusting to reduced yields

How does salinity affect nutrient availability?

- Sodium negatively impacts soil structure
- Sodium can interfere with K, Ca, Mg uptake
- Chloride can negatively impact NO_3^- uptake
- Osmotic and toxic ion effects probably outweigh any effects on nutrient availability

Can I help the plants by fertilizing?

- I’ve heard that (nutrient x, y, z) can help with (insert plant function here) – can I fertilize with that to help out my trees?
- Are your trees deficient in that nutrient?
- If not, then probably not!
- Liebig’s law of the minimum still applies
  - Salinity, drought will reduce growth, reduce nutrient demand

Can I help the plants by fertilizing?

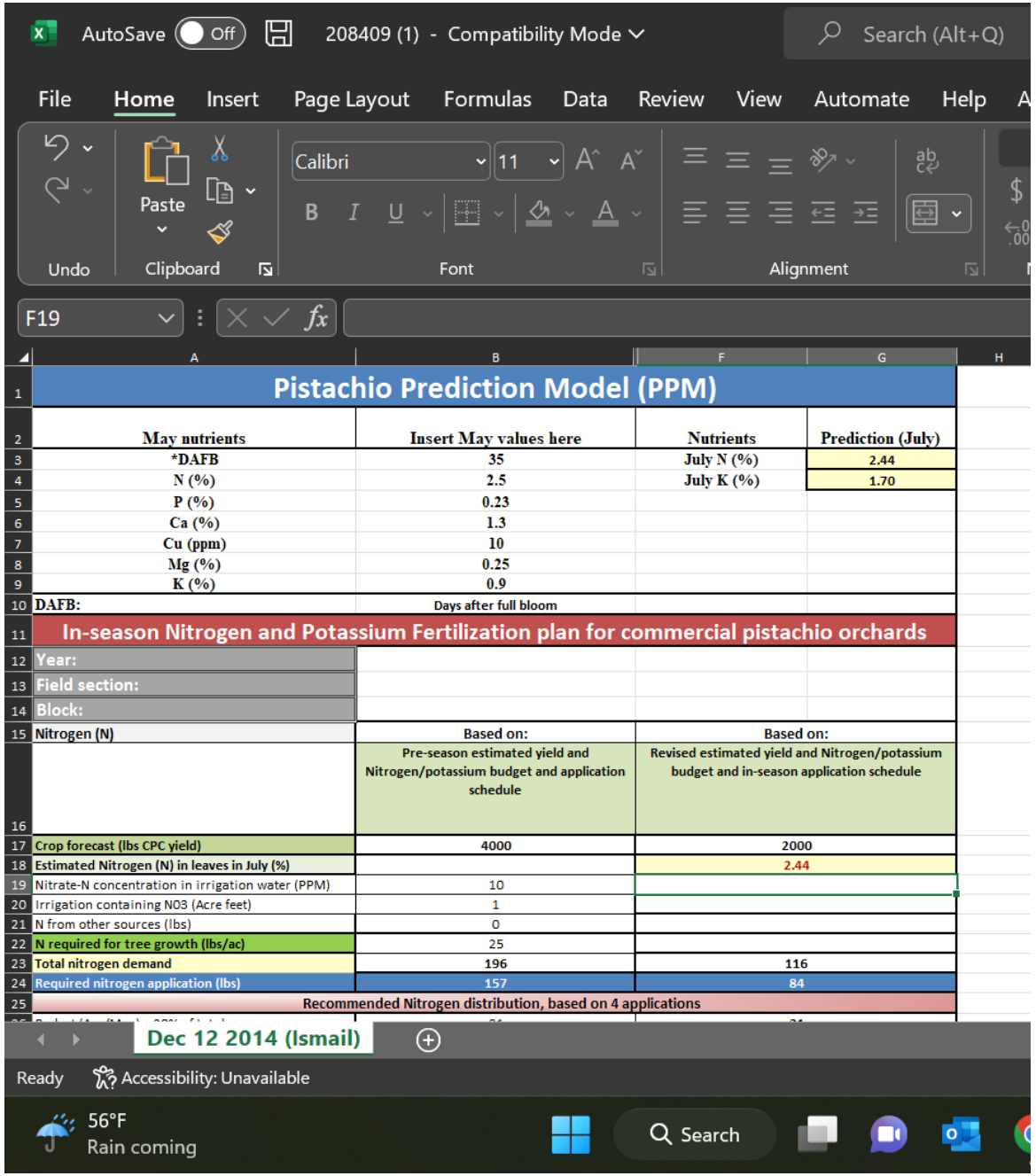
- Yes, some nutrients are known to be useful for certain functions
  - K for stomatal function and WUE as well as an osmolyte
  - Ca for involvement in stress signaling pathways
  - And possibly to mitigate salinity stress (in general)
  - And for displacing sodium on the CEC!
- Some research does show that certain species or genotypes maintain better K+/Na+ ratios
  - Probably more an indicator of tolerance to salinity stress?
- Stress tolerance is underutilized in California agriculture…

How will nutrient management change under drought?

- Reduced yields = reduced nutrient demand
  - Either through stress from lack of water
  - Or stress from increased salinity
- Less potential for nitrogen leaching in the short term
  - Not adjusting nitrogen to reflect reduced yields will load nitrogen in the soil
  - And increase nitrogen leaching when the drought finally ends

How do you manage nutrients during a drought?

- The same way you manage nutrients under normal water years!
- Accurately assess yield
  - If you have a past history under low water years, lean more heavily on those years
- Take into account nitrogen from other sources
  - Increase in well water use may mean more nitrogen
  - Saves money!
- Reassess nitrogen, potassium fertilization based off of leaf tissue samples
  - Several years of drought may compound yield losses
  - Overfertilized last year? Trees could pick it up this year!
  - Saves money!

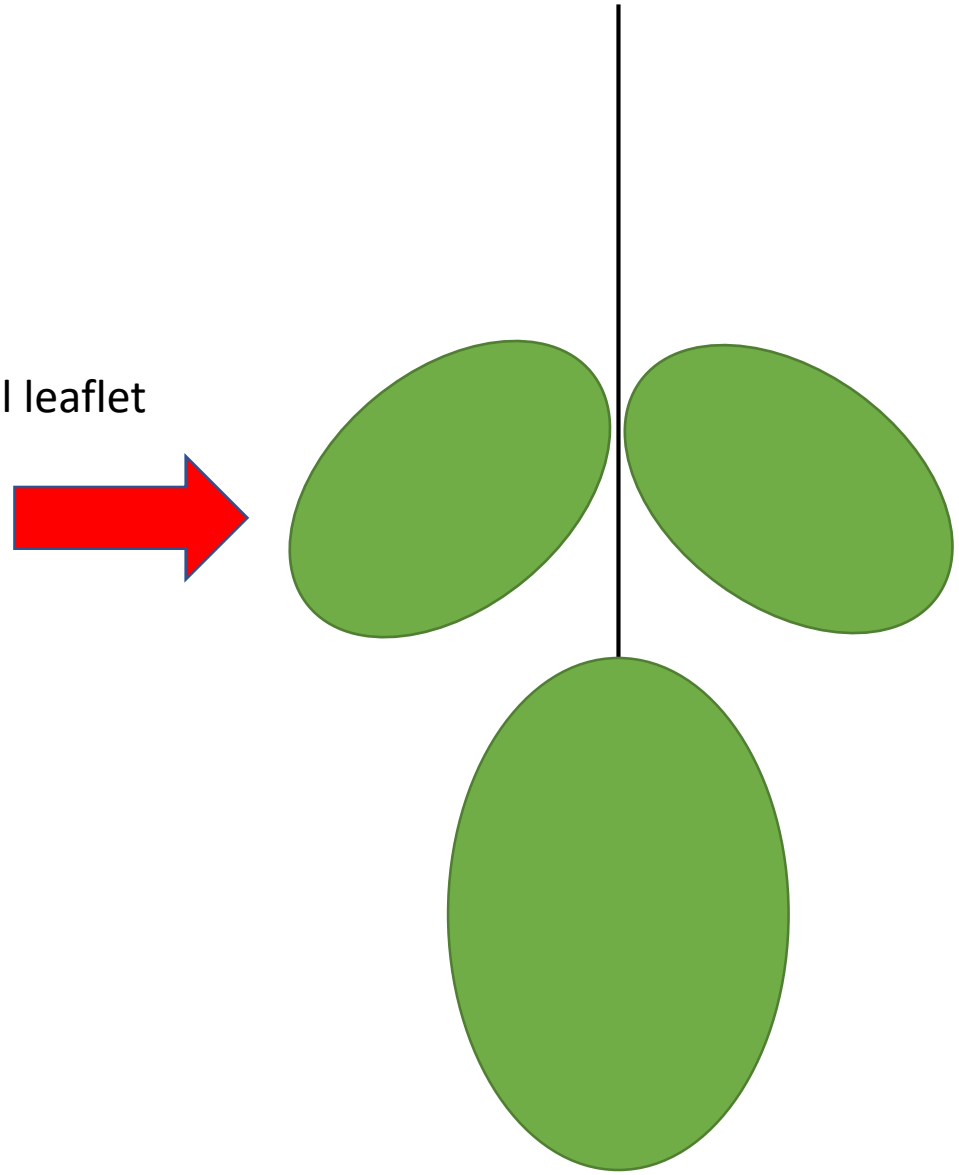


How will nutrient management change under drought?

- Use early season leaf sampling to predict your July leaf tissue levels
- Check your July leaf tissue levels

Early leaf sampling protocol

- Sample pistachio leaves 30-45 days after bloom (May-ish)
- Pull SUB TERMINAL leaflets from non-fruiting sun exposed branches 6-7 feet from the ground
  - Or… however high you can reach!
- Collect leaflets from 10 leaves per tree
- Collect leaflets from AT LEAST 18 trees
- Mix very well
- And then send to your favorite lab



RDI strategies for dealing with insufficient water

Date	Applied Water					
	Potential ETc in period	36 inches	30 inches	24 inches	18 inches	12 inches
		%ETc	%ETc	%ETc	%ETc	%ETc
Apr 16-30	1.3	100	50	50	25	10
May 1-15	2.3	100	50	50	25	10
May 16-31	3.6	50	25	25	10	10
Jun 1-15	4.8	50	25	25	10	10
Jun 16-30	5.4	50	25	25	10	10
Jul 1-15	5.0	100	100	75	75	10
Jul 16-31	4.9	100	100	75	75	50
Aug 1-15	4.9	100	100	75	75	50
Aug 6-31	3.9	100	100	75	75	50
Sep 1-15	3.3	100	100	75	75	50
Sep 16-30	2.2	100	25	25	10	10
Oct 1-15	1.4	100	25	25	10	10
Oct 16-31	0.7	100	25	25	10	10
Nov 1-15	0.4	100	25	25	10	10

Adapted from the Pistachio Production Manual

Date	Applied Water (does not include rainfall)					
	Potential ETc in period	36 inches	30 inches	24 inches	18 inches	12 inches
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Research indicates normal yields

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Thank you!

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