UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Apple Orchard Nutrient Management

Ellie Andrews - UCCE Specialty Crops Advisor

Sonoma, Marin, and Napa Counties

Photo taken by Ellie at Dave Hale's apple orchard near Sebastopol

Outline

- Nutrient management principles
- Diagnostics & assessments
- Nutrient sources, rate, placement, timing in apple orchards
- Organic topics: soil organic matter, soil health, etc.

Nutrient Management

- Which nutrients to apple trees need?

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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

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nutrient uptake by roots

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Nutrient Management

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translocation (movement) across the tree

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Nutrient Management

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

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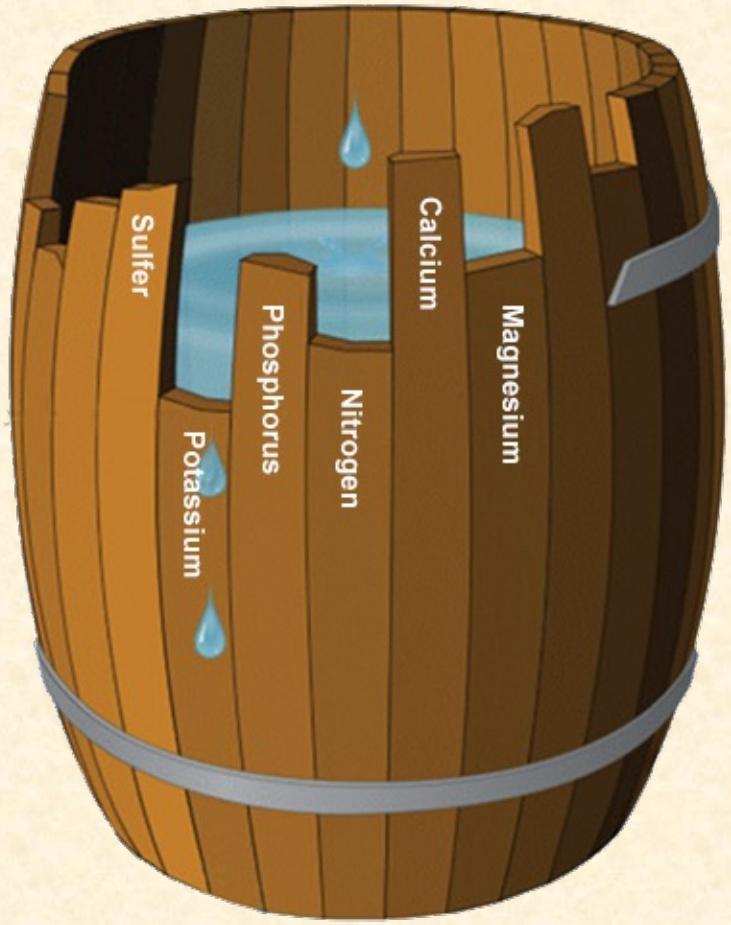
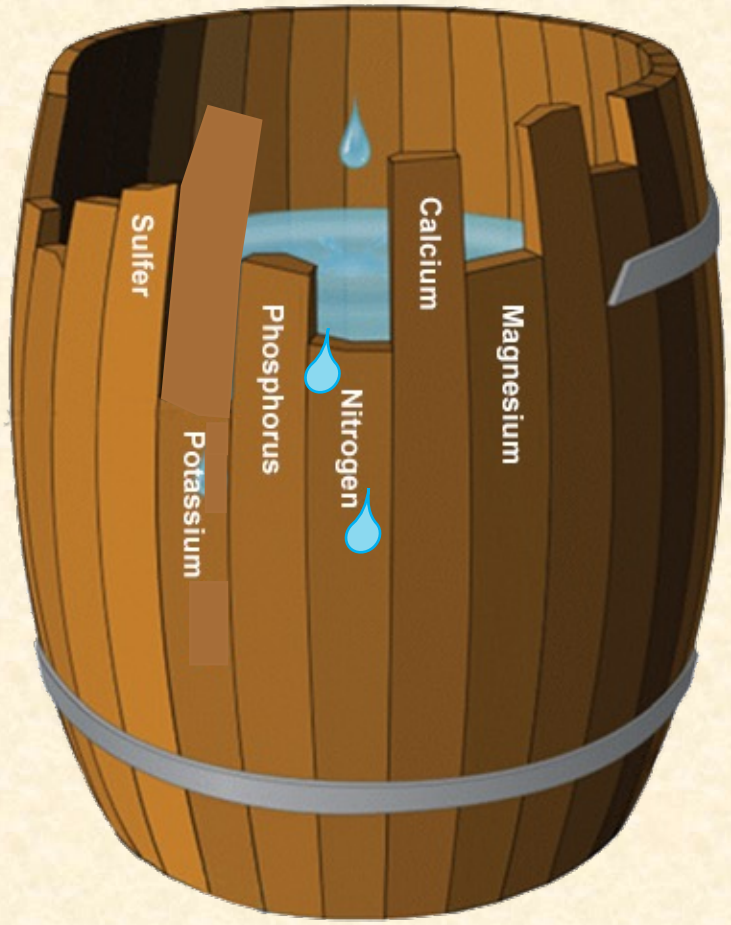
  - Barrel metaphor: lowest stave represents the most limiting nutrient (limits water/yield)



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 (limits water/yield)
  - Supplying the most limiting nutrient lifts the yield potential to the next most limiting factor – address the lowest stave



Nutrient Management

(Devoto Orchards)

- Nutrient management decisions impact
  - Tree health & apple yield quantity & quality
  - Tree resilience to stress (pests, climate, etc.)
  - Soil stability, erosion, microbes, nutrient cycling
  - Agroecosystem health & regional environment
  - Groundwater quality & human health
  - Greenhouse gas emissions

Nutrient Management

- Nutrient budget approach
  - Maintain optimum status of nutrients for plant function & yield

(Devoto Orchards)

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  - Replace amount of nutrients exported at harvest

(Devoto Orchards)

(goodeggs.com/devoto)

Nutrient Management

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

Nutrients in fruit are moved off site at harvest… for us to eat! So we need to replace what was removed in the orchard.

(Devoto Orchards)

(goodeggs.com/devoto)

Nutrient Management

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

Nutrient Inputs:
fertilizers, nutrients in cover crops, etc.

(Devoto Orchards)

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Nutrient Inputs: fertilizers, nutrients in cover crops, etc.

(Devoto Orchards)

Ideally:

- Most of our nutrient inputs go to the tree
- Some stored in the soil
- Minimal loss from the orchard

Nutrient Management

(Devoto Orchards)

- 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

- What approach is most effective & efficient at my site?

- Classic nutrient management focuses on the appropriate
  - Source: what type of fertilizers and amendments?
  - Rate: how much?
  - Timing: how often?
  - Placement: where?

(Hale's Apple Orchard)

Nutrient Management

- First step: understand your orchard's needs
- How do you know your orchard's nutrient status?

Diagnostics

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

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Diagnostics

- Nitrogen (N) deficiency symptoms
  - Typically appear first on older leaves as N is moved to younger leaves
  - Uniform light green/yellow leaves (chlorosis)
  - Reduced leaf size
  - Thin, spindly, stunted shoot growth
  - Short terminal shoots

Credit: Ontario Apple IPM, Ministry of Agriculture, Food & Rural Affairs

Diagnostics

- Nitrogen (N) deficiency symptoms
  - If severe, older leaves may die
  - Reduced bud formation and fruit set
  - Small fruit size
  - Fruit that mature early
  - Reduced yield

Credit: Ontario Apple IPM, Ministry of Agriculture, Food & Rural Affairs

Credit: Eric Hanson, MSU

Diagnostics

- Nitrogen excess symptoms
  - Large, dark green leaves that remain on the tree in the late autumn
  - Reduced fruit quality, poor color
  - Fruit lose firmness more readily in storage
  - Increased susceptibility to fire blight

Abnormally dark green foliage on left indicating N excess, healthy foliage in the center, and nitrogen deficient leaves on the right. These are not apple leaves, but do show a nice comparison of symptoms (UC IPM)

Diagnostics

- Potassium (K) deficiency symptoms
  - Symptoms first appear on older leaves, but can affect young leaves when severe
  - Yellowing of leaf margins that can turn brown over time
  - Leaf symptoms may appear as fruit reaches maturing because fruit accumulate a lot of K
  - K deficiency is more common in sandy soil than clayey soil

Credit: Spectrum Analytics, UVM

Potassium Deficient Apple

Credit: Eric Hanson, MSU

Diagnostics

- Calcium (Ca) deficiency symptoms
  - Aka bitter pit
  - Lesions often concentrated toward calix end of fruit
  - Small, corky, brown areas on fruit
  - Symptoms show up a few weeks before harvest or in storage

Credit: Eric Hanson, MSU

Credit: Yara

Diagnostics

- Boron (B) deficiency symptoms
  - Start in new leaves
  - Leaf chlorosis
  - Scorched margins that roll inward
  - Terminal bud dieoff
  - Corky spots on lateral shoots
  - Symptoms show up on fruit early in development

Credit: Yara

Credit: Eric Hanson, MSU

Diagnostics

- Boron (B) deficiency symptoms
  - Reduced fruit size
  - Deformed, dimpled, cracked fruit with corking
  - Can be confused with Ca deficiency, but B deficiency symptoms start earlier in fruit development than Ca deficiencies

Credit: Yara

Diagnostics

- Magnesium (Mg) deficiency symptoms
  - Start in older leaves first
  - Interveinal chlorosis (yellow tissue) & necrosis (dead tissue)
  - Early fruit drop

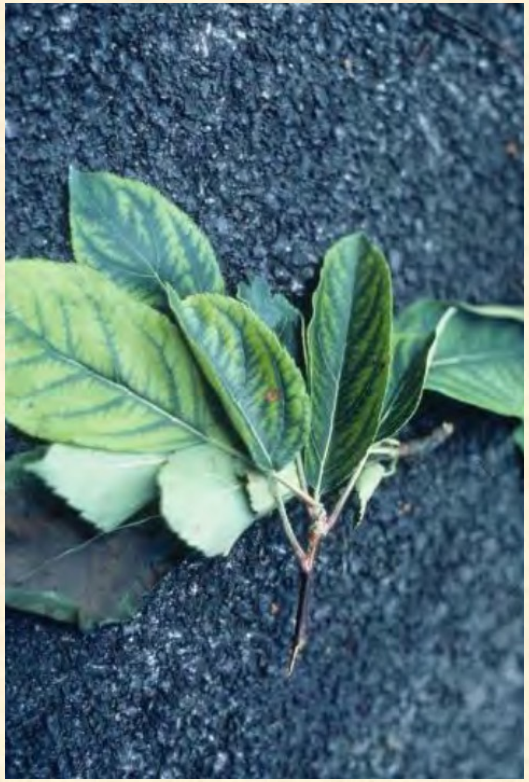
Credit: Eric Hanson, MSU

Credit: Yara

Diagnostics

- Manganese (Mn) deficiency symptoms
  - More common on alkaline soils & during dry seasons
  - Similar symptoms as Mg deficiency by appear first on young leaves
  - Interveinal chlorosis while main vein remains green

Credit: Eric Hanson, MSU



Credit: Yara

Diagnostics

- Manganese (Mn) toxicity symptoms
    - More common where pH <5.5 in young trees, Red Delicious is very susceptible
    - Cambium tissue under bark dies on young twigs causing cracked bark aka “measles”

Credit: Eric Hanson, MSU

Diagnostics

- Zinc (Zn) deficiency symptoms
  - Small, chlorotic, long leaves
  - Sometimes interveinal chlorosis
  - Rosetting caused by short internodes
  - “Blind wood” on newer shoots

Credit: Eric Hanson, MSU

Credit: Yara

Diagnostics

- Iron (Fe) deficiency symptoms
  - Symptoms start on young leaves
  - Begins with pale chlorosis
  - Then can become lemon yellow, pale yellow, whitish or bleached interveinal chlorosis over time
  - Main veins stay green
  - Can cause necrotic margins

Credit: Yara

Credit: Eric Hanson, MSU

Diagnostics

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

Leaf Tissue Sampling

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

Table 3. Optimum and deficient levels of nutrients in apple leaves.

Nutrient	Optimum range	Deficient level
N (%)	2.0-2.6 1.8-2.4[1]	2.0
P (%)	.16-.30	0.11
K (%)	1.3-1.5	1.0
Ca (%)	1.1-1.6	0.5
Mg (%)	.30-.50	0.2
B (ppm)	25-50	25
Cu (ppm)	10-20	4**
Fe (ppm)	150-250	25
Mn (ppm)	50-80	20**
Zn (ppm)	20-40	15**

[1]Optimum range for soft varieties, e.g. Golden Delicious and Macintosh.
**indicates deficient levels is not well defined

Credit: Eric Hanson, MSU

Leaf Sampling

- Protocol: see CDFA FREP website

A collaboration between:

cdfa FREP

UCDAVIS UNIVERSITY OF CALIFORNIA

Plant Tissue Sampling in Orchards and Vineyards

Patricia Lazicki and Daniel Geisseler

Background

- Plant analyses are useful for diagnosing nutritional problems and monitoring the fertilization program. Tissue testing is most effective when used together with nutrient budgets and observations of orchard performance [4,12].
- Nutrient concentrations change over the season and also differ between plant parts [4]. It is therefore important to sample the correct plant part, and at the time for which the test was calibrated (Table 1). For information on optimal nutrient concentrations see the fertilization guidelines for the different crops (https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Guidelines.html)
- Archiving the results from the analyses allows managers to track changes in the orchard over time.

General Sampling Instructions

- Nitrogen changes more quickly in the plant and the soil than other nutrients, so leaf N should be tested every year for most crops. Other nutrients may be taken less often, except in deficiency-prone crops (Table 1).
- Divide the orchard into management areas with similar characteristics and take a separate sample from each area. For example, areas with trees of different varieties, ages or under different types of irrigation should be sampled separately [5,12].
- Randomly select healthy trees throughout the orchard or management area and sample the correct plant parts (See Table 1).
- Do not take samples from dead, diseased, insect damaged, or mechanically injured plants, or plants in border areas. To determine the cause of a suspected deficiency, separate samples may be taken
- If leaves have been sprayed with N or K they should not be sampled for at least a week. Do not analyze leaves that have been sprayed with micronutrients for those nutrients [5].
- Collect the specific plant parts and place them into a clean paper bag [5]. Samples can mold in plastic bags [6].
- Samples that will be analyzed for micronutrients should be washed with water containing a little detergent, and rinsed once with tap water and twice with distilled water. Samples for N, P or K analysis don't need to be washed [5].
- Clearly label the bag and provide the information required by the test lab. Follow the lab's instructions for packaging and shipping.

Leaf Sampling for Nutrient Status

- Leaf sampling procedure:
  - Collect samples in late July or early August (stable concentrations)
  - Do not take samples from trees that have received foliar nutrients recently
  - 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

Leaf Sampling for Nutrient Status

- Leaf sampling procedure:
  - Collect 100 leaves total per area of interest, 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 micronutrients will be tested, wash leaves with tap water and a little detergent and pat dry (otherwise no need to wash)

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

Leaf Sampling

- The lab will send you your results
- Compare your results to sufficiency ranges for apples
- Are they within the optimum range?

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[1]Optimum range for soft varieties, e.g. Golden Delicious and Macintosh.
**indicates deficient levels is not well defined

Credit: Eric Hanson, MSU

Nitrogen Notes

- Avoid excess nitrogen
  - Leaf N tests should be interpreted together with observations of tree vigor & performance
  - Look for good shoot growth each year and healthy bloom & fruit set
  - When N is sufficient, don't add any fertilizer N the next year
  - Excess N can cause issues

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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 & soil 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 apples is ~6.5-6.8, or at least 6.0-7.0
- Soil tests are most useful for monitoring pH in apple orchards
- Since apple roots can access nutrients deep in the soil, they may be able to obtain sufficient nutrients even if soil tests indicate nutrient levels in the topsoil are low

Soil & Water Sampling

- Nitrogen
  - It's relatively mobile in the soil
  - Affected by rain, irrigation, tillage, etc.
  - Soil nitrogen levels often don't correlate well with plant nitrogen status
  - Nitrate in irrigated groundwater can contribute N to tree's nutrient requirement
  - Leaf tissue samples are likely going to be more reliable for N assessment than soil N

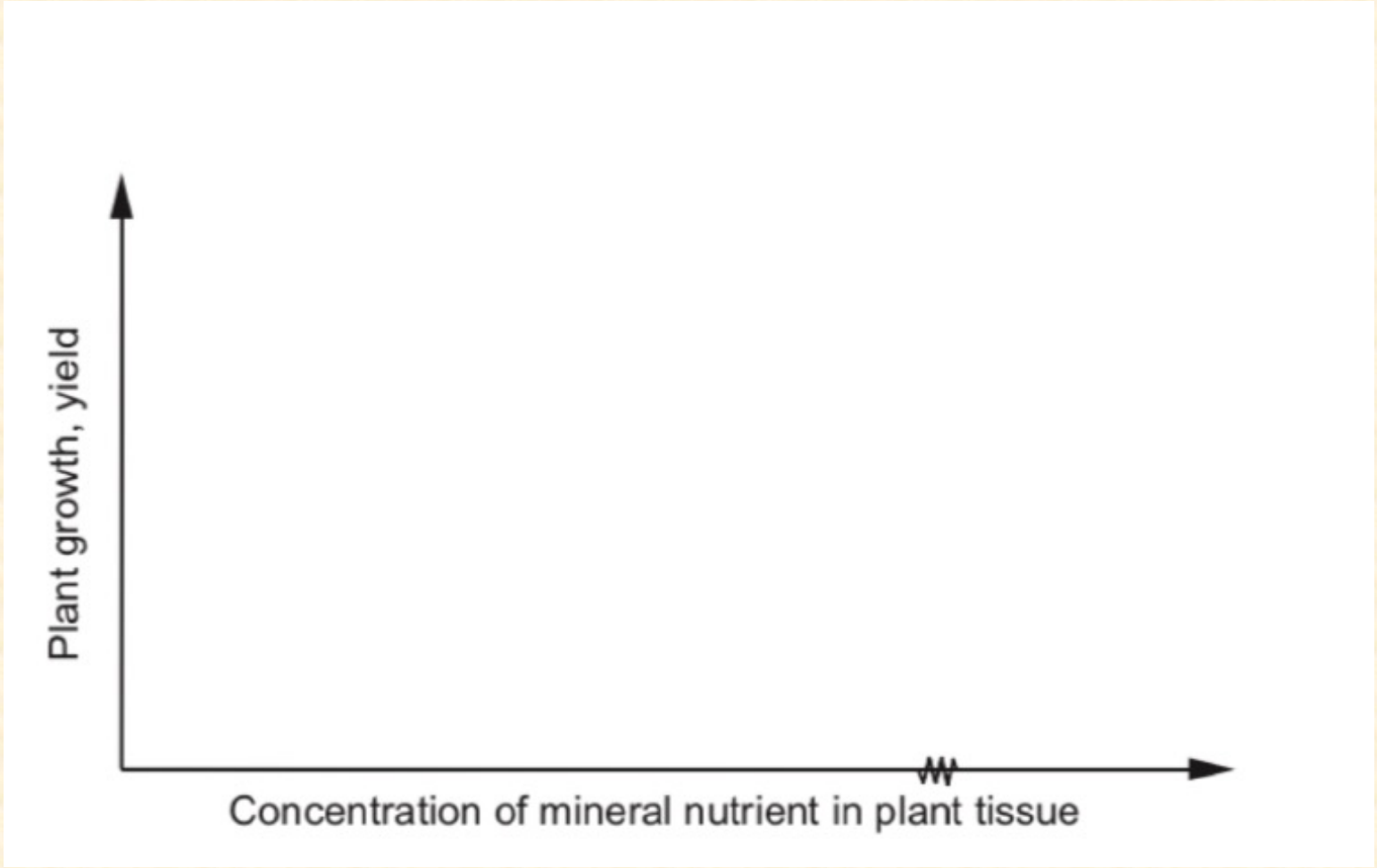
Nutrient Management

- Big-Picture Goal: moderate tree vigor with minimal but sufficient nutrition

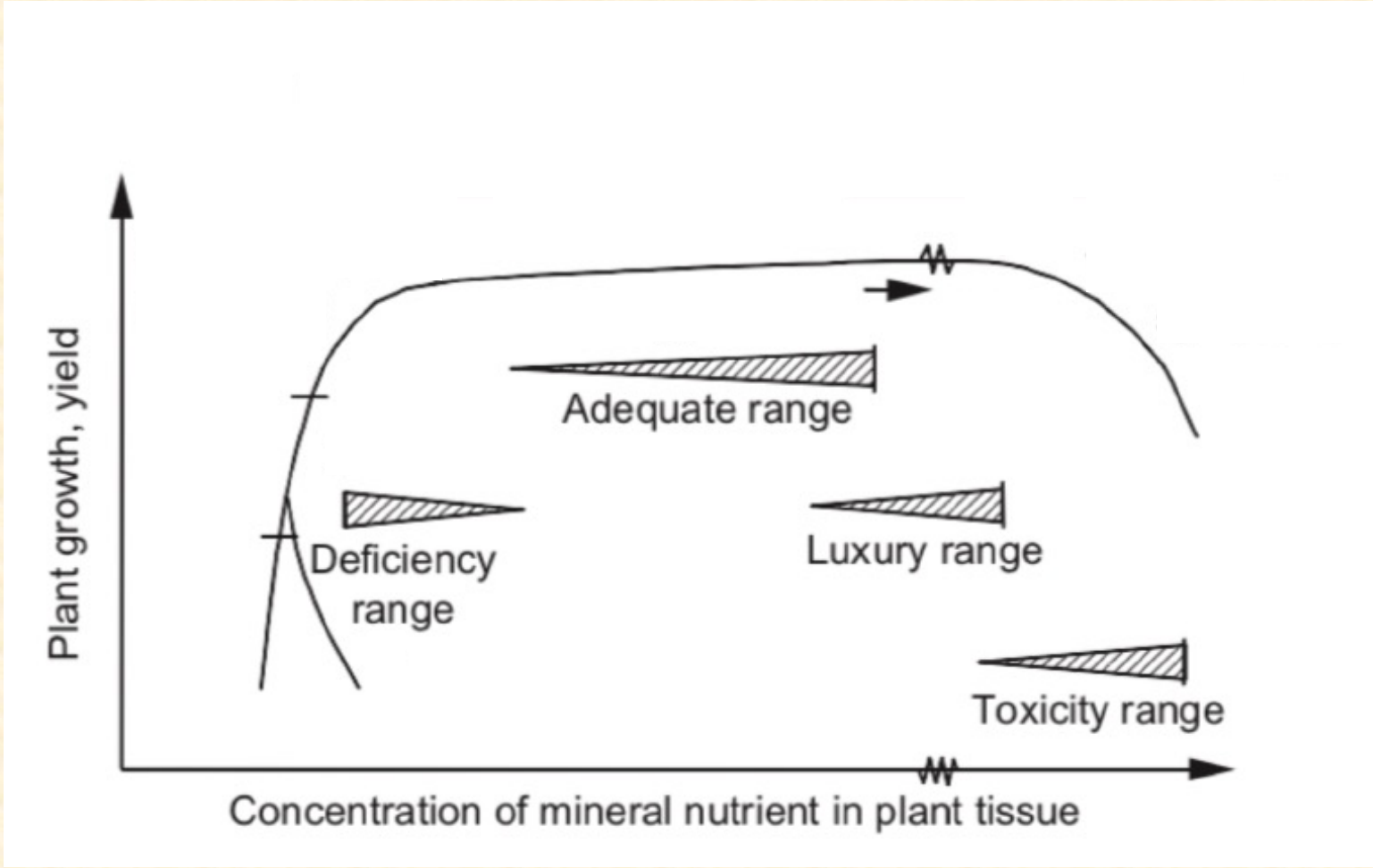
Nutrient Management

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

Rate

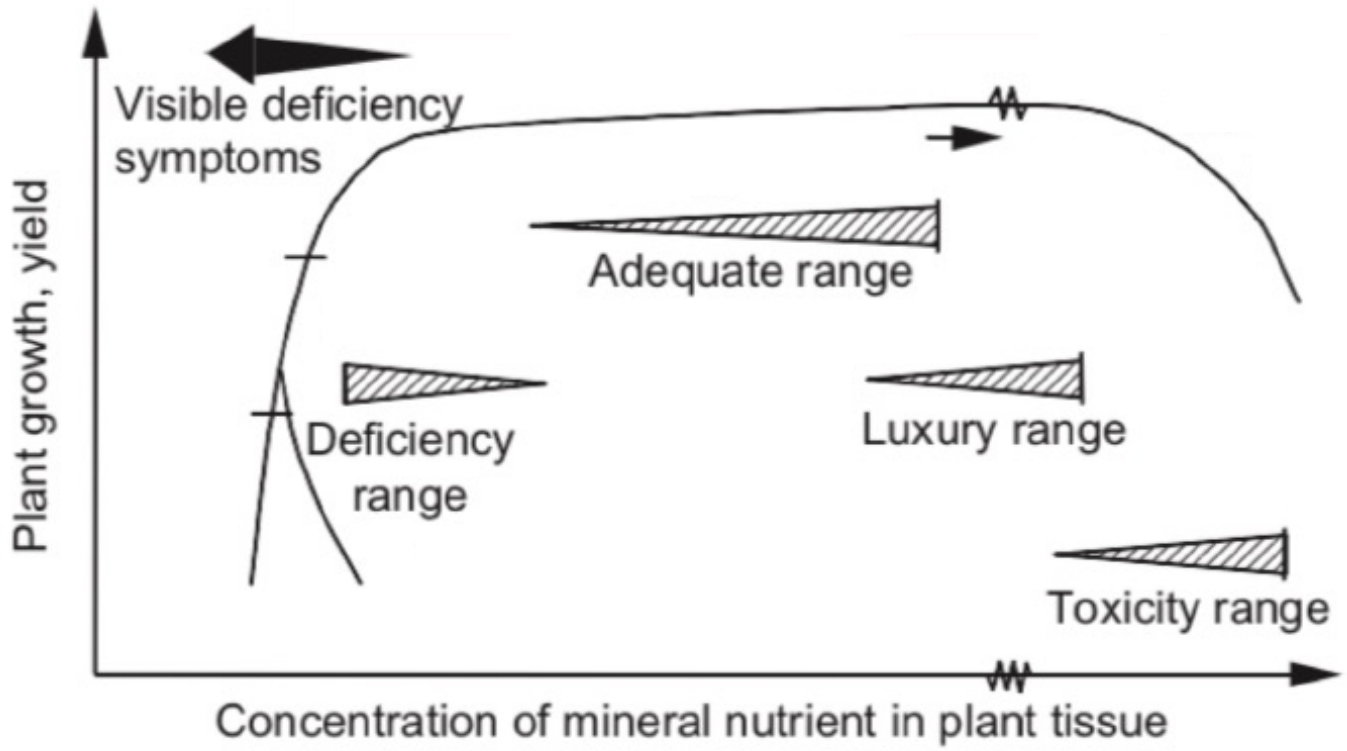

Plant growth, yield
Concentration of mineral nutrient in plant tissue

Rate

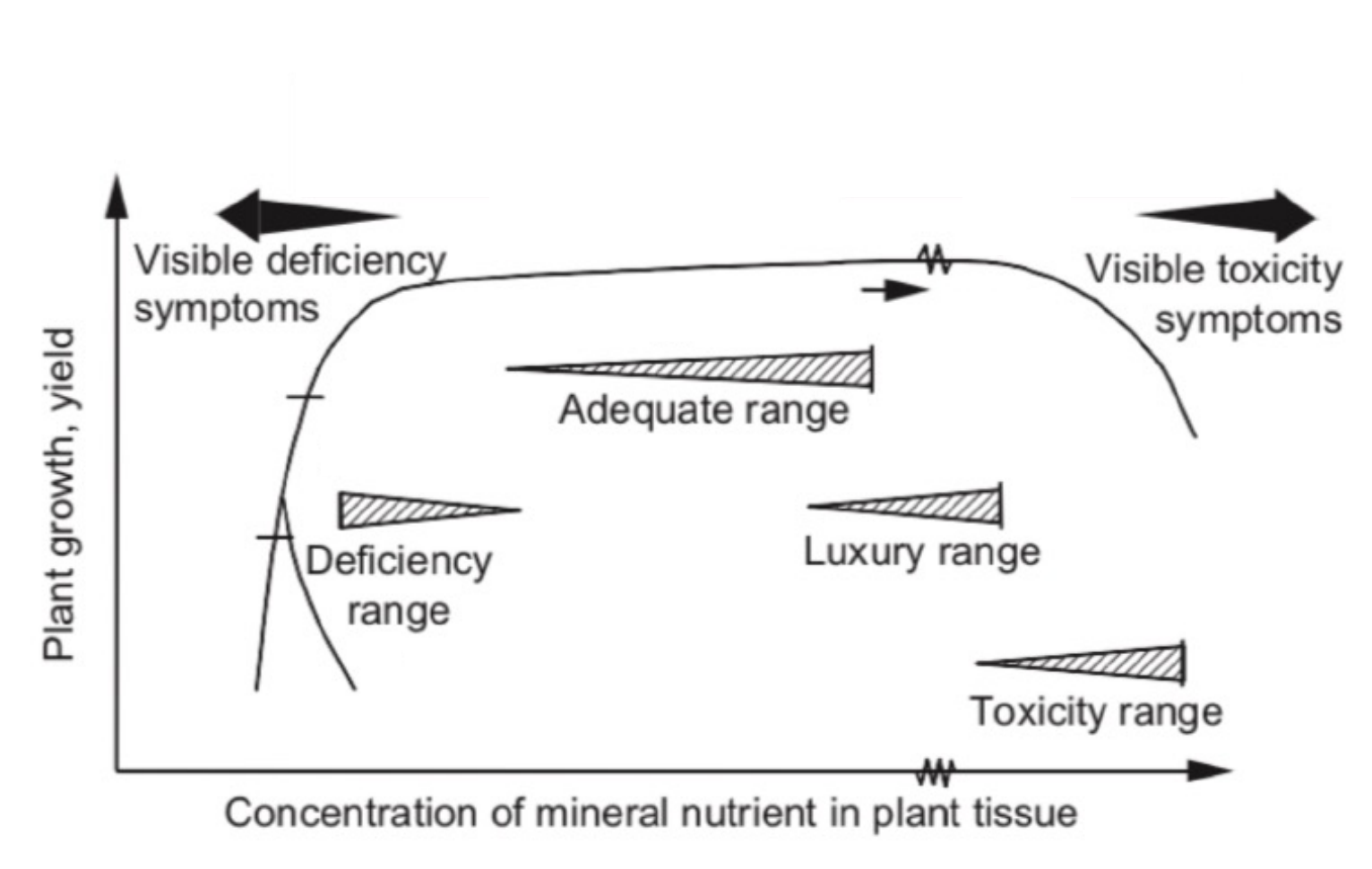

Plant growth, yield
Adequate range
Deficiency range
Luxury range
Toxicity range
Concentration of mineral nutrient in plant tissue

Rate

Deficiencies impair plant functioning & production



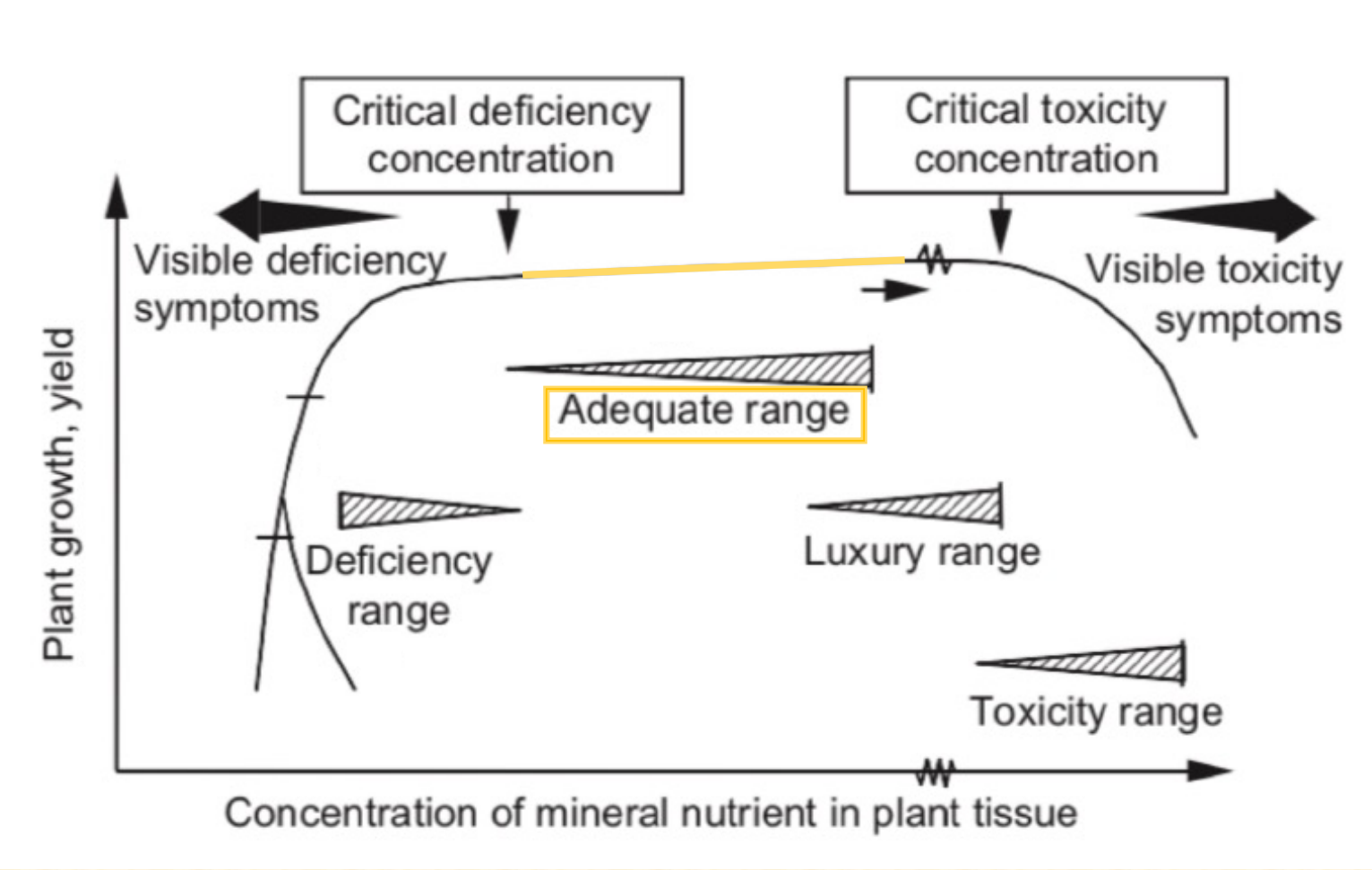
Rate



Over fertilizing can lead to

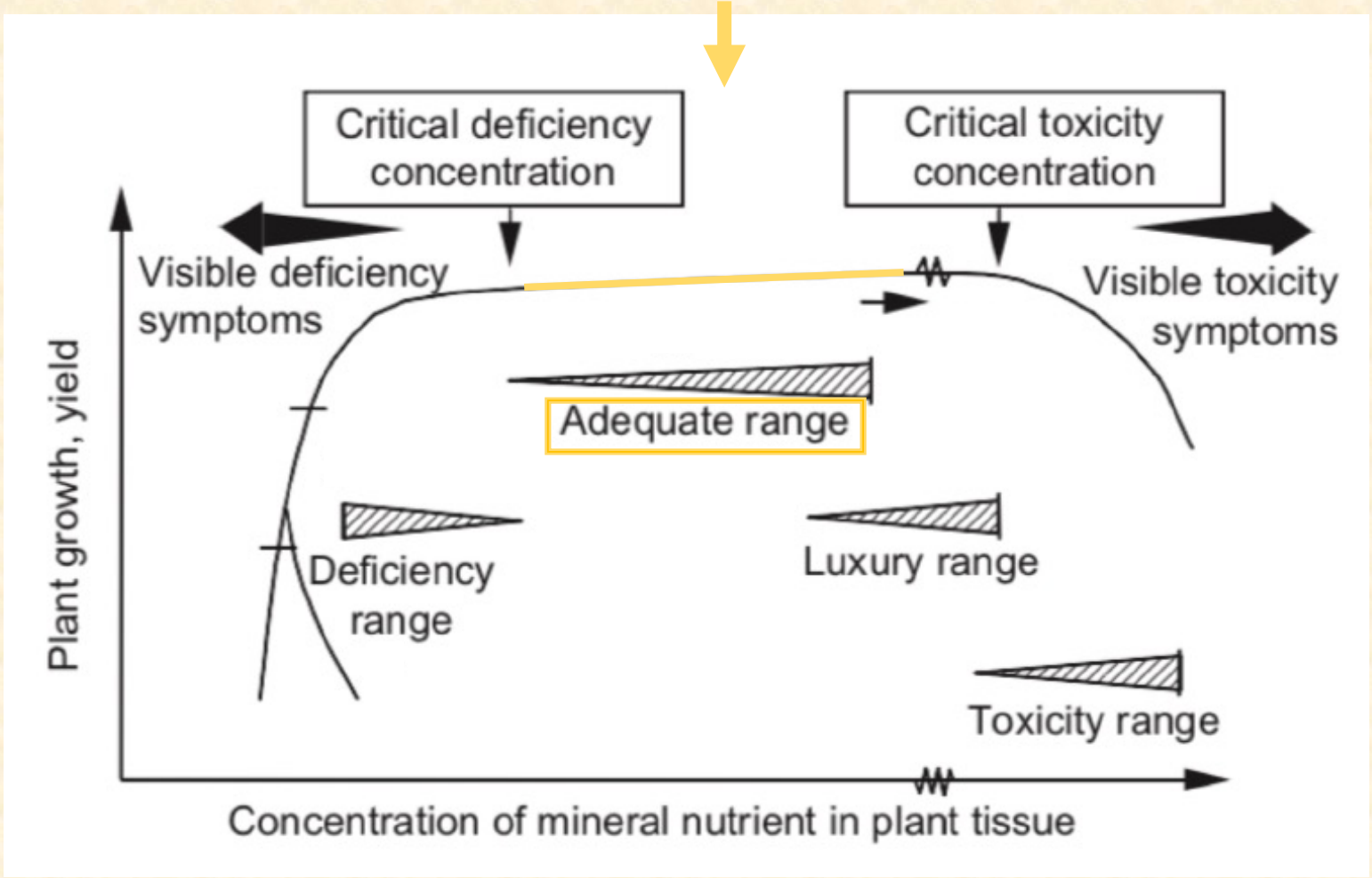
- excess vigor
- reduced yields & quality
- environmental damage
- wasted money

Rate

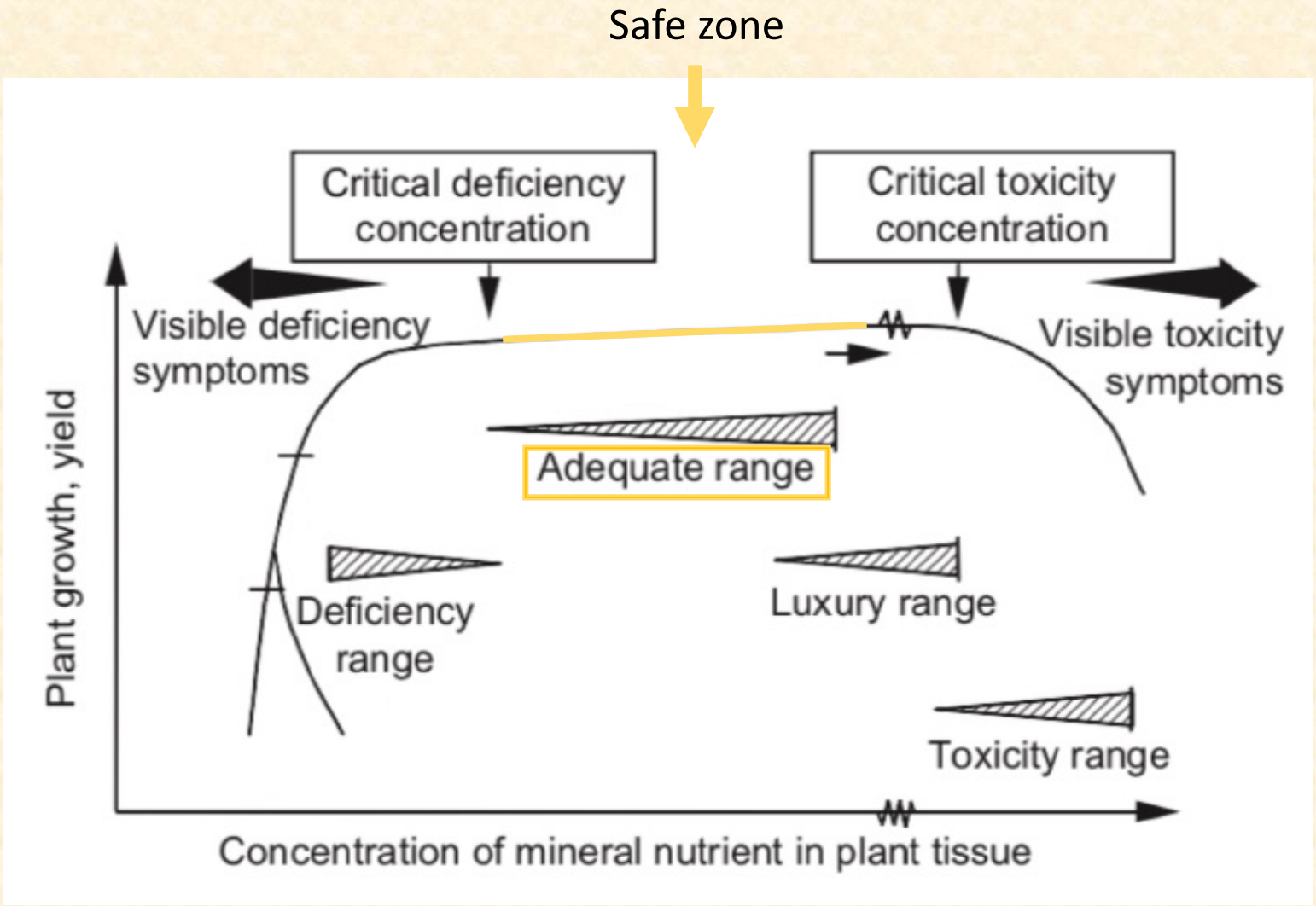

Critical deficiency concentration
Critical toxicity concentration
Visible deficiency symptoms
Visible toxicity symptoms
Adequate range
Deficiency range
Luxury range
Toxicity range
Plant growth, yield
Concentration of mineral nutrient in plant tissue

Rate

Visual assessments and diagnostic tools help keep tree nutrient status in the safe range



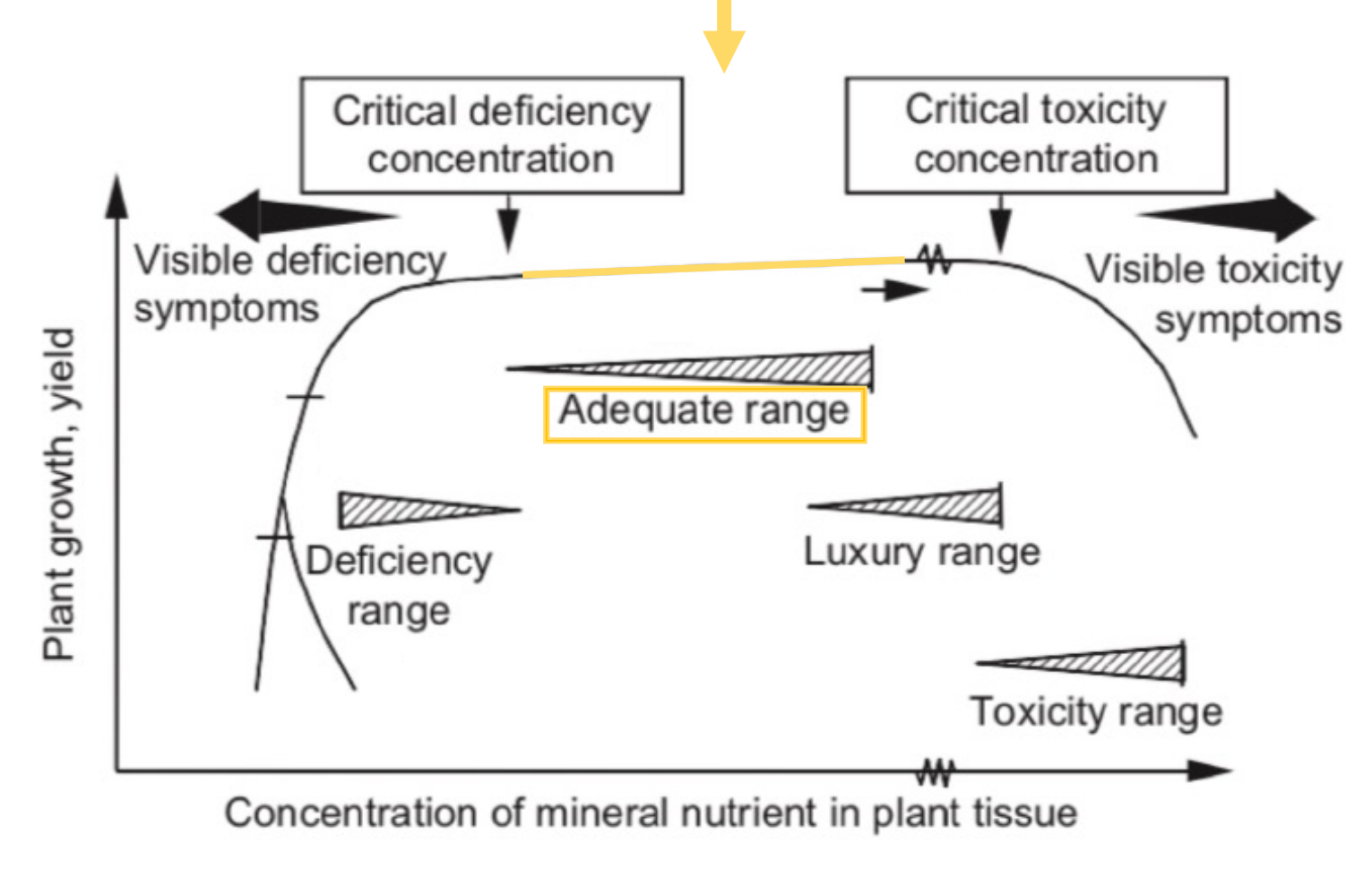
Rate


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

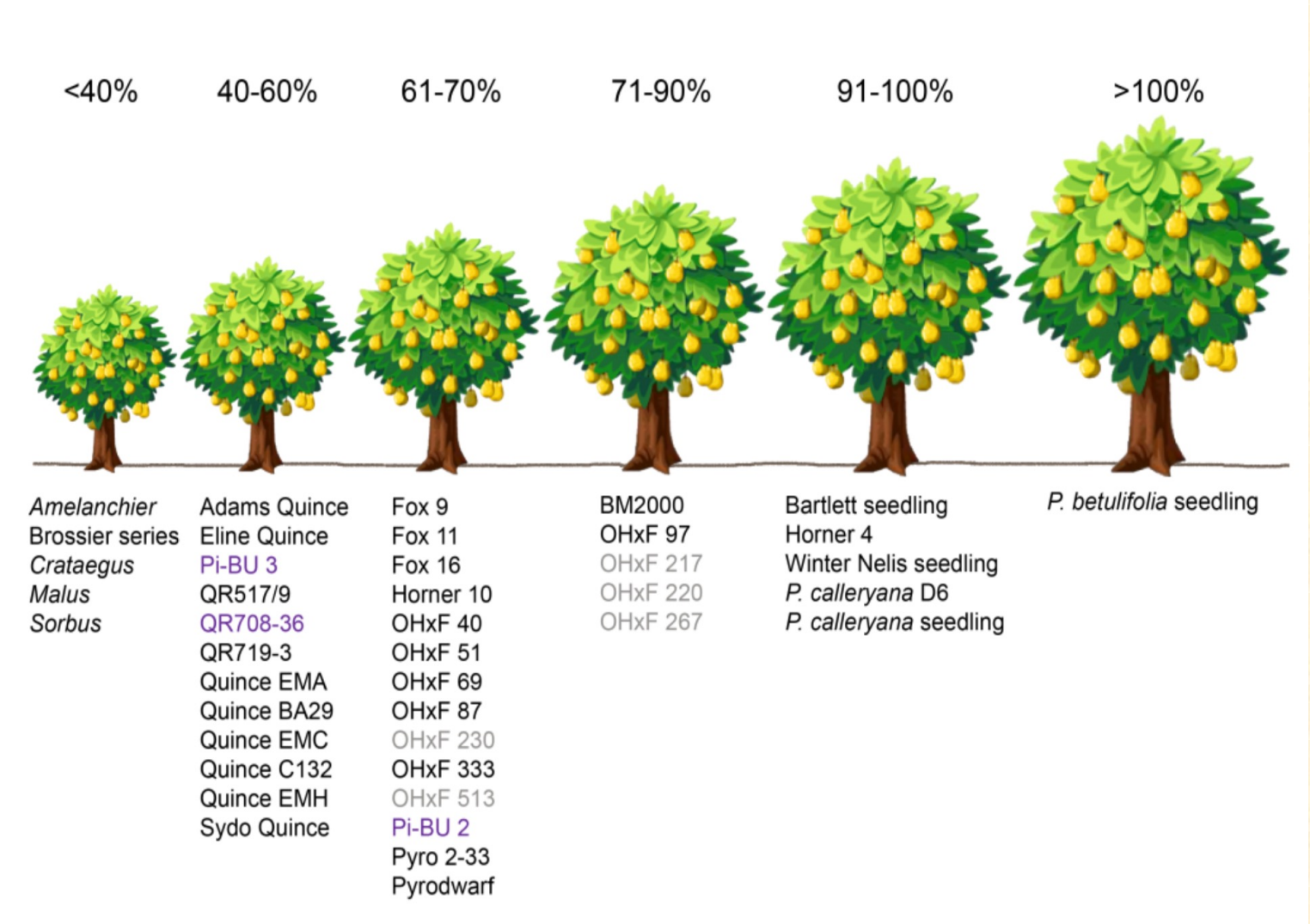
Nutrient budget approach:

1. Ensure levels are in the safe range
2. Then just replace the estimated amount of nutrients removed at harvest



Rate

- Amount of nutrients needed depends on:
  - Scion & rootstock demands
  - Tree age & canopy size



Examples of the effects of different pear rootstocks with the same scion on tree size (Washington State Extension)

Rate

- Amount of nutrients needed also depends on:
  - Soil & plant nutrient status
  - Irrigated vs. dry farmed
  - High in put vs. low input system
  - Yield demand
  - Nutrient concentration of chosen source
  - Nutrient release rate from source

Rate – General Recommendations

- Nitrogen
  - Apply N as needed annually based on leaf tissue status and vigor
  - Low vigor & pale color often indicates low N
  - Goal is 18-30 inches shoot growth in young apple trees
  - Always read the label of your fertilizer and follow the directions carefully
  - N might not need to be applied every year

Credit: Ontario Apple IPM, Ministry of Agriculture, Food & Rural Affairs

Rate – General Recommendations

- Nitrogen Rate Examples
  - Conventional growers in the Central Coast area use ammonium sulfate to provide ~125 lb/ac N annually
  - Apple growers in Washington apply between 0-60 lb/ac N per year depending on orchard need (bear in mind, those are high-yielding, high-input systems)
  - Organic growers often use cover crops, compost, and organic fertilizers (wide diversity of rates)

Credit: Ontario Apple IPM, Ministry of Agriculture, Food & Rural Affairs

Rate – General Recommendations

- Potassium
  - Tailor application rate to severity of deficiency shown on leaf tissue results
  - Leaf K deficiency symptoms look a lot like severe water stress symptoms
  - Could be related to low water uptake—could try increasing irrigation to see if that increases tree K status
  - K deficiencies are more common in sandy soils (low CEC)
  - It takes longer to see improvements in leaf K than leaf N status

Potassium Deficient Apple

Credit: Spectrum Analytics, UVM

Rate – General Recommendations

- Calcium
  - Use leaf tissue results and directions on product label to guide Ca application rate
  - If you're about to plant an orchard, look at soil test results: if you see low Ca and/or low pH, you could apply lime to help with both

Credit: Yara

Rate – General Recommendations

- Zinc
  - If leaf tissue results indicate it's needed, can consider foliar applying zinc (it's not very mobile in the soil)
  - Follow label directions very carefully for your specific product
  - It is easy to over-apply foliar nutrients and "burn" your tree (due to toxicity)
  - Be sure the product has completely dissolved before spraying

Credit: Yara

Avoiding Over-Fertilizing

- Applying too high of a rate is easy to do
- If growth isn't adequate, make sure you know why before you take action
- Could be inadequate water or weed control

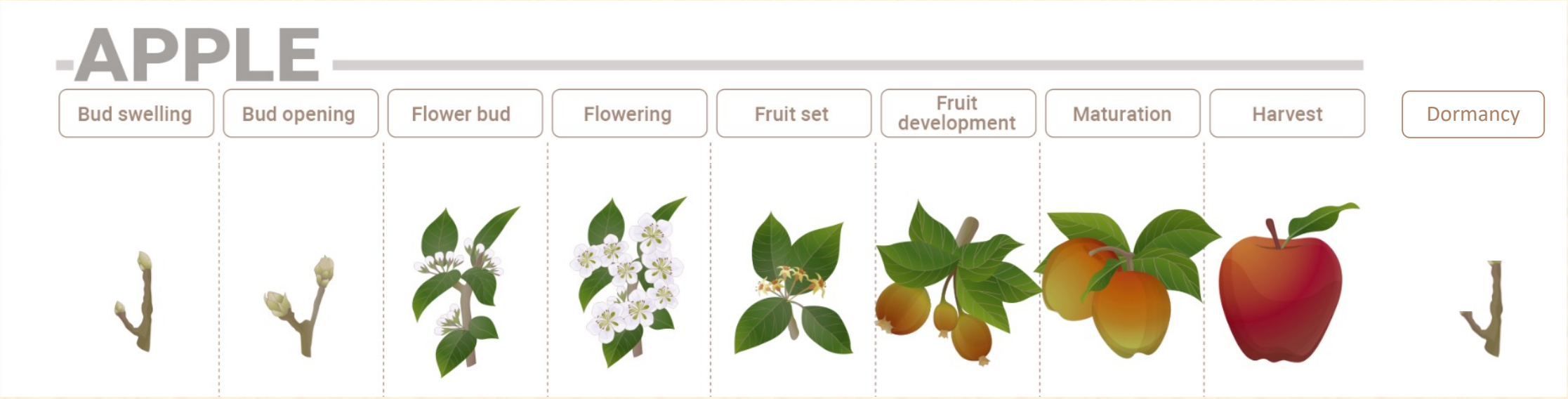
Abnormally dark green foliage on left indicating N excess, healthy foliage in the center, and nitrogen deficient leaves on the right. These are not apple leaves, but do show a nice comparison of symptoms (UC IPM)

Placement

- Above roots in or along the side of the tree row (no need to apply in alley)
- Within irrigation area where water will solubilize nutrients into rootzone
- Apple tree root structure: growers report that dry farmed roots tend to go deep, whereas irrigated roots tend to be more shallow
- Foliar applications can help for micronutrients – but beware of overapplication

Timing

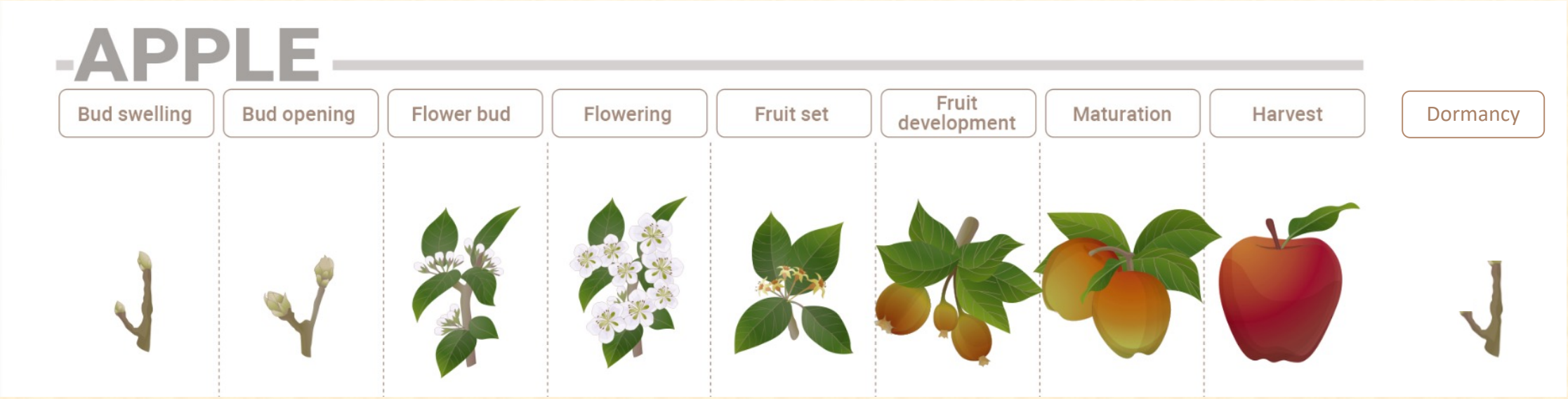
- Timing of nutrient availability should match the timing of crop demand
- Apple phenology: when are nutrients needed?



Credit: SQM Nutrition

Timing

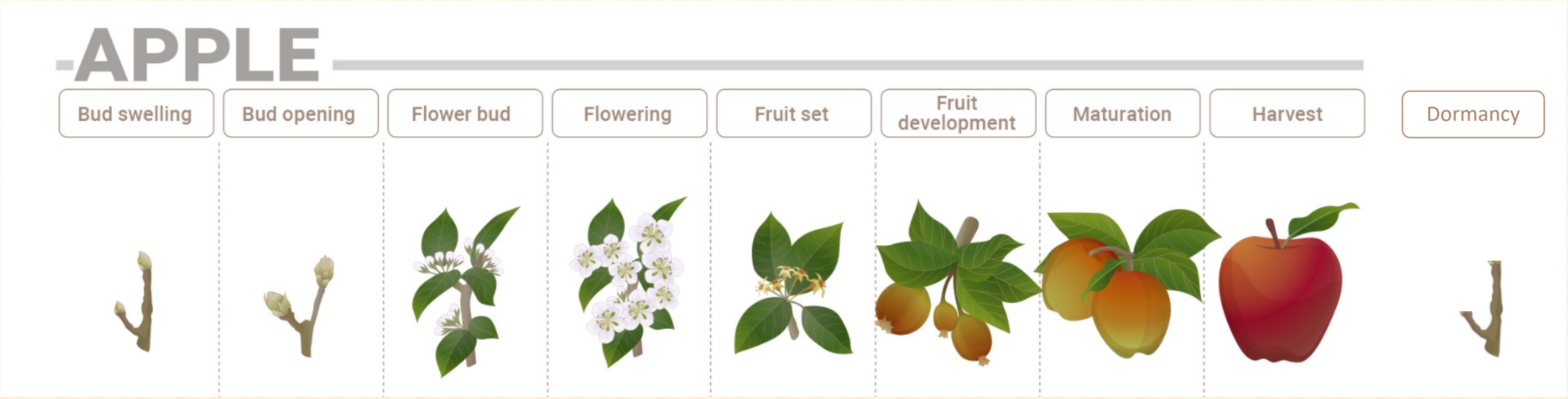
- Timing of nutrient availability should match the timing of crop demand
- Apple phenology: when are nutrients needed?
  - Mainly in the spring & summer when trees are actively taking up water



Credit: SQM Nutrition

Timing – Nitrogen Notes

Ensure N is in root zone right before uptake in early spring, just ahead of shoot growth & bloom



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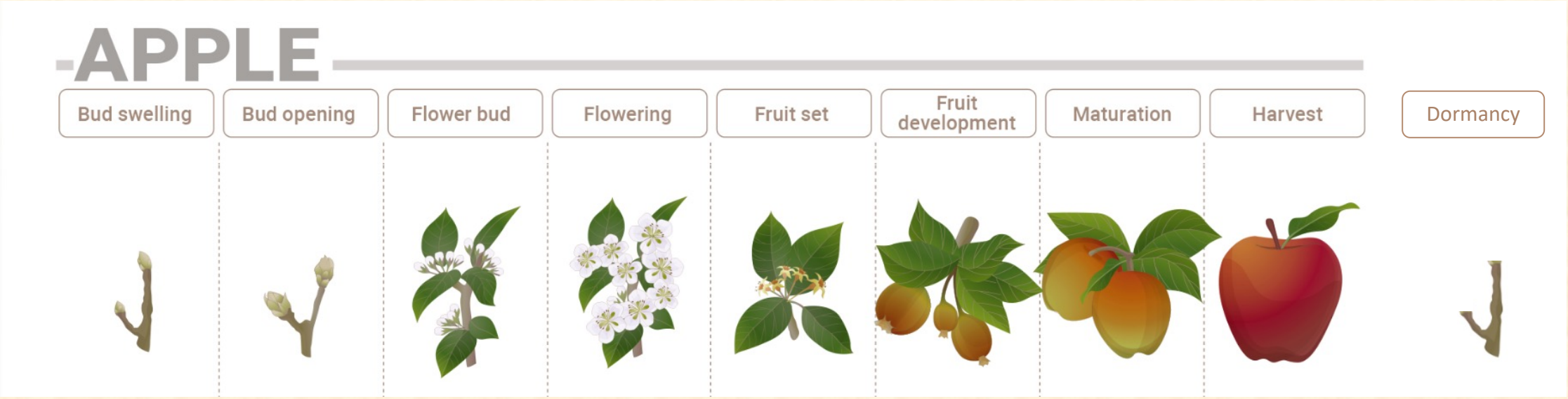
Timing – Nitrogen Notes

Ensure N is in root zone right before uptake in early spring, just ahead of shoot growth & bloom

Small, frequent N applications during the growing season help reduce risk of nitrate leaching compared to a large N application

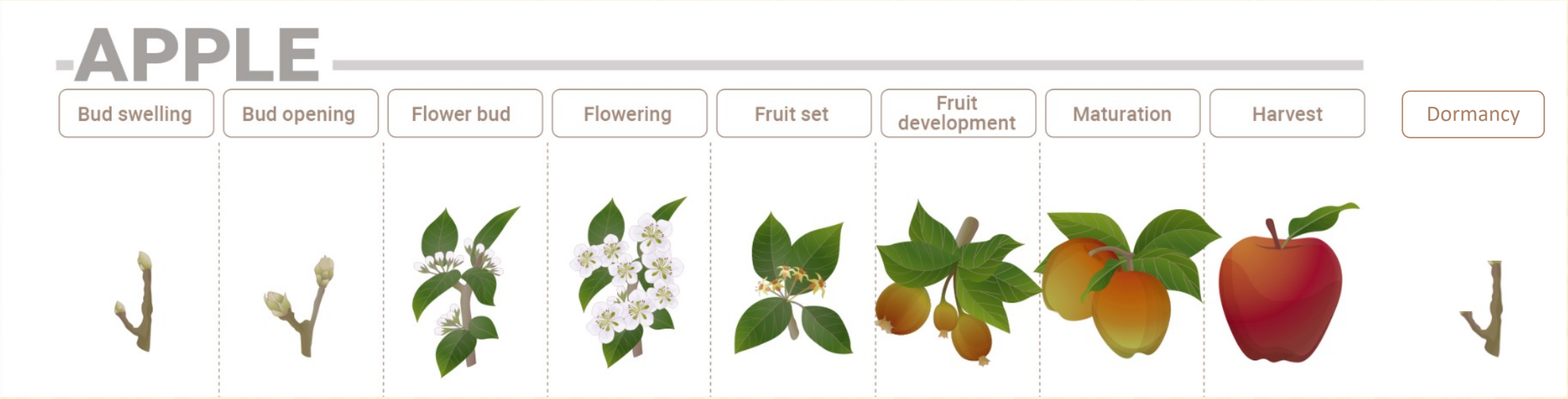


Credit: SQM Nutrition

Timing – Nitrogen Notes

Cover crops are typically seeded late autumn, grow during the winter and spring, then disced in

Compost is usually applied in during dormancy

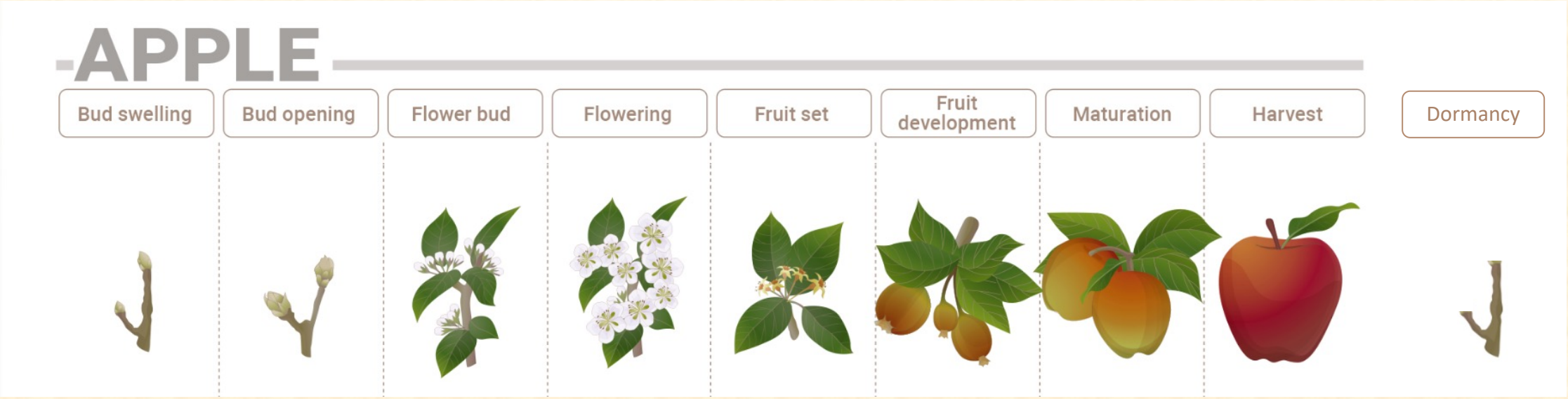


Credit: SQM Nutrition

Timing – Nitrogen Notes

If you're on sandy soil and have a K deficiency, consider fertilizing in early spring before irrigation/rain event

Only if needed: zinc sulfate sprays & other micronutrient sprays are typically late-dormant applied



Credit: SQM Nutrition

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 with manure-based composts, apply 120 days before harvest

Compost pile at Laura’s Apples

Source

- Conventional apple growers in the Central Coast area often use ammonium sulfate
- Organic growers in the Central Coast area use cover crops to supply most of the orchard's N needs annually, compost can be used to supplement
- In our region, it varies a lot—some growers don't use any fertilizer, others use conventional fertilizers, others use organic sources

(Devoto Orchards)

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 (K)
  - Many K fertilizers are mined from natural sources, most are classified as organic
  - Manures and compost contain some K but are highly variable
  - Conventional growers often prefer K sulfate over K chloride to avoid salt toxicity from the chloride
- Boron: U.S. Borax products are OMRI listed
- Beware of salts in manure-based sources

Composting operation.
Photos from Joe Connell.

Source

Adding lime to soil before planting (treefruit.com)

- Calcium
  - Adding lime (calcium carbonate) can provide Ca and increase pH
  - Calcium sulfate fertilizer (aka gypsum) can add Ca without affecting pH as much

Source

- Examples of organic sources
  - Commercial organic fertilizer mixes
  - Marine-derived products such as fish meal & kelp dry meal
  - Blood/bone/feather meal
  - Composted manures & green waste
  - Nitrogen fixed by legume cover crops
  - Nutrients from recycled orchard biomass: mowed clippings, pruned & chipped branches, composted pomace, etc.

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

Source

- When comparing fertilizer options, consider:
  - Nutrient concentrations
  - Nutrient release rates
  - Equipment needed for application
  - Price
  - Consider ordering with other growers in bulk to save on costs
  - Local availability

If you are Certified Organic

- 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

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

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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

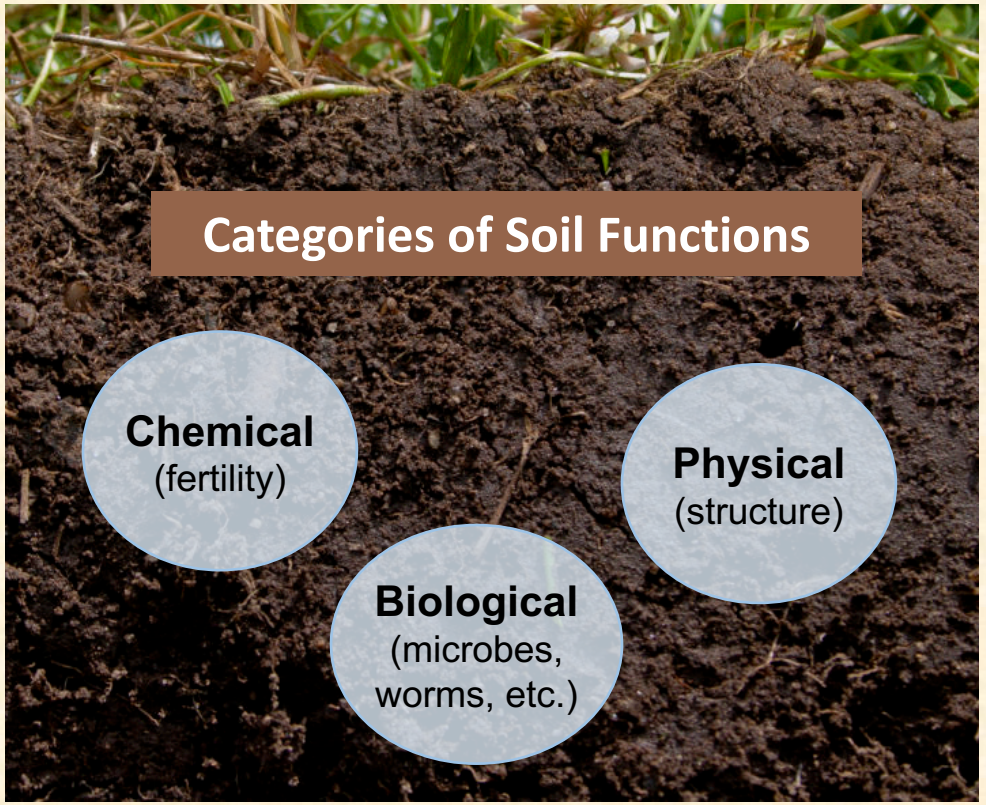
Organic Nutrient Management

- 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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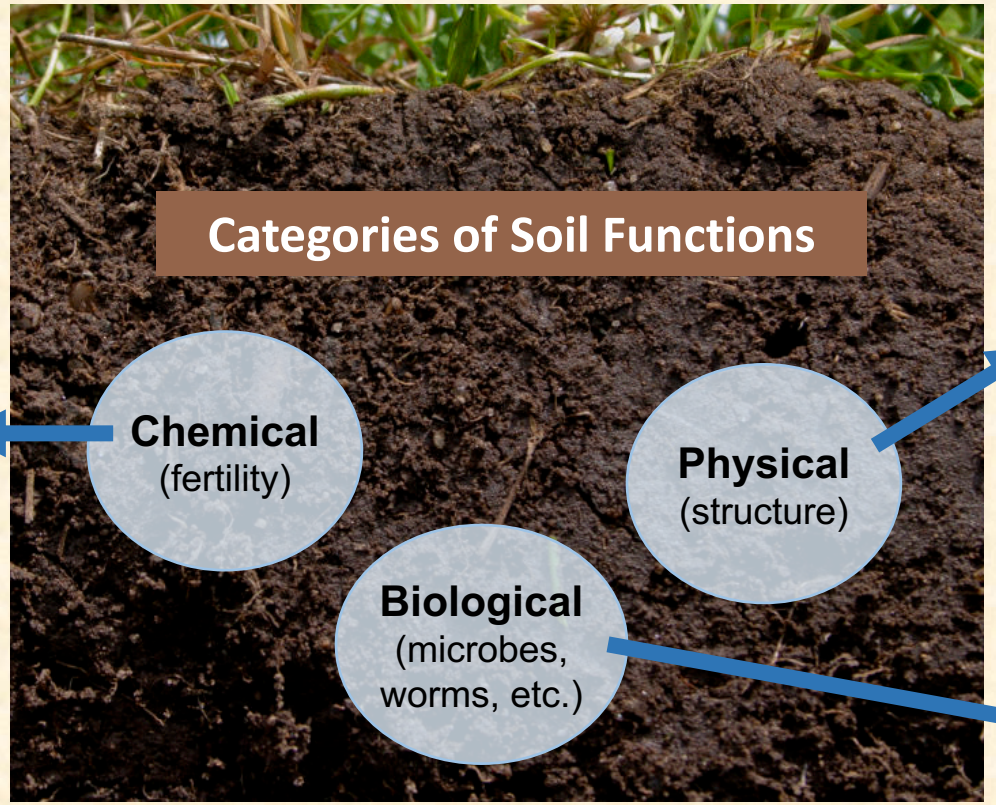


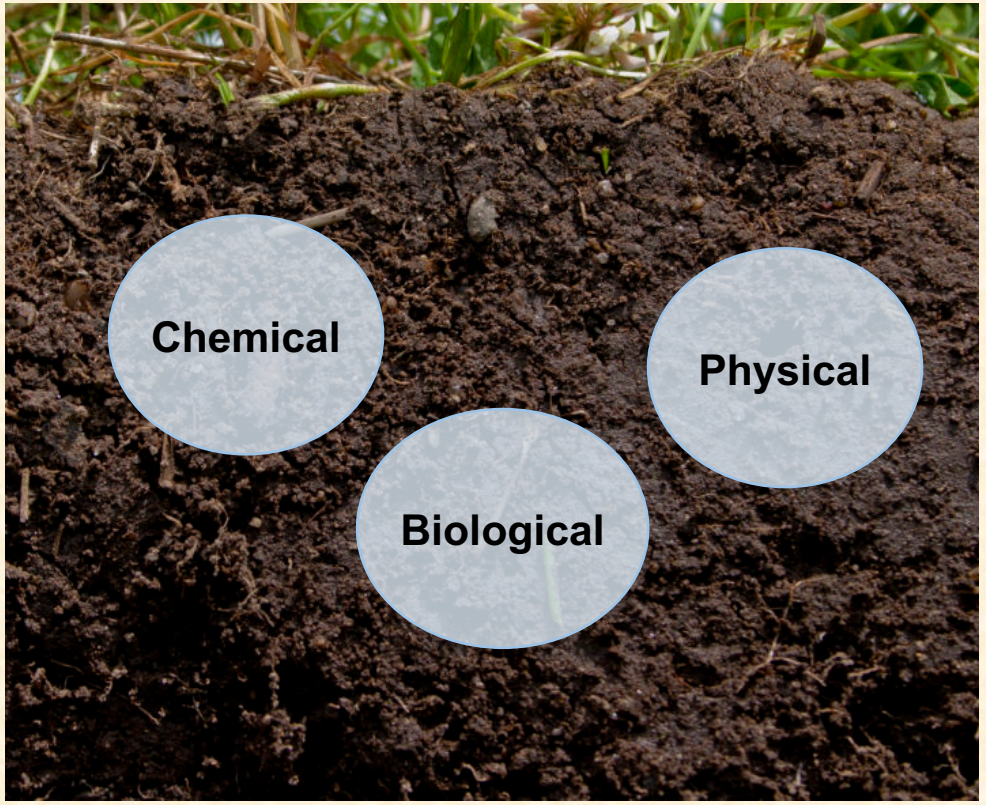
nutrients, pH, Cation Exchange Capacity (CEC)

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

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  - Add organic matter amendments
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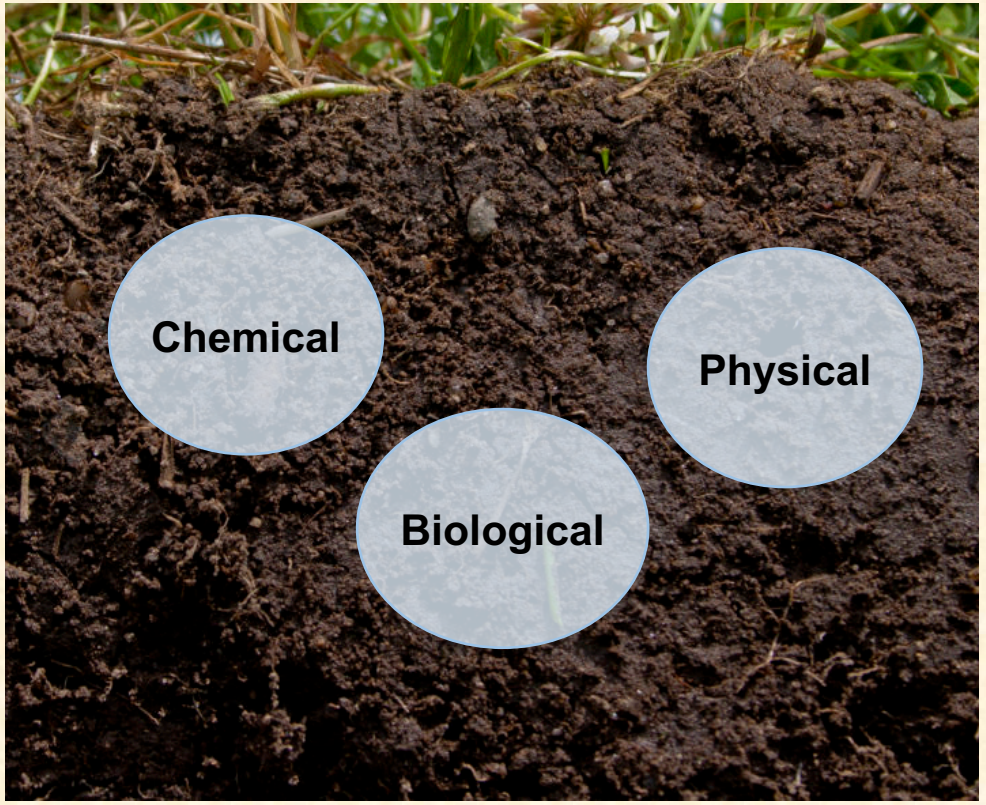
- Choose the strategies that work for your system & unique site characteristics



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
  - Mulch can increase risk of fire spreading quickly

Cover Crops

- Benefits
  - Provide nutrient inputs
  - Keep roots in the soil
  - 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 or discing to terminate
  - Can encourage gopher populations
  - Might require additional water

Recycled Orchard Materials

- Inputs can be expensive…what could be recycled on site? Or nearby?
- Pruned branches can be chipped & used as mulch
- Cover crops can be mowed and placed over tree roots
- Recycle nutrients stored in plant biomass when possible

Example of chipping pruned branches in olives: McEvoy Ranch

Why do we need nutrient management?

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

Why do we need 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 apples

Nitrogen deficiency symptoms.
Credit: Eric Hanson, MSU

Tools

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

Nitrogen deficiency symptoms.
Credit: Eric Hanson, MSU

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. could be factors

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 as needed

Resources

UCDAVIS

Agricultural & Resource Economics UCDAVIS

Cost & Return Studies

Apples

Home • Current Studies • Commodities • Apples

Current Studies

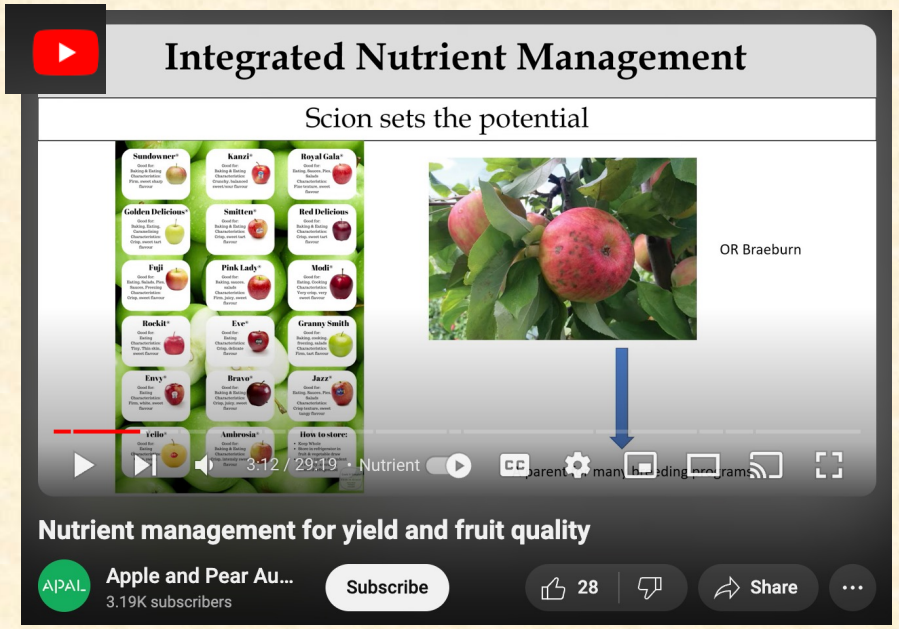
Study	Regions	Counties	Year	Production conditions
Apples (pdf) Apples (xlsm)	Central Coast	San Benito, Monterey, Santa Cruz	2023	Processing
Apples (pdf) Apples (xlsm)	Central Coast	San Benito, Monterey, Santa Cruz	2023	Processing, organic

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

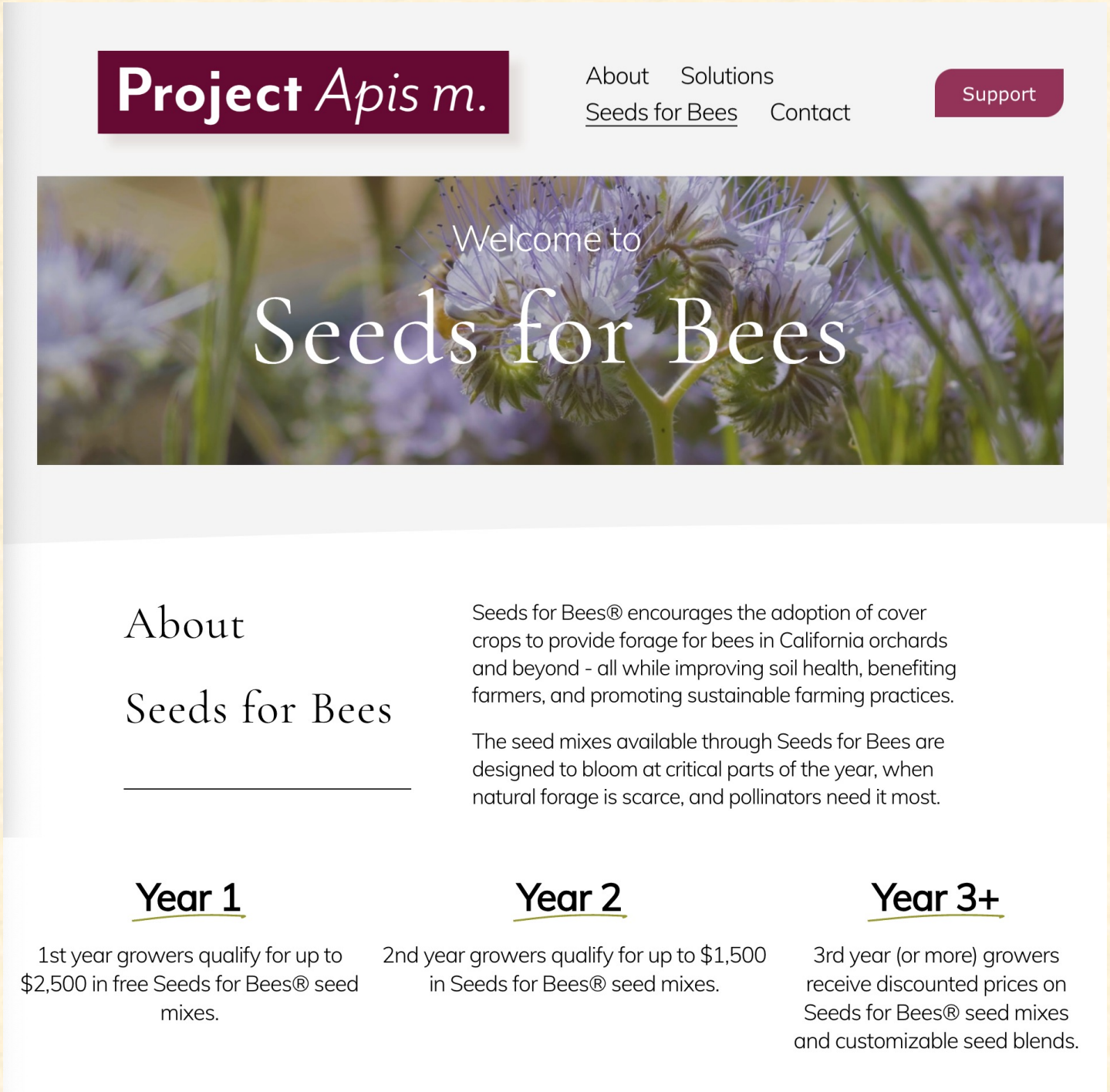
Selected Plant and Soil Laboratories in Northern and Central California

Downloadable List of Selected Plant and Soil Analytical Laboratories

Click here to download table

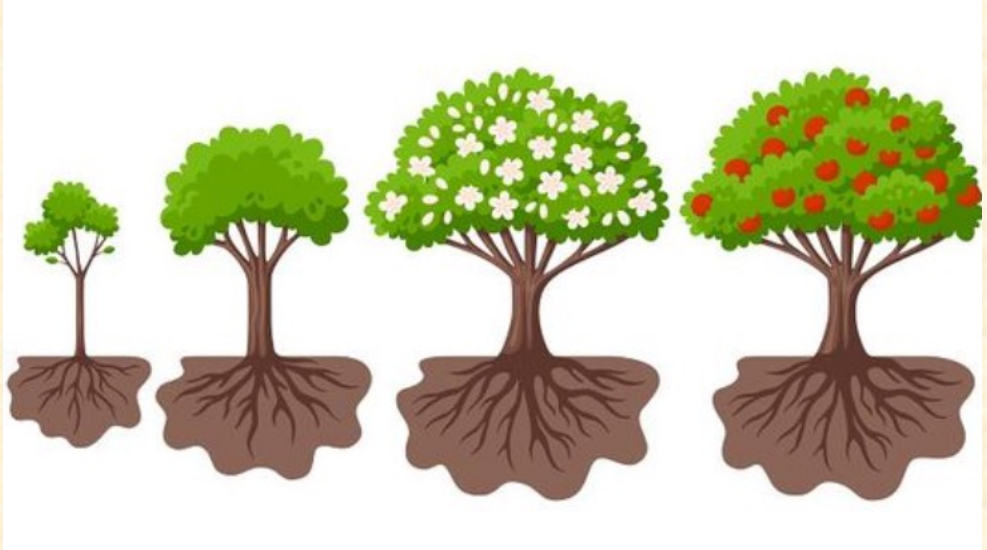


Funding for Cover Crops



Discussion

- Examples? Anecdotes?
- What are the main challenges with nutrient management in apples?
- What could help?
- Success stories? Ideas?



Credit: Pinterest, Creative Market

Thank you!