Organic Nutrient Management in Olive Orchards

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UC Davis Olive Center Organic Management Course

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Outline

- Nutrient management principles
- Appropriate (organic) sources, rate, placement, timing
- Diagnostics & assessments
- Organic topics: soil organic matter, soil health, etc.

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Nutrient Management

- Which nutrients to olive trees need?

Nutrient Management

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<u>Macronutrients</u>
(need large amount)
Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Magnesium

<u>Micronutrients</u>
(need small amount)
Iron
Manganese
Copper
Zinc
Molybdenum
Boron
Chloride
Nickel

Nutrient Management

- Which nutrients to olive trees need?

nutrient uptake

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(need large amount)
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Micronutrients
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Nutrient Management

- Law of the Minimum
    - If one of the essential elements is low, plant functioning and yield will be low until that deficiency is lifted

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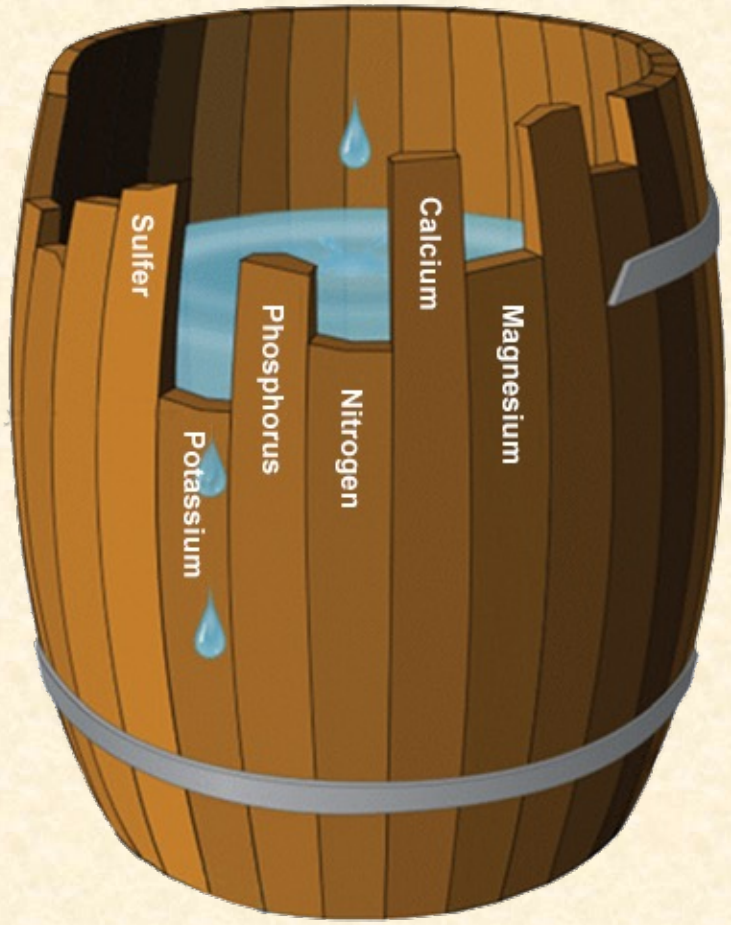
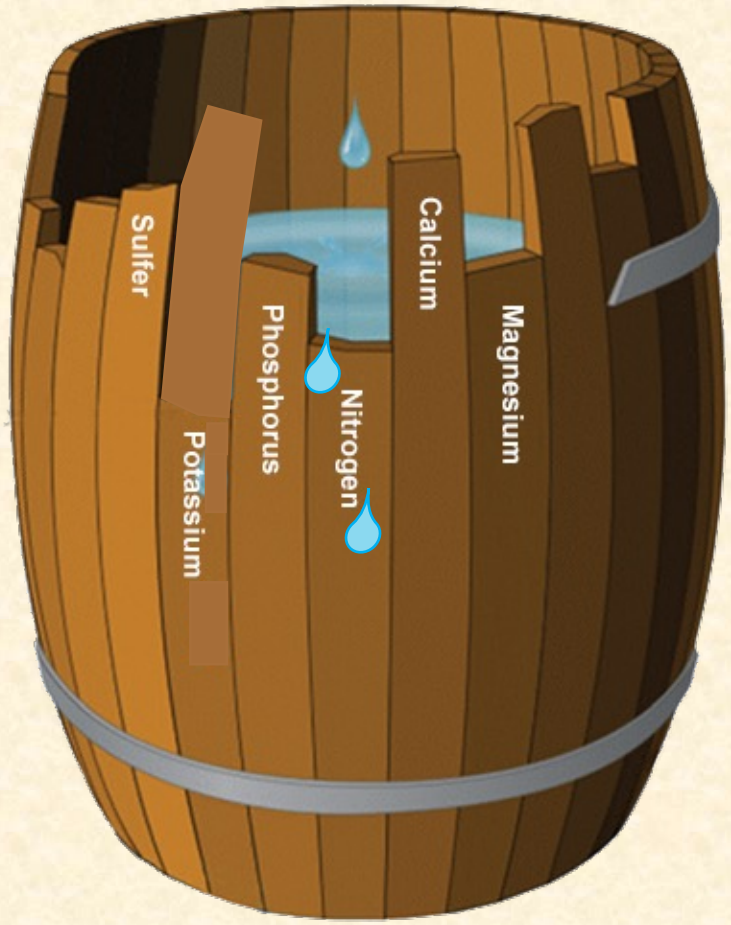
  - Barrel metaphor: lowest stave represents the most limiting nutrient



Nutrient Management

- Law of the Minimum
  - If one of the essential elements is low, plant functioning and yield will be low until that deficiency is lifted
  - Barrel metaphor: lowest stave represents the most limiting nutrient
  - Supplying the most limiting nutrient lifts the yield potential to the next most limiting factor (sometimes, it's water)



Nutrient Management

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- Nutrient management decisions impact
  - Crop health & yield
  - Soil stability, erosion, microbes, nutrient cycling
  - Agroecosystem health & regional environment
  - Groundwater quality & human health
  - Greenhouse gas emissions

Nutrient Management

- Nutrient budget approach
  - Replace amount of nutrients exported at harvest
  - Maintain optimum status of nutrients for plant function & yield

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Nutrient Management

- Nutrient use efficiency: what percentage of the applied nutrients are actually taken up and used by the crop?

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Nutrient Management

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- Goals:
  - Supply sufficient nutrients to meet crop needs & optimize plant function
  - Minimize environmental impacts
  - Minimize off-farm inputs & integrate recycled biomass when possible
  - Be economically efficient

Nutrient Management

- Classic nutrient management focuses on the appropriate
  - Source
  - Rate
  - Timing
  - Placement

Nutrient Management

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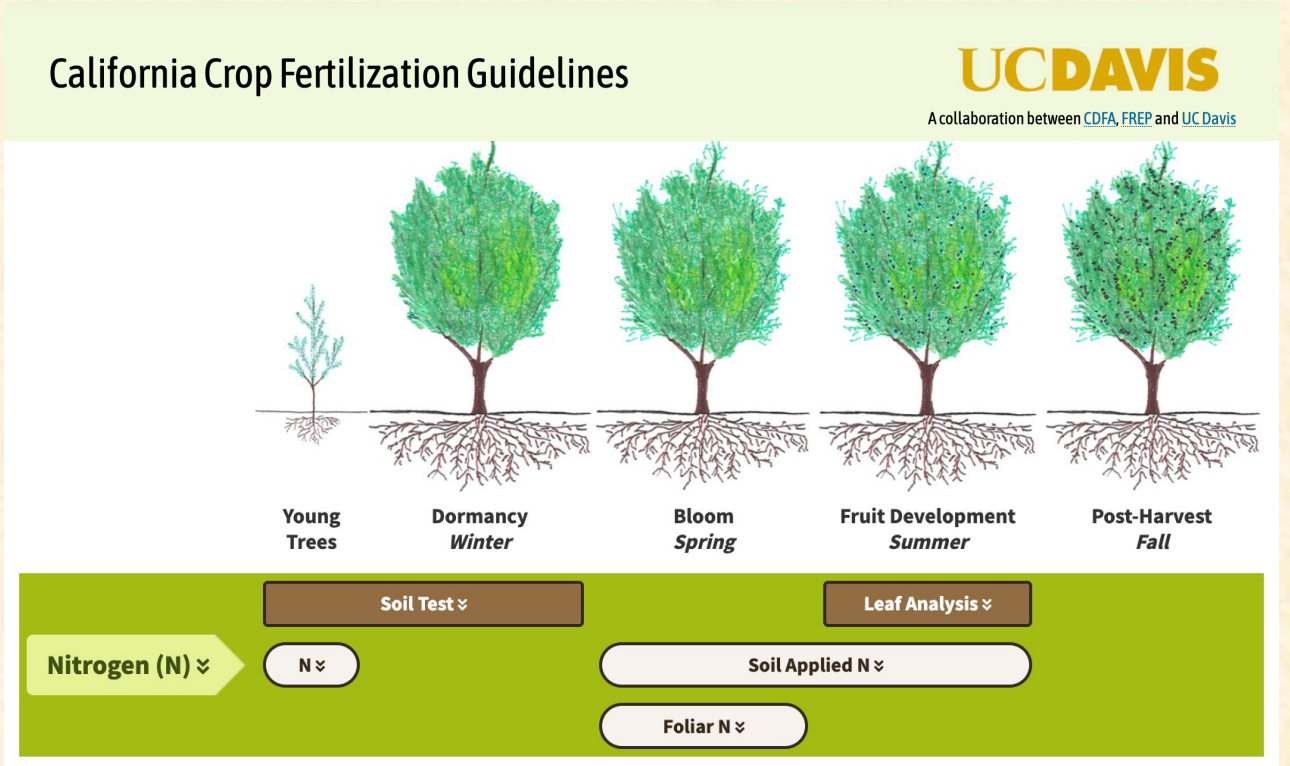
  - Placement

- What is most effective & efficient?

Nutrient Management

- See CDFA FREP's science-based California Crop Fertilization Guidelines

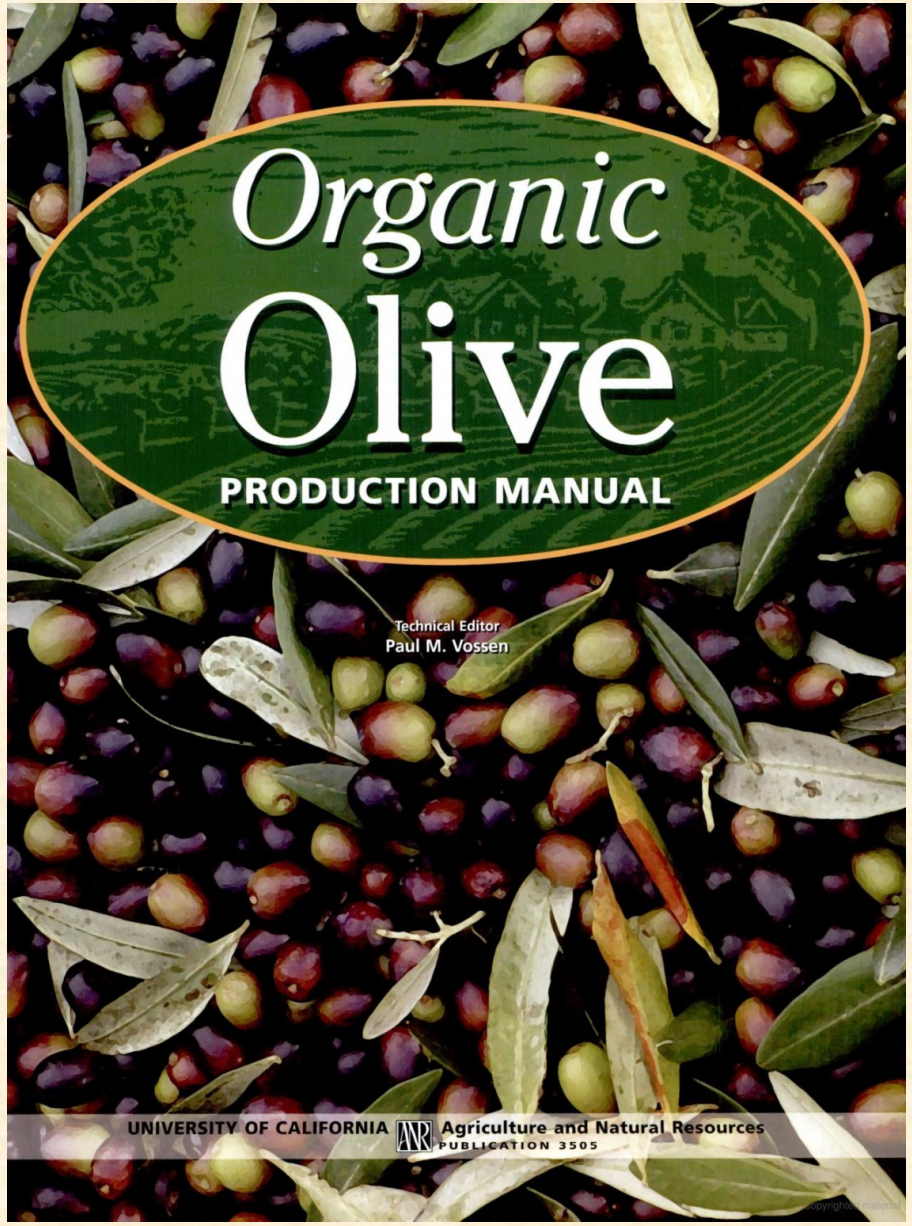


Nutrient Management

- We'll focus on nitrogen, potassium, & boron
  - Historically the most common nutrient deficiencies in commercial CA olive orchards

Nutrient Management

- Olive trees are not heavy feeders
- Tolerate low fertility better than most fruit trees
- Olives are more tolerant of high soil boron levels
- Fertile soils with high nitrogen are not ideal for olives, leads to excessive shoot growth
- Goal: moderate vigor with minimal but sufficient nutrition



Nutrient Management

- But first, how do you know your orchard's nutrient status?

Diagnostics

1) Visual deficiency symptoms
2) Leaf tissue analysis
3) Soil & water analysis

Diagnostics

★ 1) Visual deficiency symptoms ★

2) Leaf tissue analysis

3) Soil & water analysis

Diagnostics

- Nitrogen deficiency symptoms
  - small yellow (chlorotic) leaves
  - poor shoot growth <8 inches
  - shoot dieback
  - low fruit set, light crop
  - defoliation
  - tree stunting

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  - small yellow (chlorotic) leaves
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→ chlorosis often occurs in winter when N is not readily available, but might disappear when root activity increases in early summer

Diagnostics

- Potassium deficiency symptoms
  - dead leaf tips or margins especially in older leaves
  - light green leaves, especially basal leaves
  - defoliation, dead areas in canopy
  - twig dieback
  - short internodes
  - small fruit, less crop
  - whole tree has a weeping willow appearance, weak branches

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(might be transient in winter/spring)

Diagnostics

- Boron deficiency symptoms
  - dead leaf tips with a yellow band, green base
  - twig & limb dieback
  - excessive short branched growth
  - rough bark
  - low fruit set
  - premature fruit drop
  - defective & misshapen fruit

Diagnostics

1) Visual symptoms
2) ☆ Tissue analysis ☆
3) Soil & water analysis

Olive Leaf Sampling for Nutrient Status

- Leaf tissue analysis tells us concentration of nutrients in olive leaves
- A direct assessment of tree nutrient status
- Compare results to existing standards for olive (critical values)
- Compare results from same trees over time to understand changes

Olive Leaf Sampling for Nutrient Status

- Leaf sampling procedure:
  - take samples in July (stable concentrations)
  - do not take samples from trees that have received foliar nutrients within 1 week prior
  - divide orchard into blocks based on soil type, tree age, variety, management
  - label each bag with location/block info
  - flag the trees that you sample from so you can come back in the future

Olive Leaf Sampling for Nutrient Status

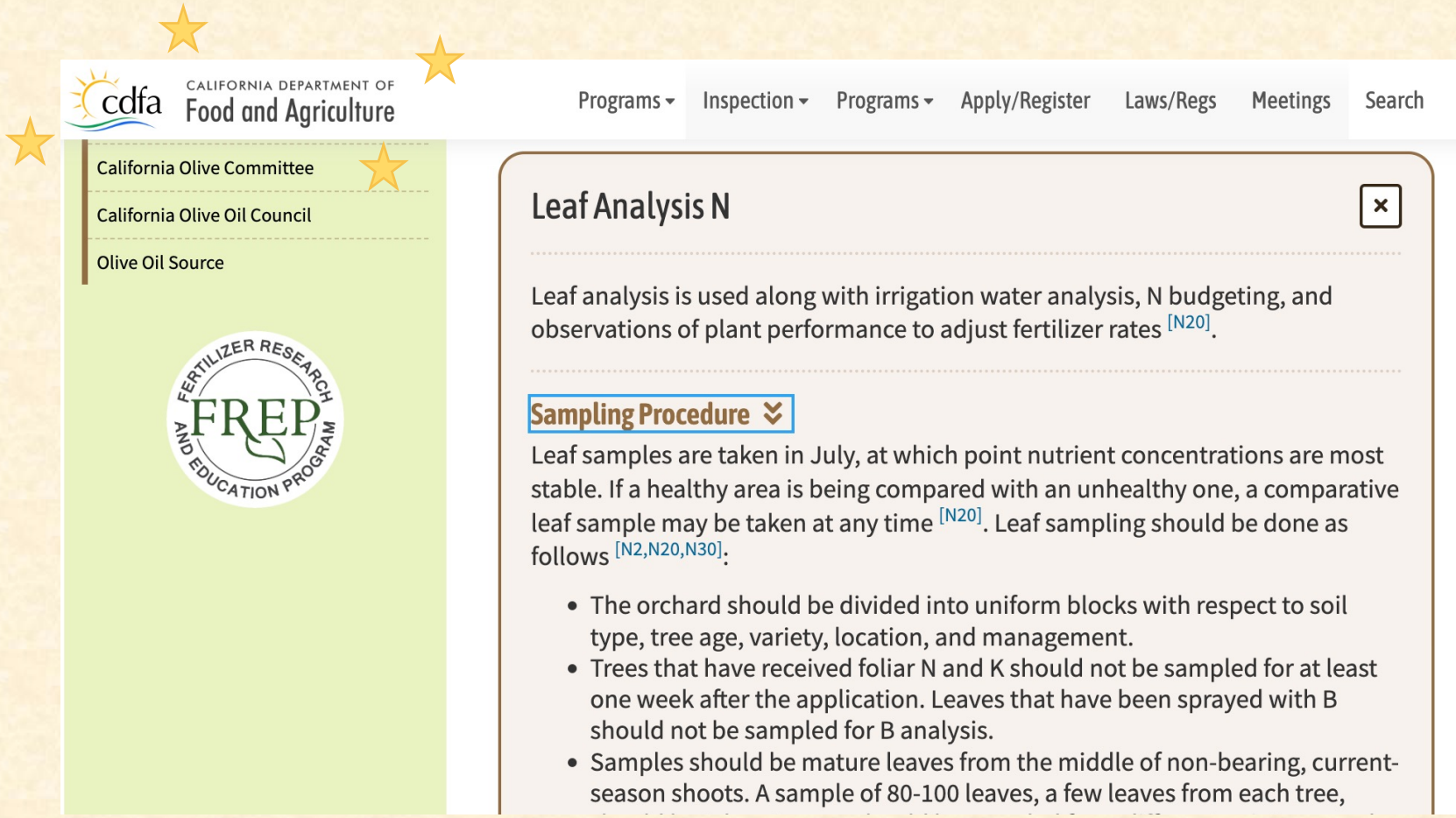
- Leaf sampling procedure:
  - collect 100 leaves total per block, taking several leaves from each tree
  - collect leaves at the same height from around the tree canopy
  - choose mature leaves from the middle of nonbearing current-season shoots
  - if boron will be tested, wash leaves with tap water and a little detergent (otherwise no need to wash)

Olive Leaf Sampling for Nutrient Status

- Leaf sampling procedure:
  - send to the lab for analysis ASAP
  - if a delay is expected, refrigerate samples until they can be sent

Olive Leaf Sampling for Nutrient Status

- Protocol: see CDFA FREP website for olives



Olive Leaf Sampling for Nutrient Status

- Sufficiency ranges for olives

Interpretation of Results

Critical nutrient levels in July olive leaf samples [N7].

Nutrient	Deficient	Sufficient	Excessive
N (%)	<1.4	1.5-2.0	>2.0
P (%)	<0.1	0.1-0.3	
K (%)	<0.4	>0.8	
B (ppm)	14	19-150	>185

Olive Leaf Sampling for Nutrient Status

- Avoid excess nitrogen
  - leaf N tests should be interpreted together with observations of tree vigor & performance
  - optimal: 8-20 inches shoot growth per year with healthy bloom & fruit set

Olive Leaf Sampling for Nutrient Status

- Avoid excess nitrogen
  - when N is sufficient, don’t add any fertilizer N the next year
  - excess N can lead to decreased fruit set and oil quality

Olive Leaf Sampling for Nutrient Status

- Potassium notes
  - K deficiency can occur before visual leaf symptoms appear
  - keep an eye on K status especially in sandy soils

Nutrient	Deficient	Sufficient	Excessive
K (%)	<0.4	>0.8	

Olive Leaf Sampling for Nutrient Status

- Boron notes
  - Deficiency symptoms tend to be well correlated with low leaf B status

Nutrient	Deficient	Sufficient	Excessive
B (ppm)	14	19-150	>185

Diagnostics

1) Visual symptoms
2) Tissue analysis
3) Soil & water analysis ☆

Soil & Water Sampling

- Helps diagnose issues prior to planting and over time
- Understand nutrient availability & constraints
- Provides complementary info with leaf sampling, a fuller picture
- Helps guide fertilizer & amendment applications

Soil & Water Sampling

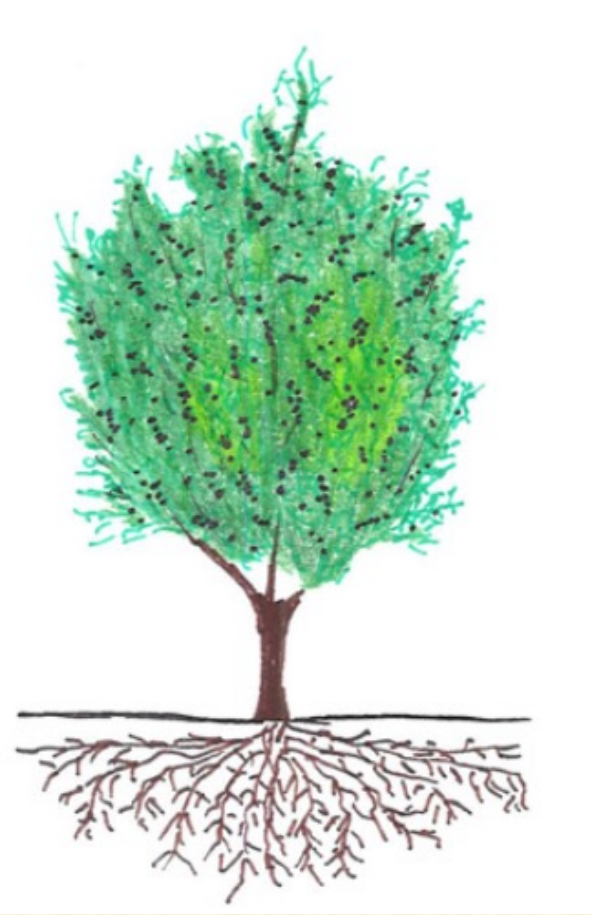
- Soil: pH, EC, CEC, available nutrients (Ca, Mg, Na, B, etc.)
- Water: salts concentrations, nitrate-N

Soil & Water Sampling

- Ideal soil pH range for olives is ~6.5-8.5
- Olives have relatively high tolerance for saline conditions

Soil & Water Sampling

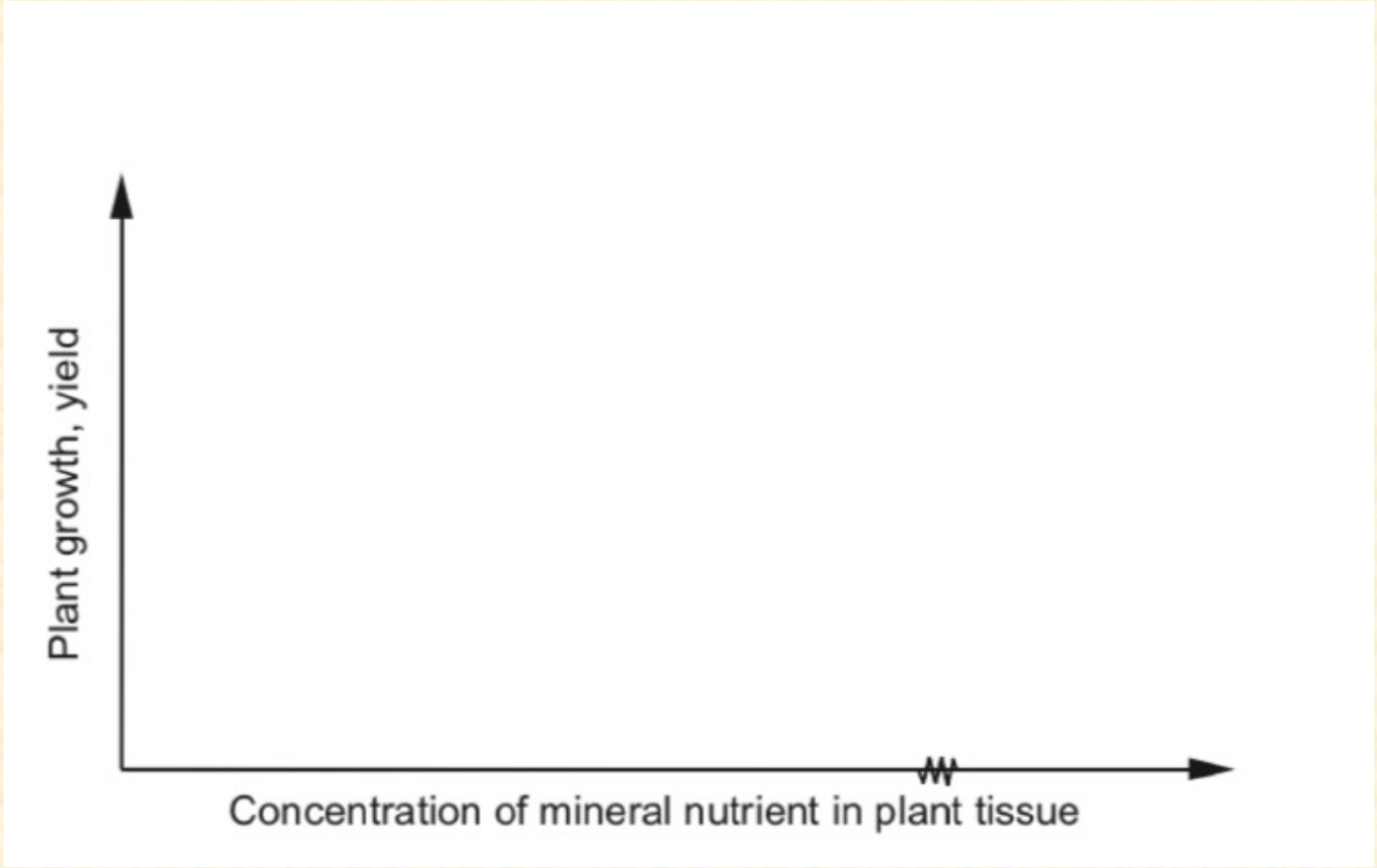
- Nitrogen
  - Soil nitrogen levels often don’t correlate well with plant nitrogen status
  - Nitrate in irrigated groundwater can contribute N to tree’s nutrient requirement



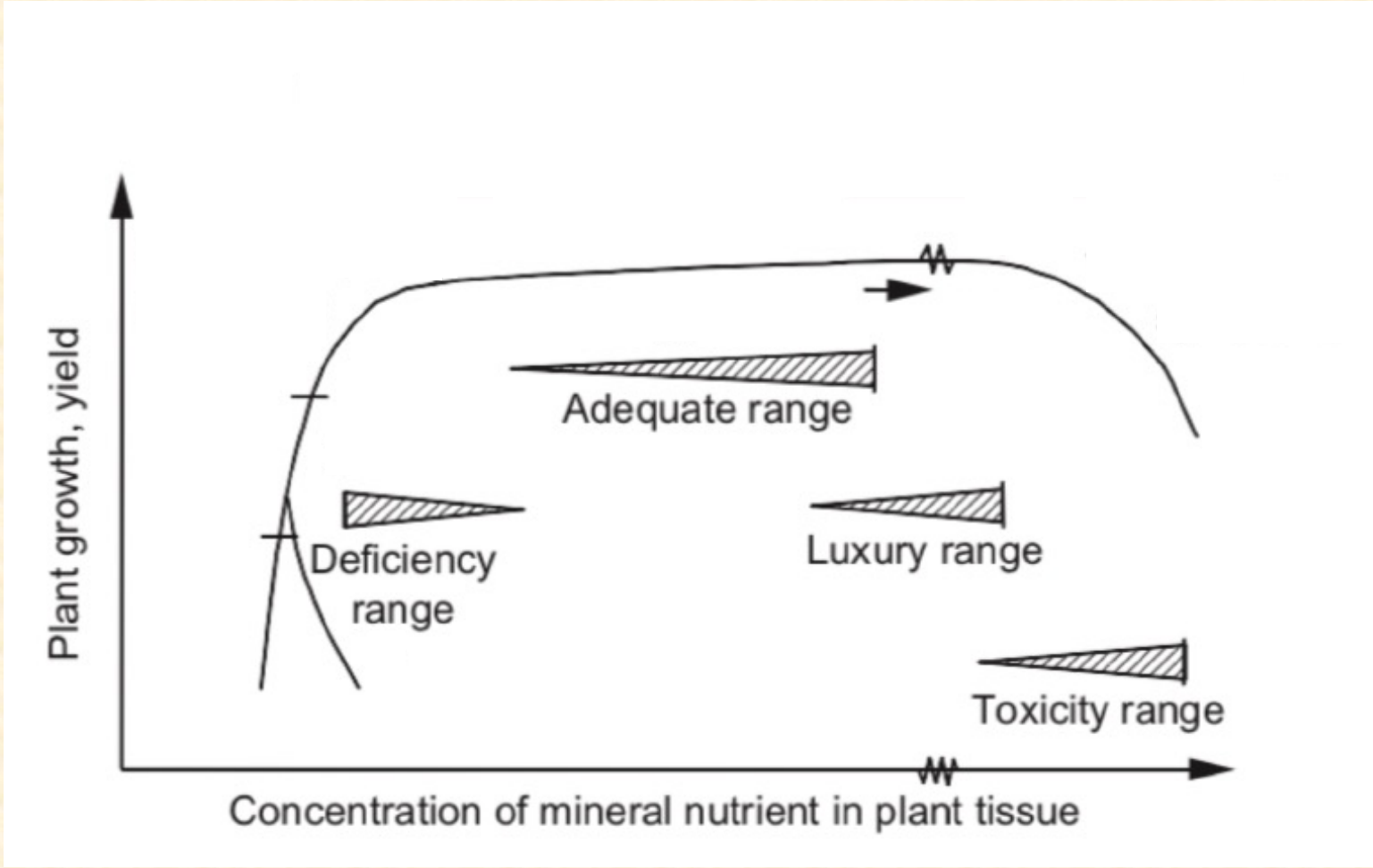
Nutrient Management

1) Rate
2) Placement
3) Timing
4) Source

Rate

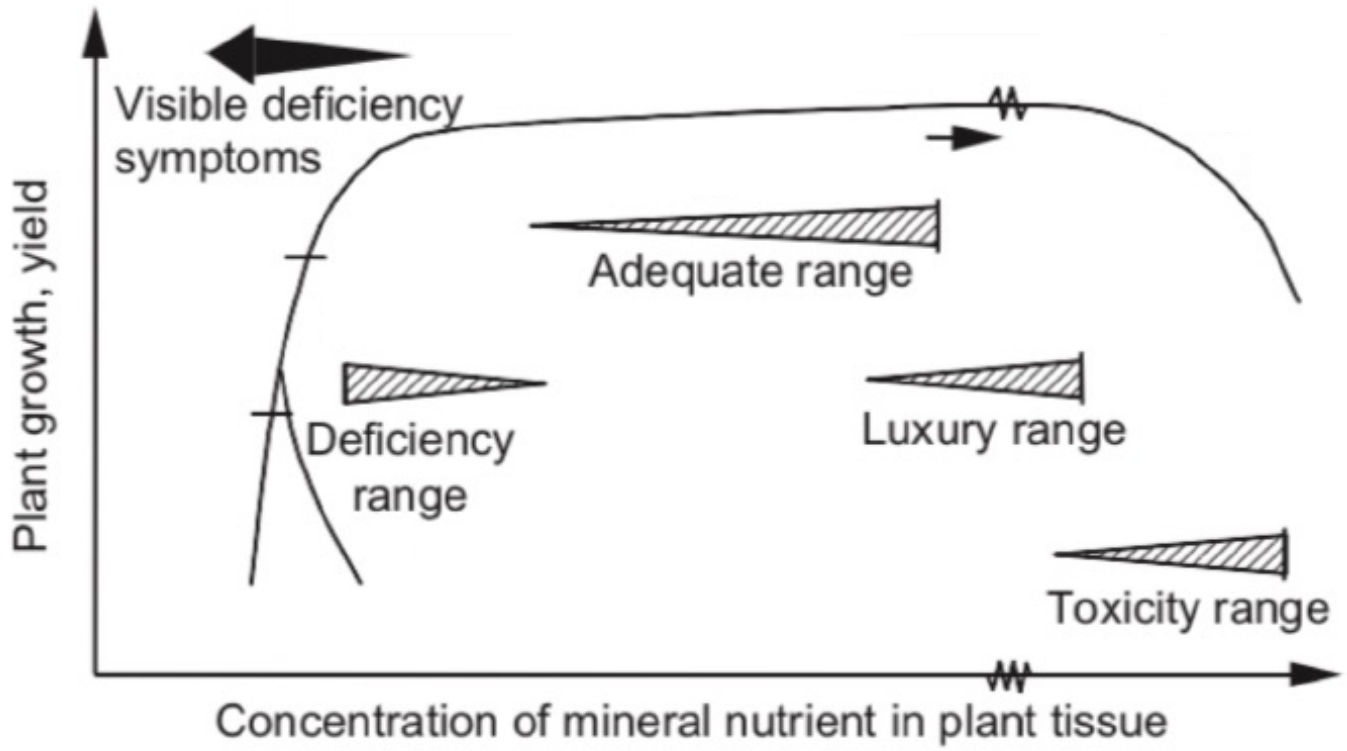

Plant growth, yield
Concentration of mineral nutrient in plant tissue

Rate

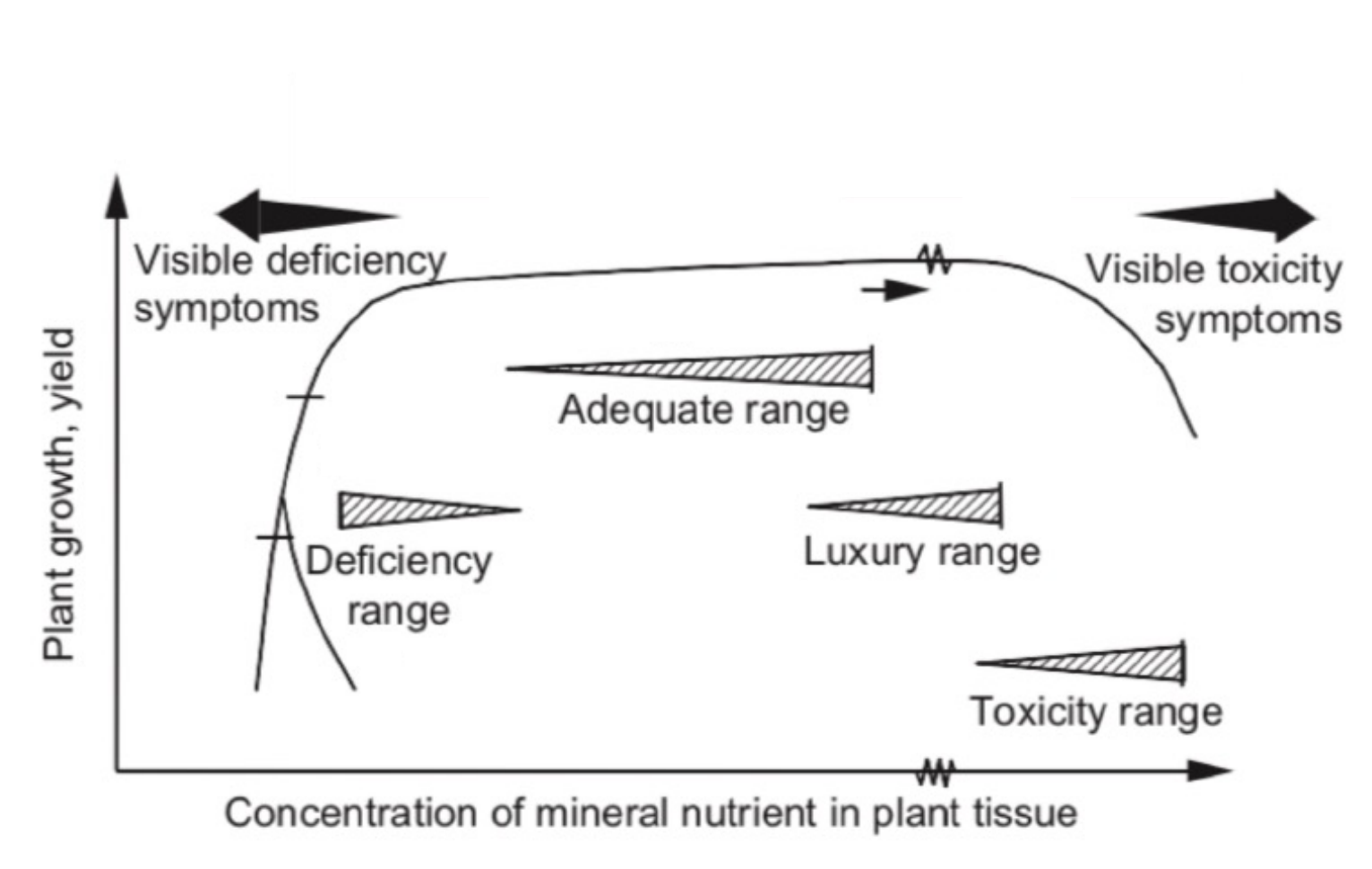

Plant growth, yield
Adequate range
Deficiency range
Luxury range
Toxicity range
Concentration of mineral nutrient in plant tissue

Rate

Deficiencies impair plant functioning & production



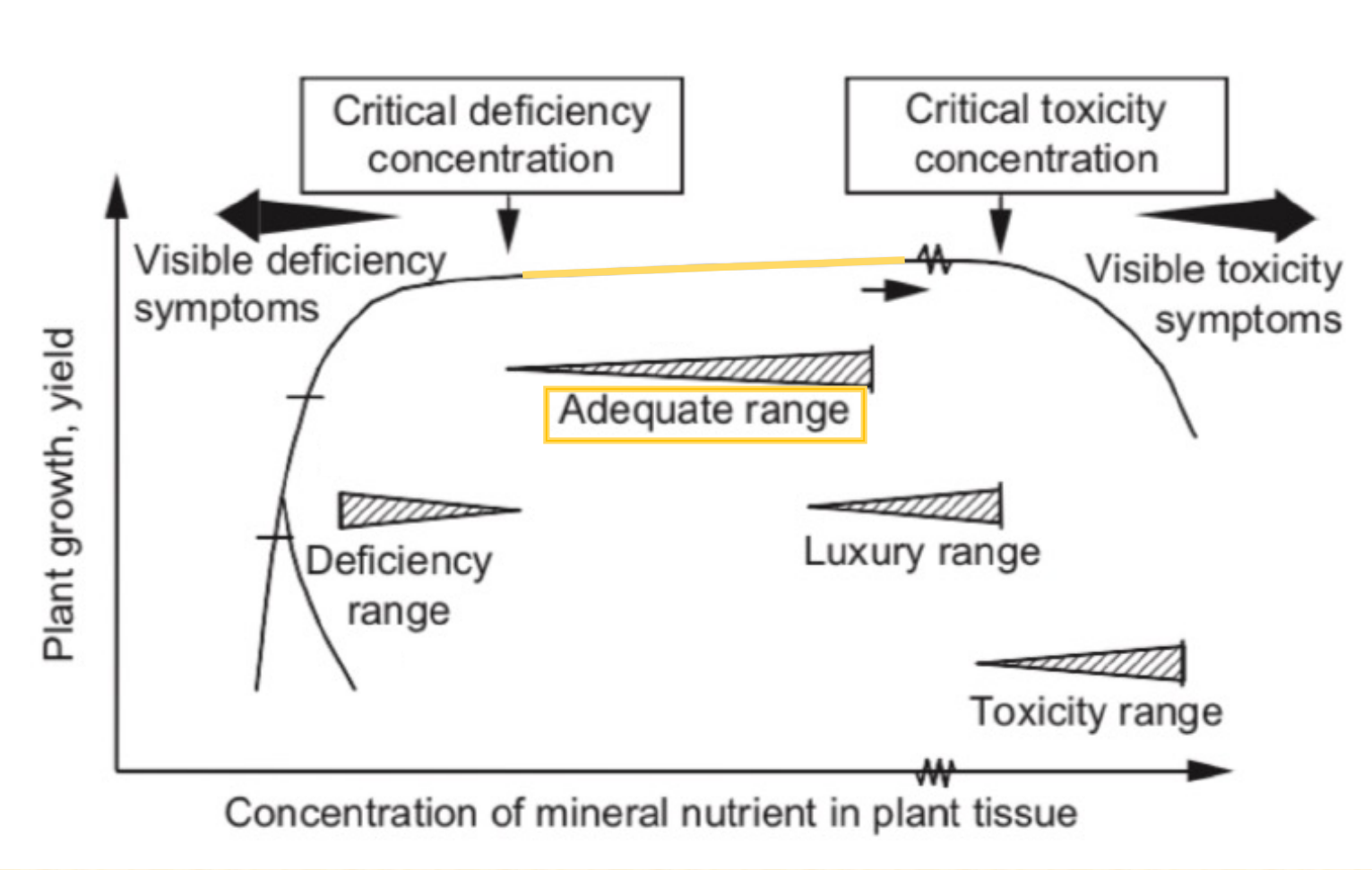
Rate



Over fertilizing can lead to

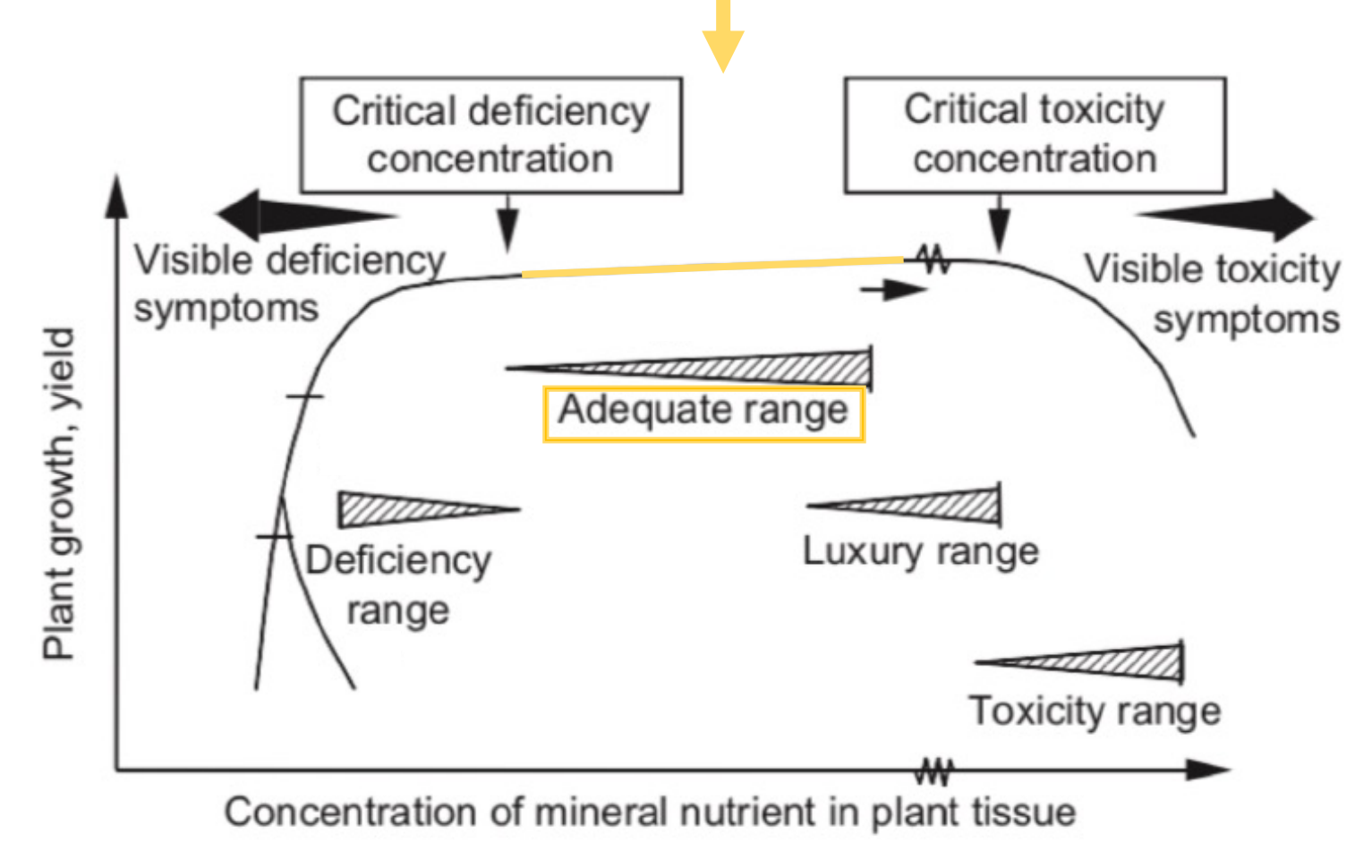
- excess vigor
- reduced yields & quality
- environmental damage
- wasted money

Rate

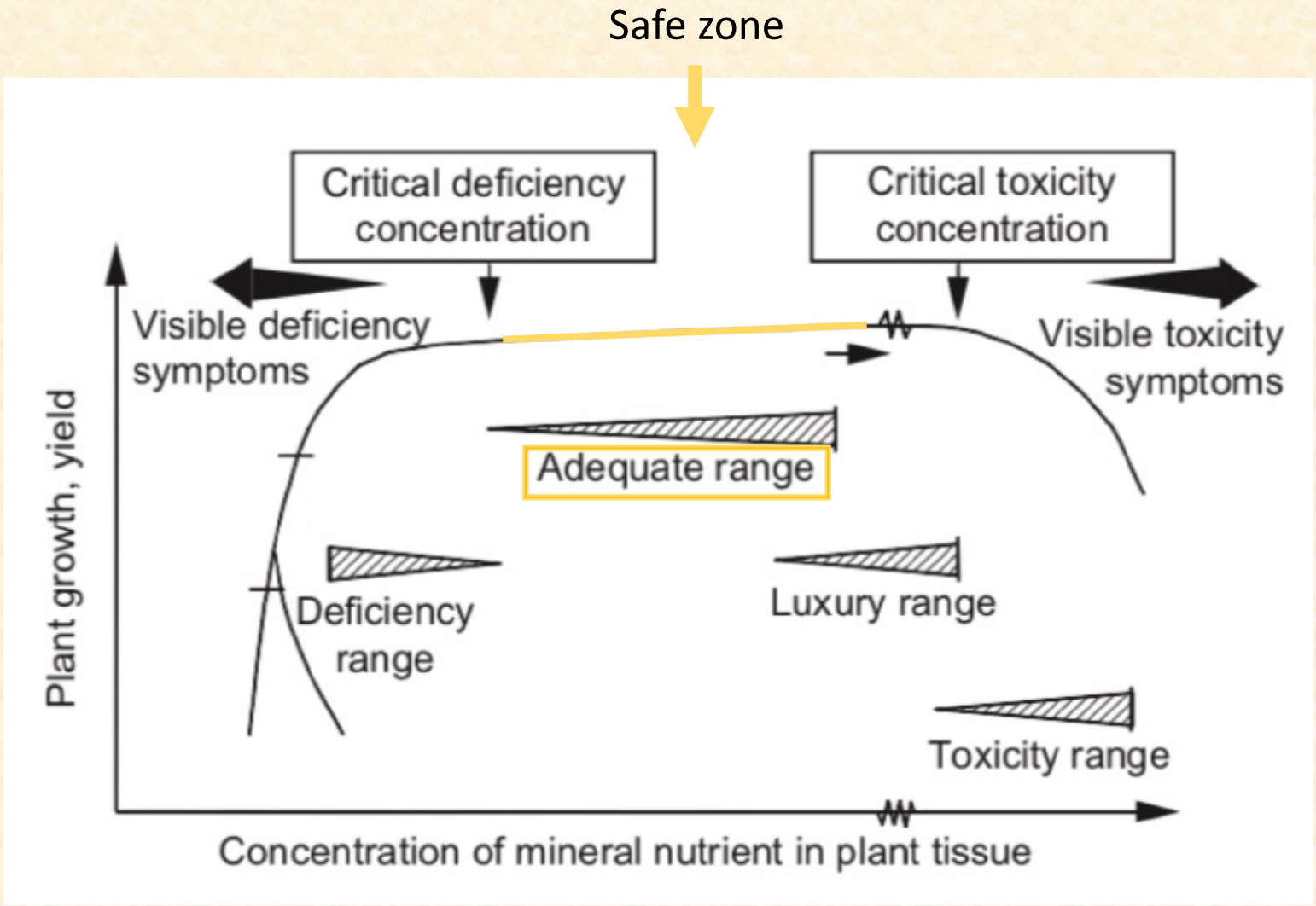

Critical deficiency concentration
Critical toxicity concentration
Visible deficiency symptoms
Visible toxicity symptoms
Adequate range
Deficiency range
Luxury range
Toxicity range
Plant growth, yield
Concentration of mineral nutrient in plant tissue

Rate

Diagnostic tools help keep tree nutrient status in the safe range



Rate


Safe zone
Critical deficiency concentration
Critical toxicity concentration
Visible deficiency symptoms
Visible toxicity symptoms
Adequate range
Deficiency range
Luxury range
Toxicity range
Plant growth, yield
Concentration of mineral nutrient in plant tissue

Rate

- Nutrient budget approach: replace the estimated amount removed
- Big differences: irrigated vs. non-irrigated systems, low input vs. high input

Rate

- Amount to apply depends on:
  - plant nutrient status (leaf tissue sampling)
  - nutrient concentration of chosen source
  - nutrient release rate from source
- For young trees: multiply canopy percentage by the fertilizer rate provided for a mature tree

Rate – General Recommendations

- Nitrogen
  - Apply ~40-100 lb/ac N as needed annually based on leaf tissue status
  - Might not need to be applied every year
  - Goal is ~8-20 inches shoot growth

Rate – General Recommendations

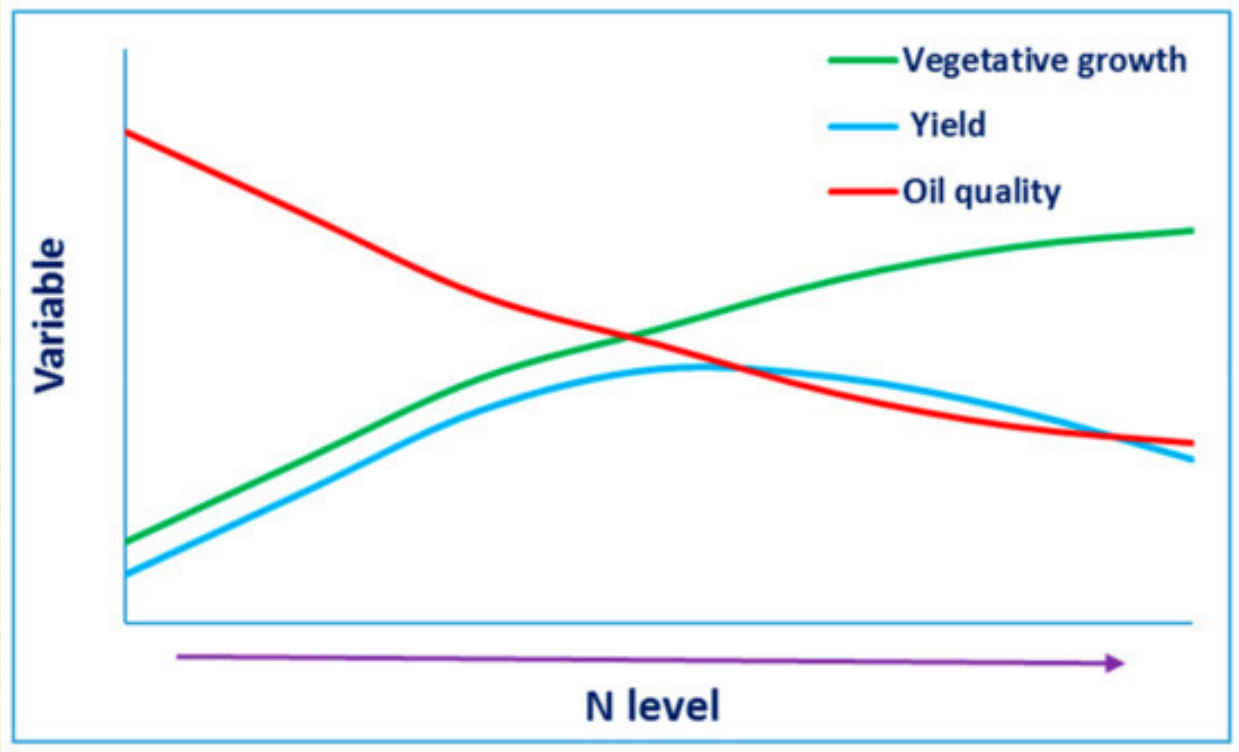
- Potassium
  - Apply as needed based on leaf tissue status (deficiencies are rare)
  - 10-20 lb potassium sulfate per tree can help correct deficiency

Rate – General Recommendations

- Boron
  - Apply as needed based on leaf tissue status (deficiencies are rare)
  - Broadcast ~25-50 lb/ac of 14-20% U.S. Borax material (OMRI listed) on soil surface (½ - 1 lb per tree)
  - Or foliar Borax sprays: 7 oz per 100 gal water
  - Beware of over-applying & toxicity damage

Avoiding Over-Fertilizing

- Common mistake
- If growth isn't adequate, make sure you know why before you take action
- Could be inadequate water or weed control



The response of olive trees to nitrogen fertilization. Zipori et al. 2020

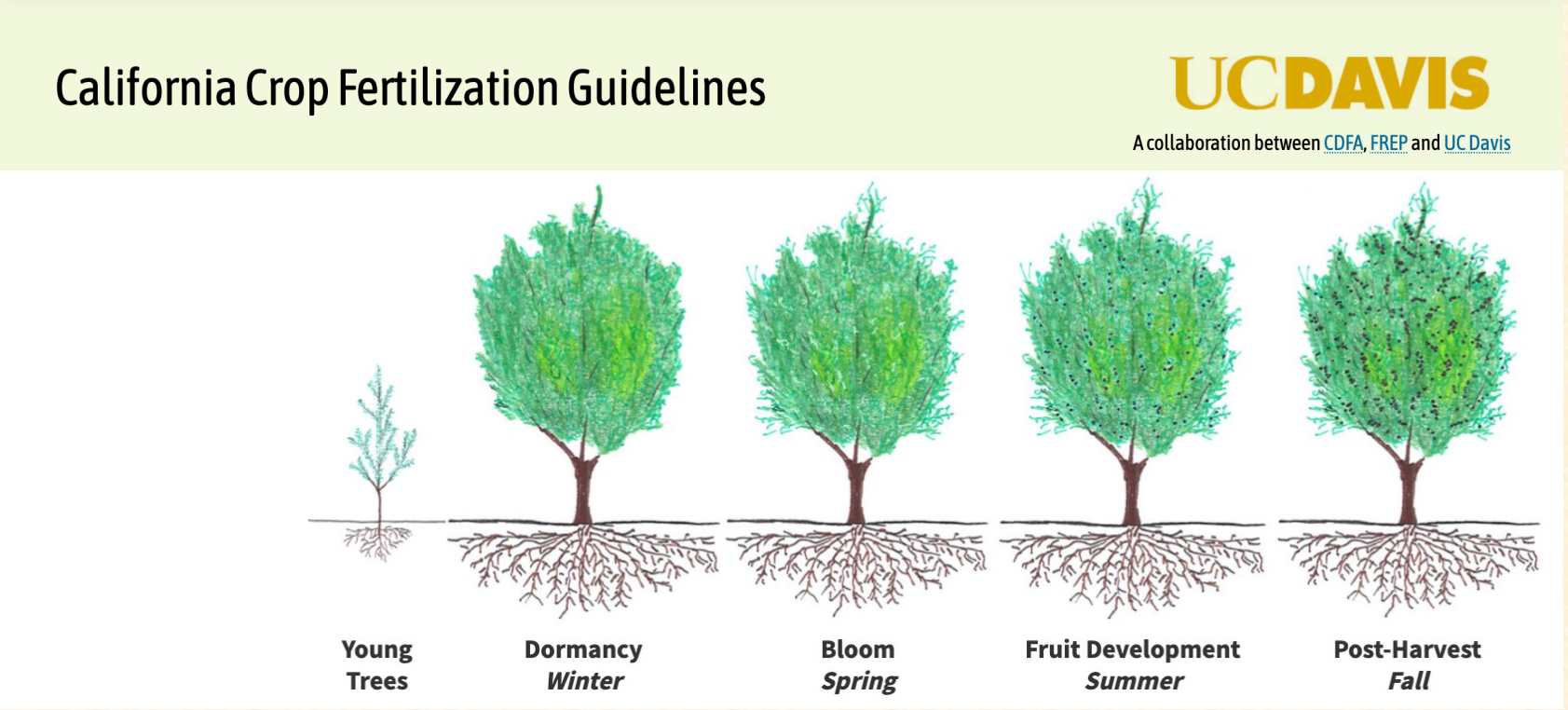
Placement

- Above roots in or along the side of the tree row
- Within irrigation area where water will solubilize nutrients into rootzone
- Olive trees have shallow, spreading root systems

Photos from Joe Connell.

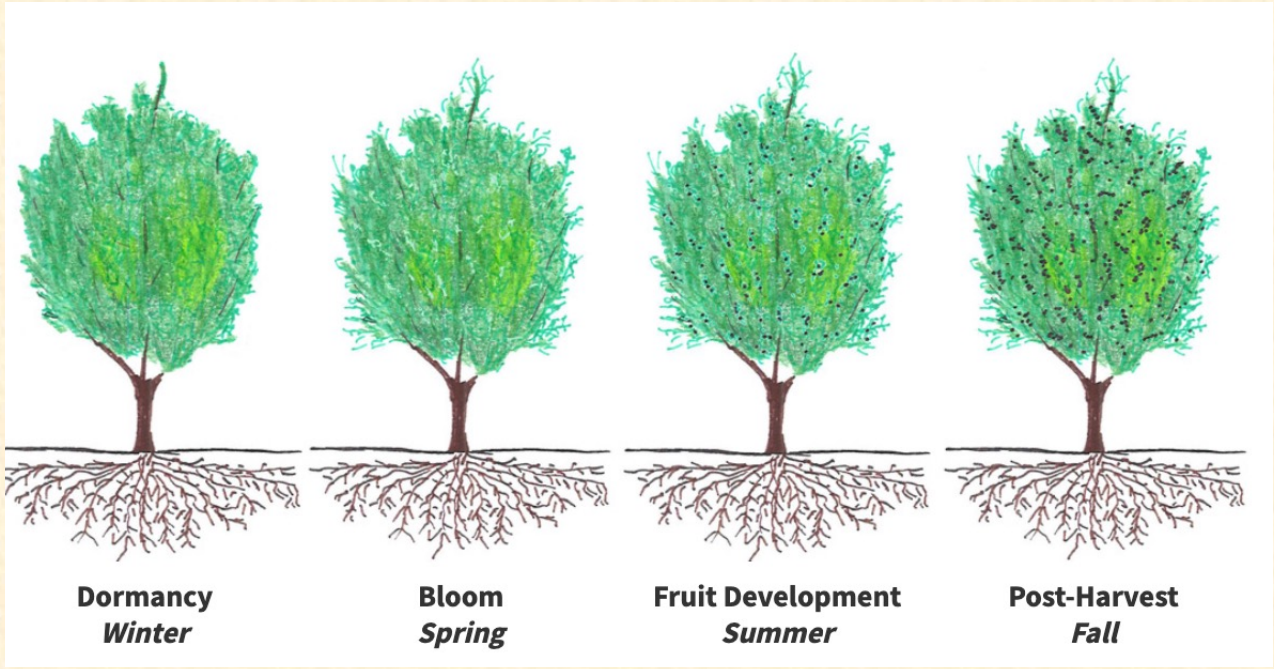
Timing

- Timing of nutrient availability should match the timing of crop demand



Timing

- Olive phenology: when do they need nutrients?
  - Mainly spring & summer
  - Ensure N is in root zone right before uptake in early spring, just ahead of shoot growth & bloom
  - Apply K & B in winter so rain helps move it into rootzone for spring uptake



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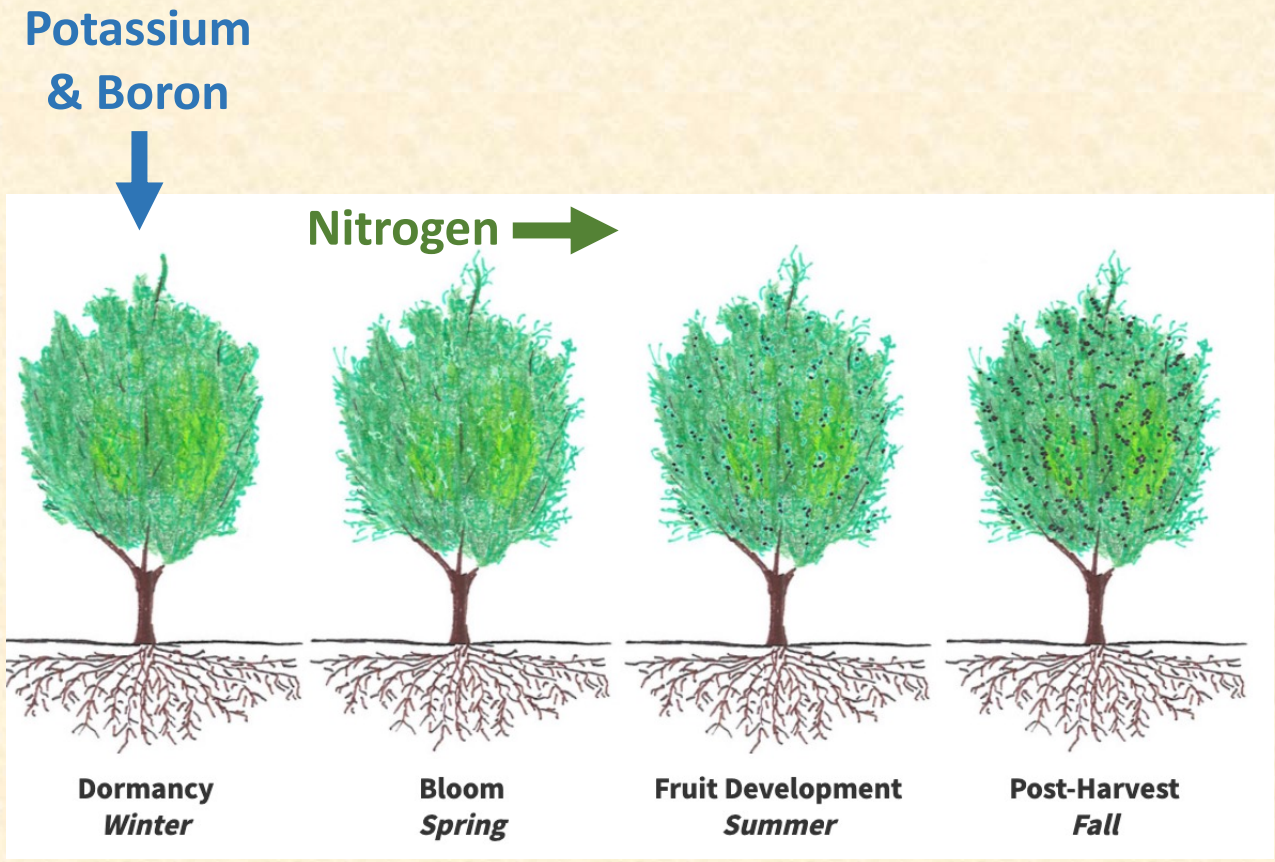


Timing

- Compost Timing
  - Apply compost when 4-7 inches of rainfall is expected so N is moved into soil without being leached or lost in runoff
  - To reduce food safety risks, apply 120 days before harvest

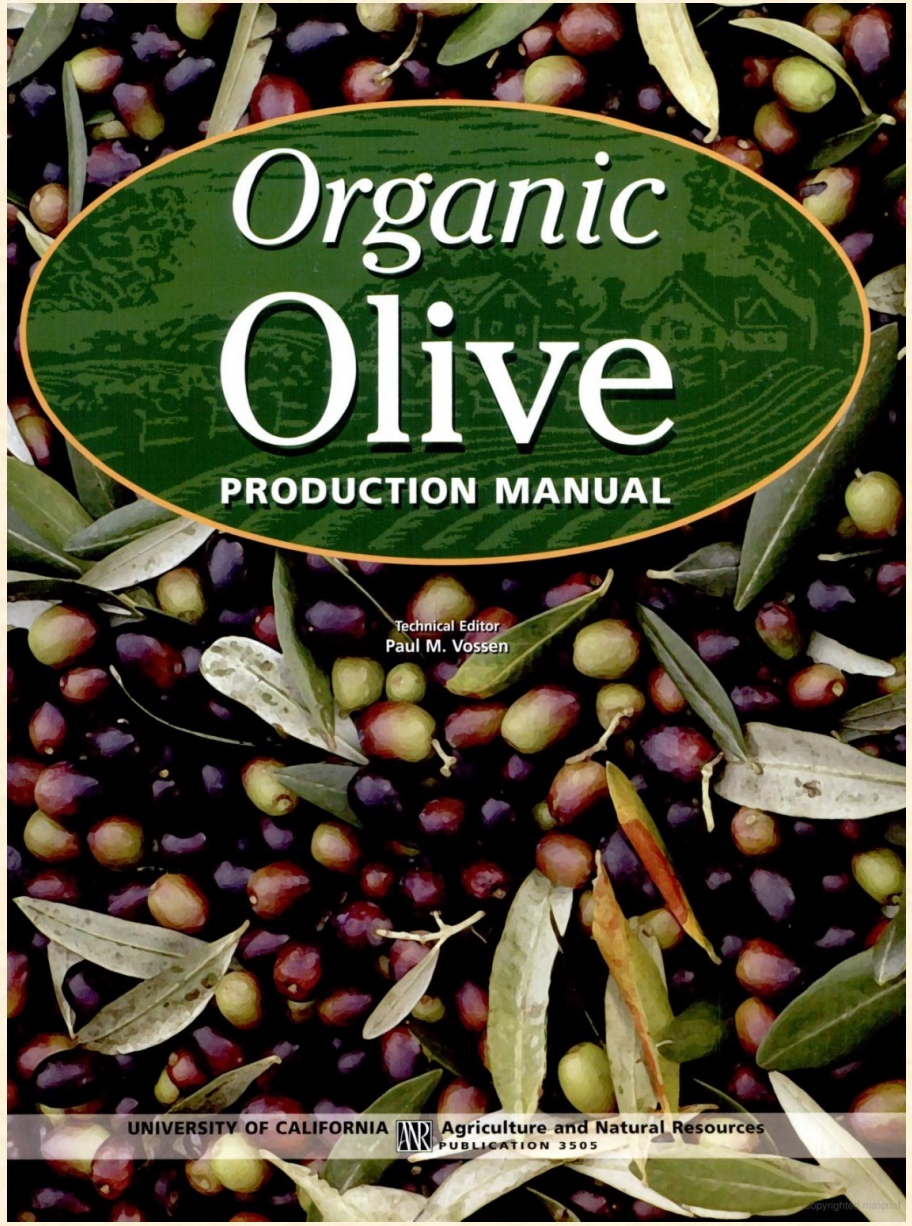
Photo from Joe Connell.

Source

- Comply with USDA certified organic standards, use recognized organic fertilizers
- Check Organic Materials List of products that comply with the law at Organic Materials Review Institute (OMRI)
- Check with your organic certifier to make sure they'll approve the use of your intended product

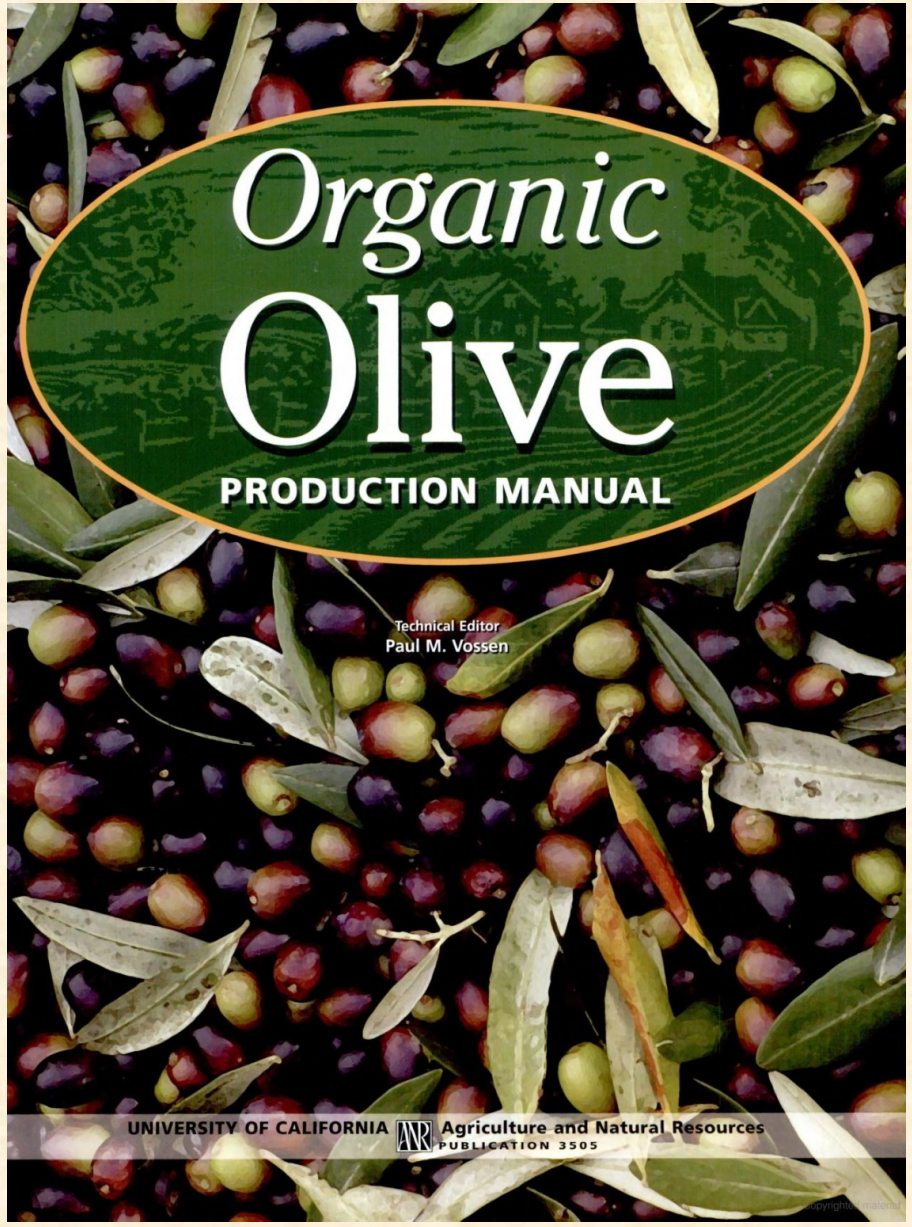
Source

- Examples of organic sources
  - commercial organic fertilizer mixes
  - marine-derived products such as fish meal & kelp dry meal
  - blood/bone/feather meal



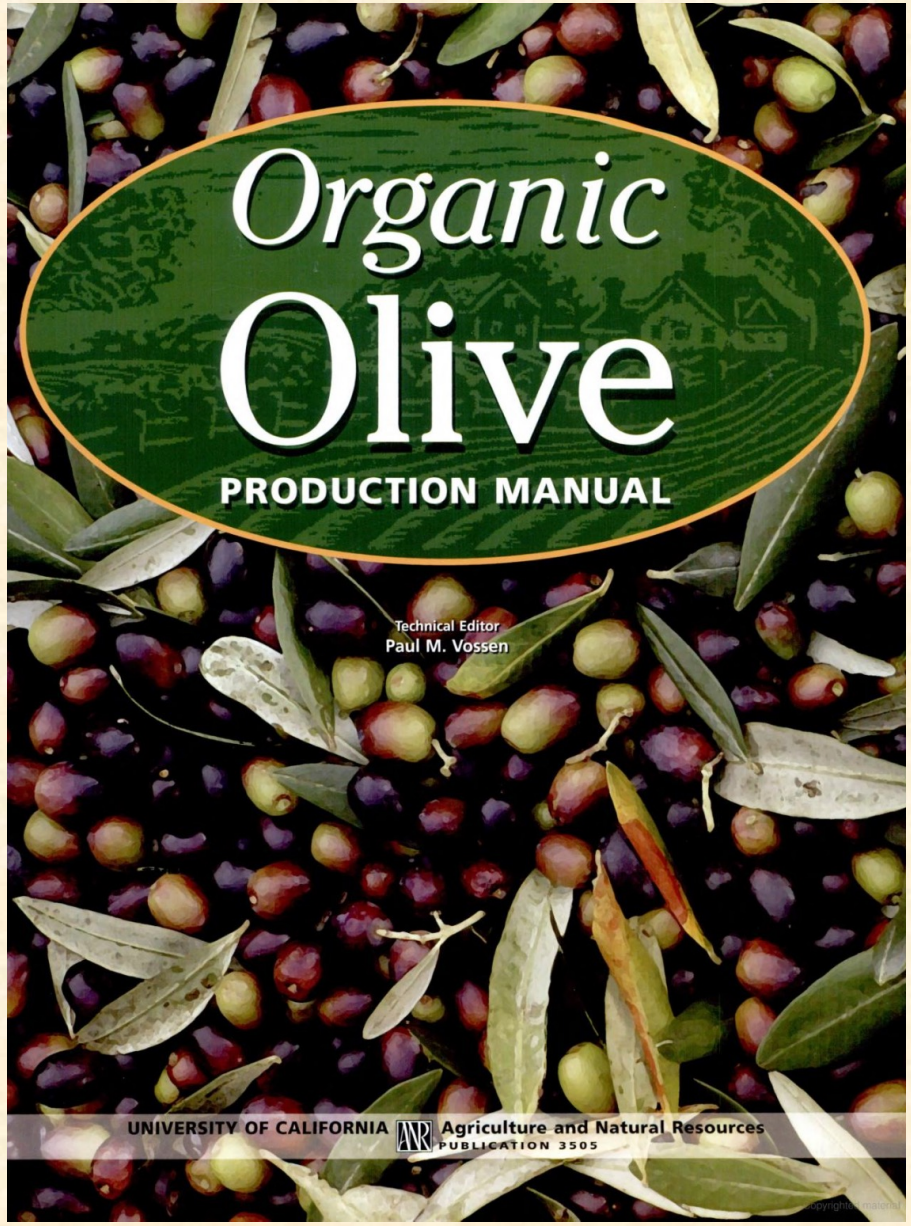
Source

- Examples of organic sources
  - composted manures & green waste
  - nitrogen fixed by legume cover crops
  - nutrients from recycled orchard biomass: mowed clippings, pruned & chipped branches, composted pomace, etc.



Source

- When comparing fertilizer options, consider:
  - nutrient concentrations
  - nutrient release rates
  - equipment needed for application
  - price
  - local availability



Organic Sources – Examples & Estimates

Source	N (%)	P (%)	K (%)
Commercial organic fertilizers	varies – wide range of product options		
Fish meal	10-12	3-4	3-4
Fish emulsion	5-6	1-2	1-2
Kelp dry meal	1	0.2	2.7
Blood meal	10-14	1.0-1.5	0.6-0.8
Bone meal	2-4	22-24	0
Feather meal	10-16	0.2	0.1

Organic Sources – Examples & Estimates

Source	N (%)	P (%)	K (%)
Fresh poultry manure	1.75 – 4.6	1.1 – 3.6	1.5 – 3.3
Composted rice hull / poultry manure	1.7 – 2.0	1.9	2.1
Fresh dairy manure	2.0 - 2.9	0.3 – 0.7	0.3 – 5.8
Composted dairy manure	0.5 - 2.1	0.6	2.4
Composted olive pomace	1.1 – 2.8	0.2 – 1.5	1.1 – 2.4

Composting olive pomace, Italy.
Photo from Joe Connell.

Source

- Organic nitrogen sources
  - Often provide the benefit of slow N release
  - Help build soil organic matter
  - Often more expensive
  - Harder to fine-tune than conventional N
  - Can have more variable N concentration
  - Leaching can happen in winter under heavy rains

Composting operation.
Photos from Joe Connell.

Source

- Potassium
  - Many K fertilizers are mined from natural sources, most are classified as organic
  - Manures and compost contain some K but are highly variable
- Boron: U.S. Borax products are OMRI listed
- Beware of salts in manure-based sources

Composting operation.
Photos from Joe Connell.

Organic Nutrient Management

- Standard nutrient management focuses on: right rate, source, timing, placement

Organic Nutrient Management

- Organic nutrient management adds on concepts

Substitute synthetic or highly processed fertilizers for organic sources

Organic Nutrient Management

- Organic nutrient management adds on concepts

Substitute synthetic or highly processed fertilizers for organic sources

Build soil organic matter & soil health

Harness agroecological processes & nutrient cycles

Organic Nutrient Management

- Organic nutrient management adds on concepts

Substitute synthetic or highly processed fertilizers for organic sources

Build soil organic matter & soil health

Reduce external inputs & recycle nutrients in orchard biomass when possible

Harness agroecological processes & nutrient cycles

Focus on ecosystem management & soil conservation

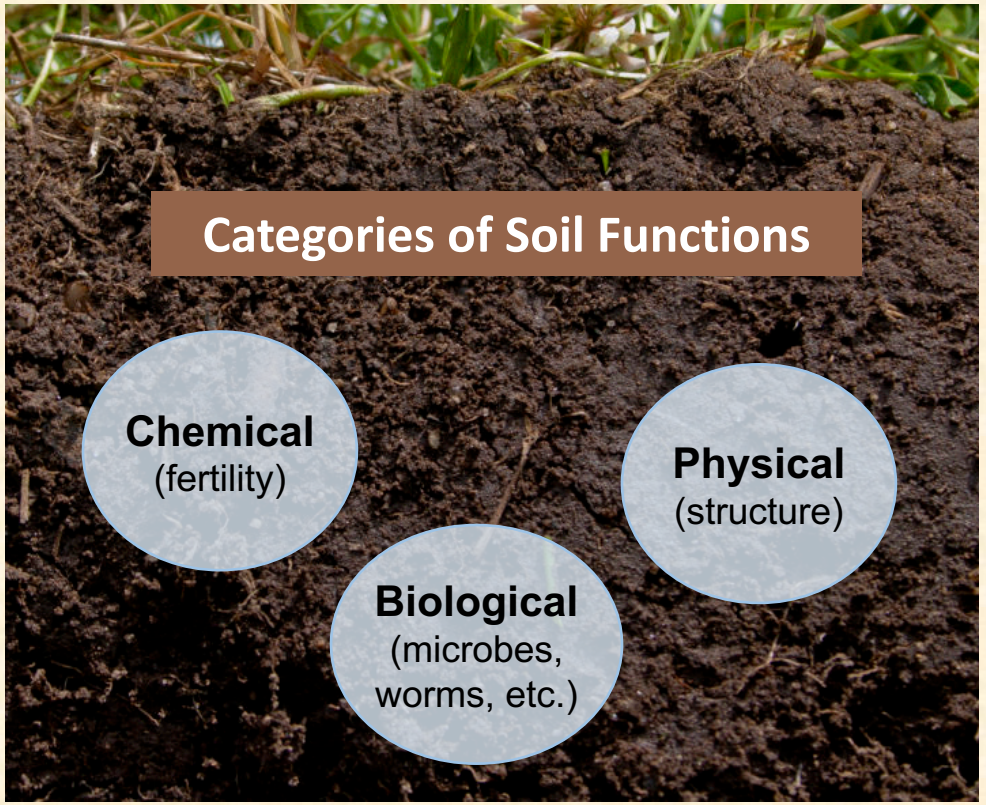
Organic Nutrient Management

- Increase Soil Organic Matter (SOM): all stages of decomposing organic materials
  - promotes water infiltration
  - helps build soil structure
  - reservoir for nutrients
  - slow nutrient release

Chopped prunings used as mulch create an organic layer on the soil surface and will eventually decompose. Photos from Zipori et al. 2020.

Organic Nutrient Management

- Increase soil health: the soil's ability to function and support life



Organic Nutrient Management

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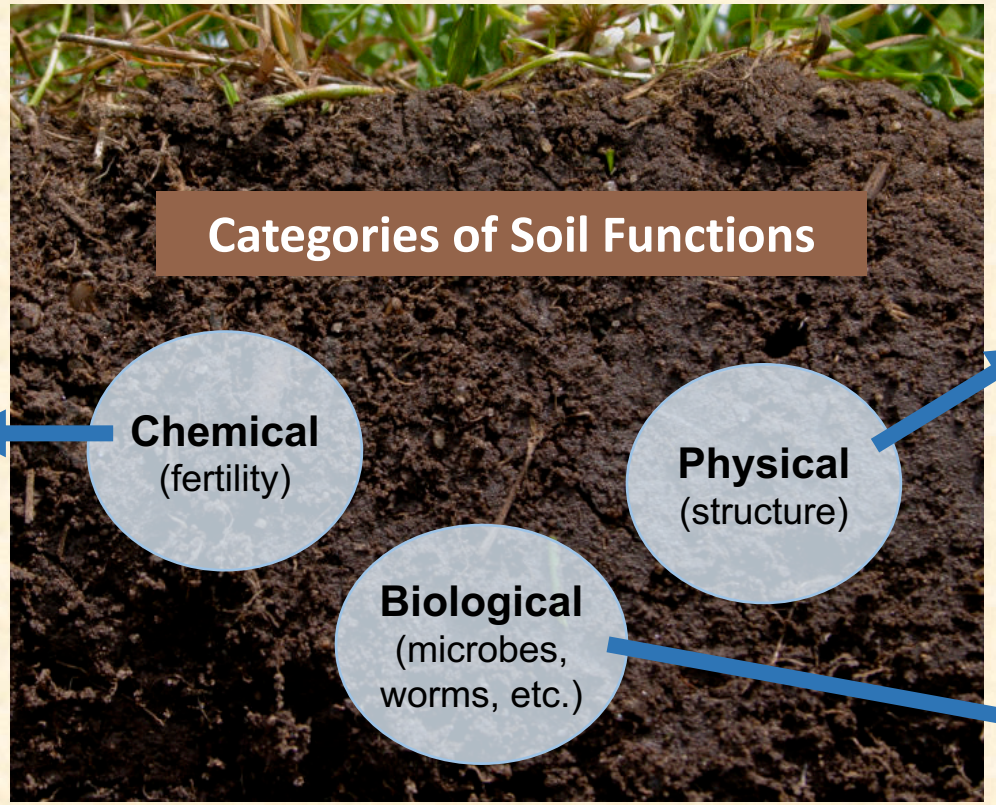


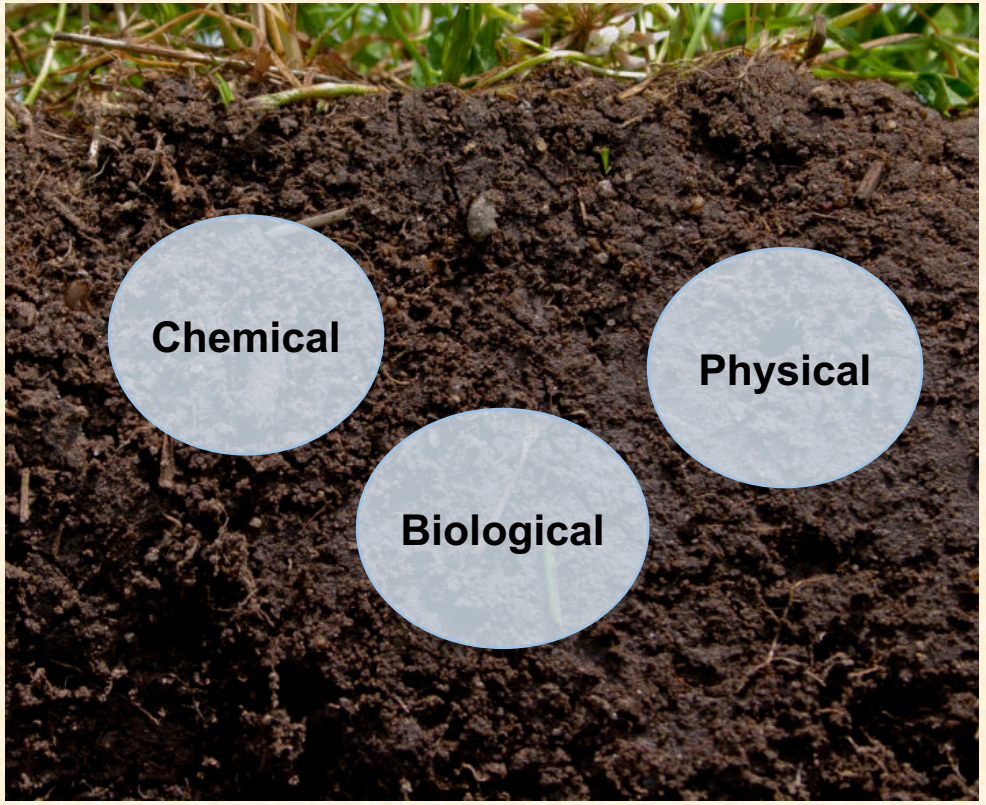
nutrients, pH, Cation Exchange Capacity (CEC)

aggregate stability, compaction, water infiltration

arthropods, microbial biomass, microbial community composition

Organic Nutrient Management

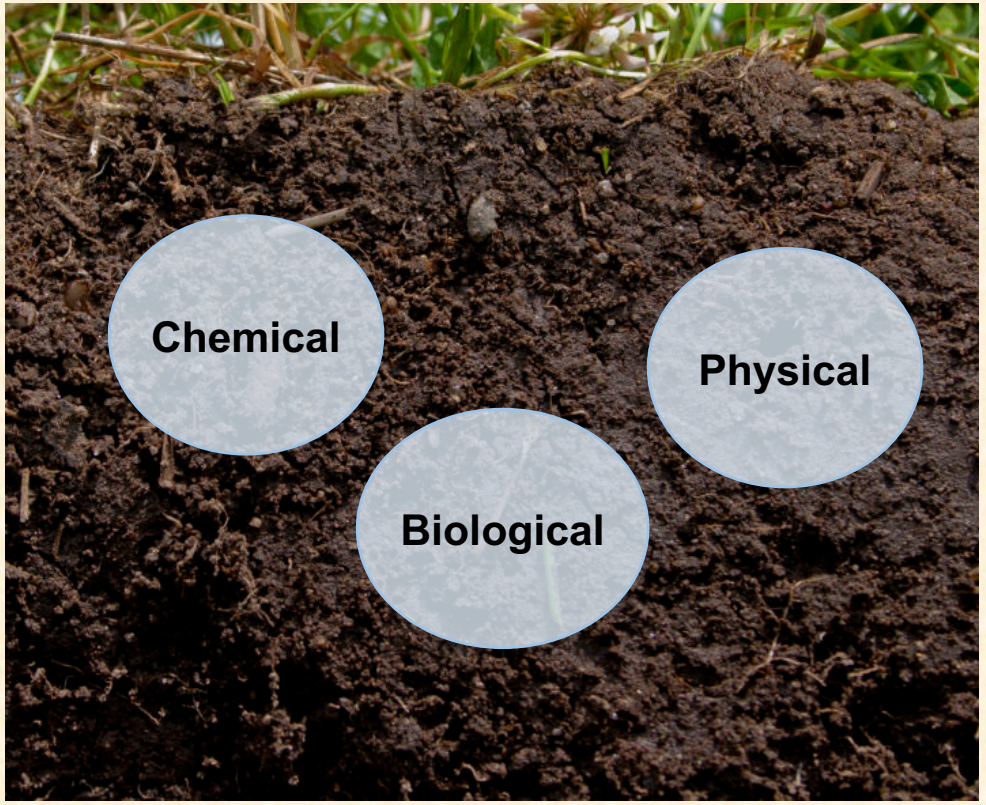
- How to increase SOM & soil health?
  - Add organic matter amendments
  - Minimize soil disturbances
  - Only use organic pesticides when necessary (as part of IPM)
  - Keep living roots in the soil
  - Diversify plant species



Organic Nutrient Management

- How to increase SOM & soil health?
  - Add organic matter amendments
  - Minimize soil disturbances
  - Only use organic pesticides when necessary (as part of IPM)
  - Keep living roots in the soil
  - Diversify plant species

- Choose the strategies that work for your system & unique site characteristics

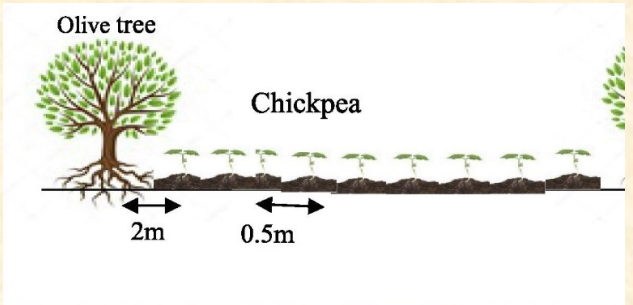


Organic Matter Amendments

- Benefits
  - Provide nutrient inputs
  - Increase SOM, nutrient reservoir
  - Improve soil ecology
  - Promote nutrient cycling
- Tradeoffs
  - Larger N reservoir needs to be managed year-round or nitrates can leach out of orchard
  - Beware of applying too much N

Cover Crops & Intercrops

- Benefits
  - provide nutrient inputs
  - mow & throw into tree row to place recycled nutrients over tree roots in early spring
  - legumes fix N, can improve water infiltration
- Tradeoffs
  - require mowing
  - can encourage gopher populations
  - might require additional water



Chickpeas interplanted in olive orchard. Amassaghrou et al. 2023.

Legume cover crop: annual sub clover can work well. Photos from Joe Connell.

Recycled Orchard Materials

- Pruned branches can be chipped & used as mulch
- Olive pomace can be composted
- Recycle nutrients stored in plant biomass

McEvoy Ranch

Why do we need organic nutrient management?

- Match crop demand with supply
- Optimum plant function & productivity
- Not too much, not too little
- Improve economic efficiency

Why do we need organic nutrient management?

- Match crop demand with supply
- Optimum plant function & productivity
- Not too much, not too little
- Improve economic efficiency
- Reduce environmental impacts
- Increase soil organic matter & soil health
- Long-term orchard sustainability

Tools

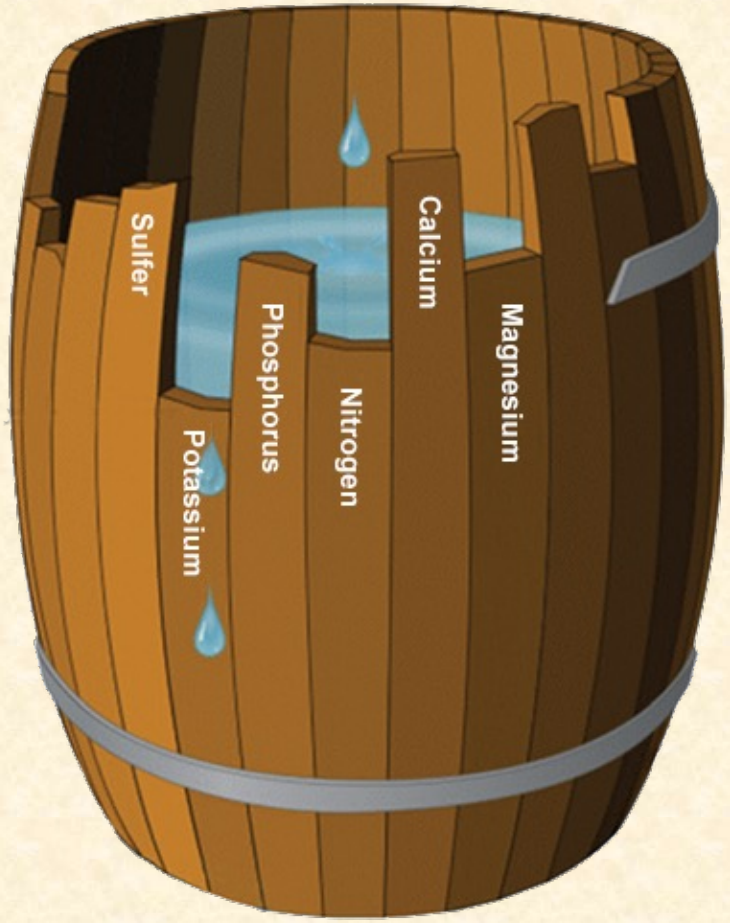
- Start by scouting & monitoring visual deficiency symptoms
- Assess tree nutrient status using leaf samples
- Compare to sufficiency ranges for olives

Tools

- Start by scouting & monitoring visual deficiency symptoms
- Assess tree nutrient status using leaf samples
- Compare to sufficiency ranges for olives
- Adjust nutrient management strategies accordingly
- Can use soil & water tests as needed
- Consider range of organic nutrient sources, pros & cons
- Don’t over-fertilize

Notes

- Water is often more limiting than nutrients for olives
- Olives are not heavy feeders



Notes

- Consider nutrient management in larger context
- Don’t apply nutrients at the first signs of low growth
- Water, pathogens, insect pests, weed competition, etc.

Notes

- Orchard uniformity is rare
  - different soil types, slope, tree ages, varieties, etc.
- Problem areas: compare visual symptoms & leaf samples with nearby good areas
- Precision nutrient management: where possible, tailor nutrient management to smaller targeted areas

Resources

UCDAVIS Olive Center

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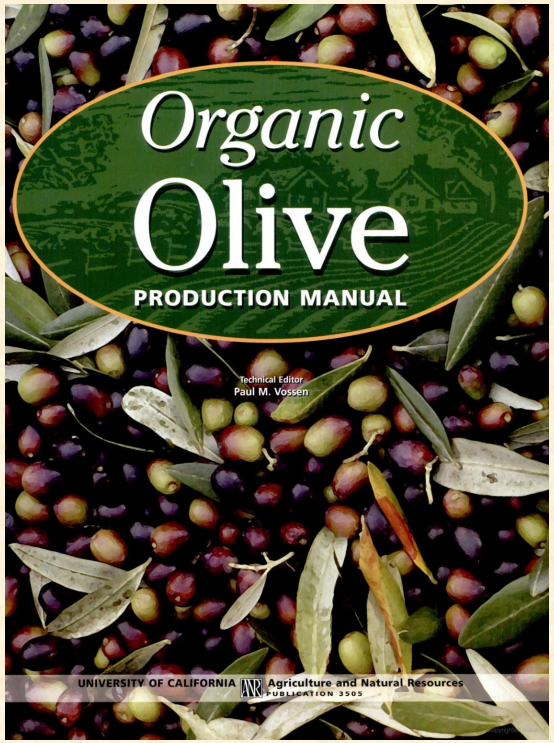
Home / Learn / Best Practices for Growers

Best Practices for Growers

These Best Practices are based on California research conducted by UC Davis, UC Cooperative Extension (UCCE) and UC Agricultural and Natural Resources (ANR).

They were prepared by the UC Davis Olive Center and G. Steven Sibbett, UCCE Farm Advisor Emeritus, Dr. Louise Ferguson, ANR Extension Specialist and Dr. Elizabeth Fichtner, UCCE Farm Advisor. We recommend that growers also review comprehensive research information available through ANR, including the Olive Production Manual, Organic Olive Production Manual and UC IPM Online.

- Siting an Olive Orchard
- Establishing an Olive Orchard
- Maintaining the Orchard



UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Selected Plant and Soil Laboratories in Northern and Central California

Downloadable List of Selected Plant and Soil Analytical Laboratories

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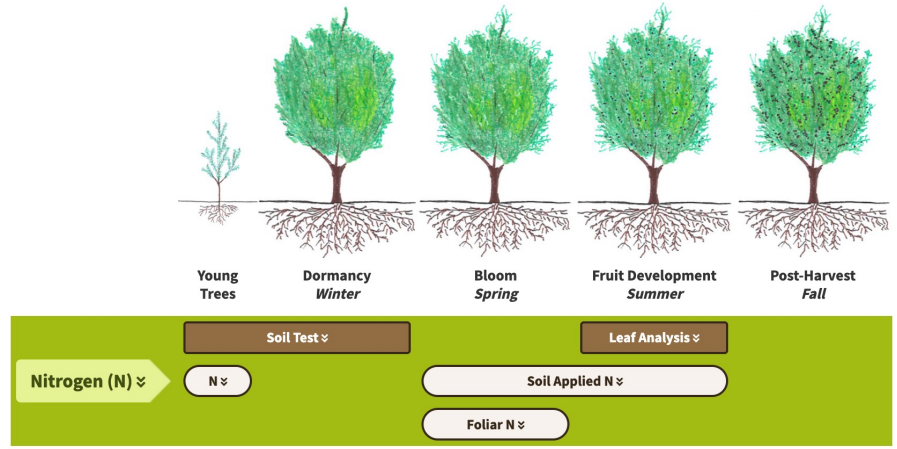
Agriculture **2020**

Sustainable Management of Olive Orchard Nutrition: A Review

by Isaac Zipori, Ran Erel, Uri Yermiyahu, Alon Ben-Gal and Arnon Dag *

California Crop Fertilization Guidelines UCDAVIS



Discussion

- Examples? Anecdotes?
- What are the main challenges with organic nutrient management in olives?
- What could help?

Thank you!

Rate

Pruned Material						
Weight (kg ha^{-1})	Concentration in DM (%)			Amounts Removed (kg ha^{-1})		
	N	P	K	N	P	K
10609	0.59	0.064	0.56	59.3	6.9	60.5

Fruit						
	Concentration in DM (%)			Amounts Removed (kg ha^{-1})		
5776	0.71	0.080	1.36	40.4	4.4	78.1

An example: nitrogen, phosphorus, and potassium concentrations and amounts removed form an intensive, commercially fertilized olive orchard. Zipori et al. 2020

Olive Soil & Water Sampling

- Helpful for diagnosing source of toxicities from sodium, chlorine, & boron
  - soil salinity: >3 EC (dS/m) leads to yield decline for olives
  - water salinity: >2.5 EC (dS/m)
  - soil boron: >2 ppm can lead to toxicity
  - water boron: >1 ppm

Source

- Nitrogen

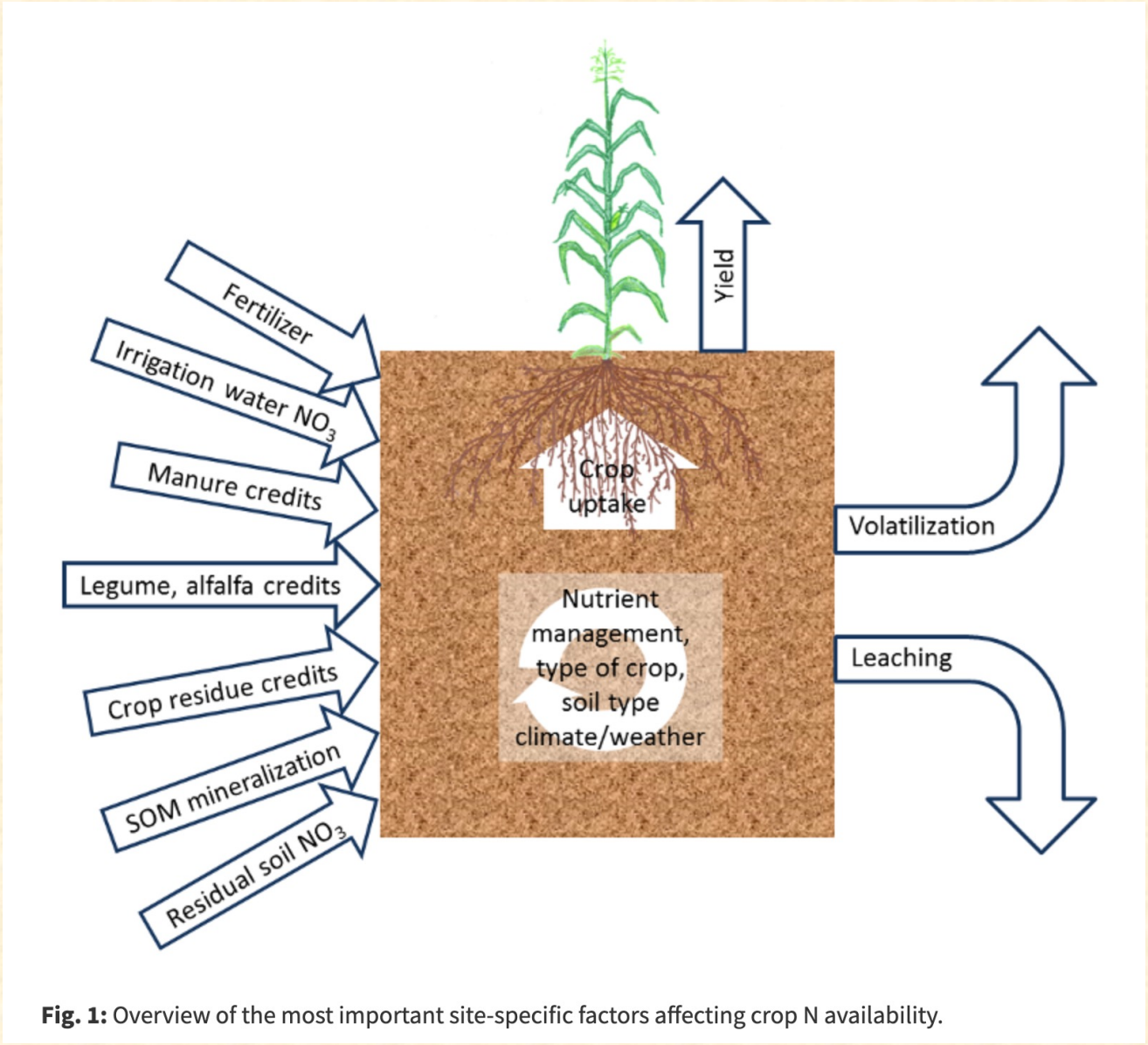


Fig. 1: Overview of the most important site-specific factors affecting crop N availability.

By Daniel Geisseler and William Horwath, CDFA FREP website.