Macronutrients

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7th Advances in Pistachio Production
SHORT COURSE
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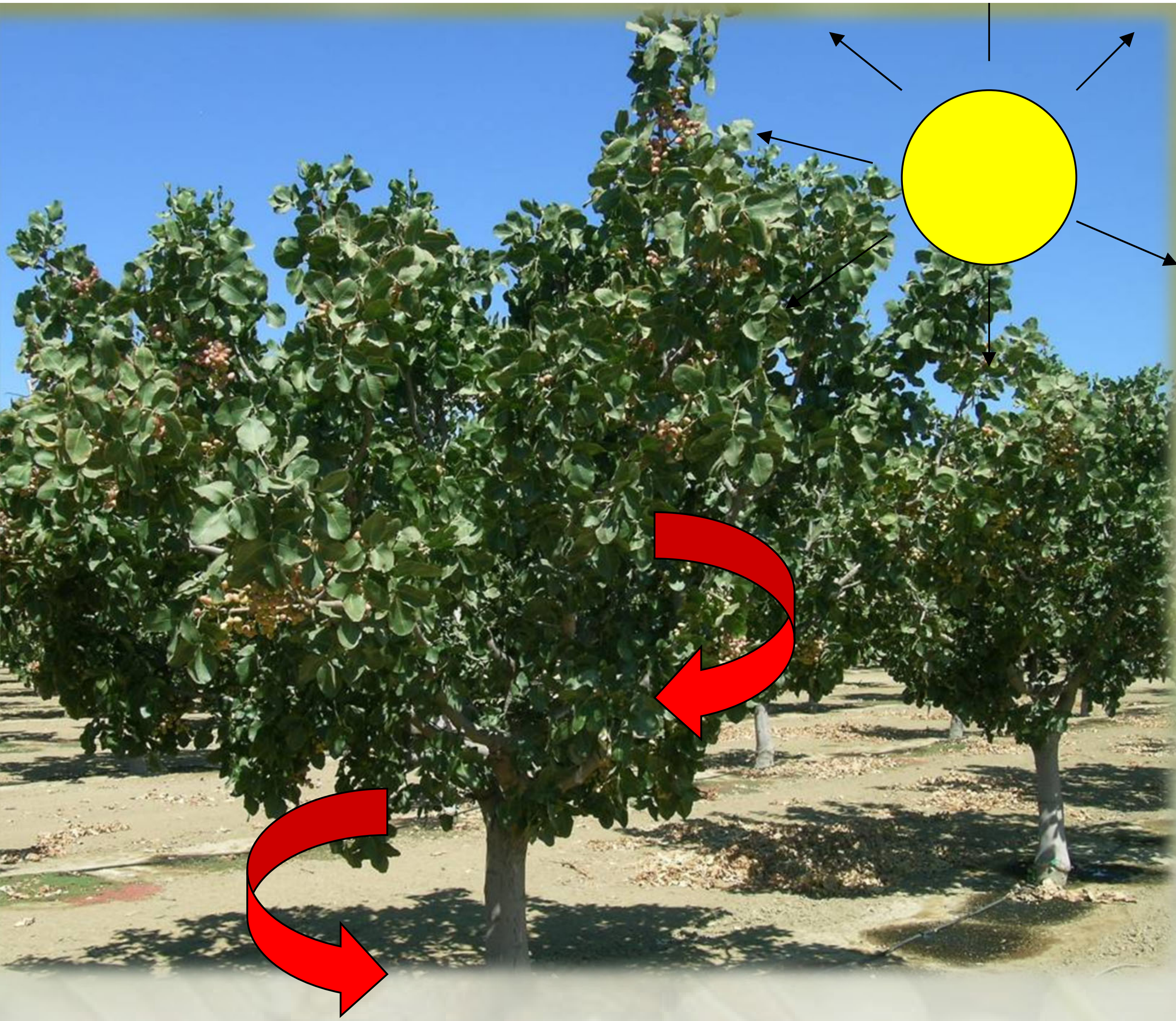
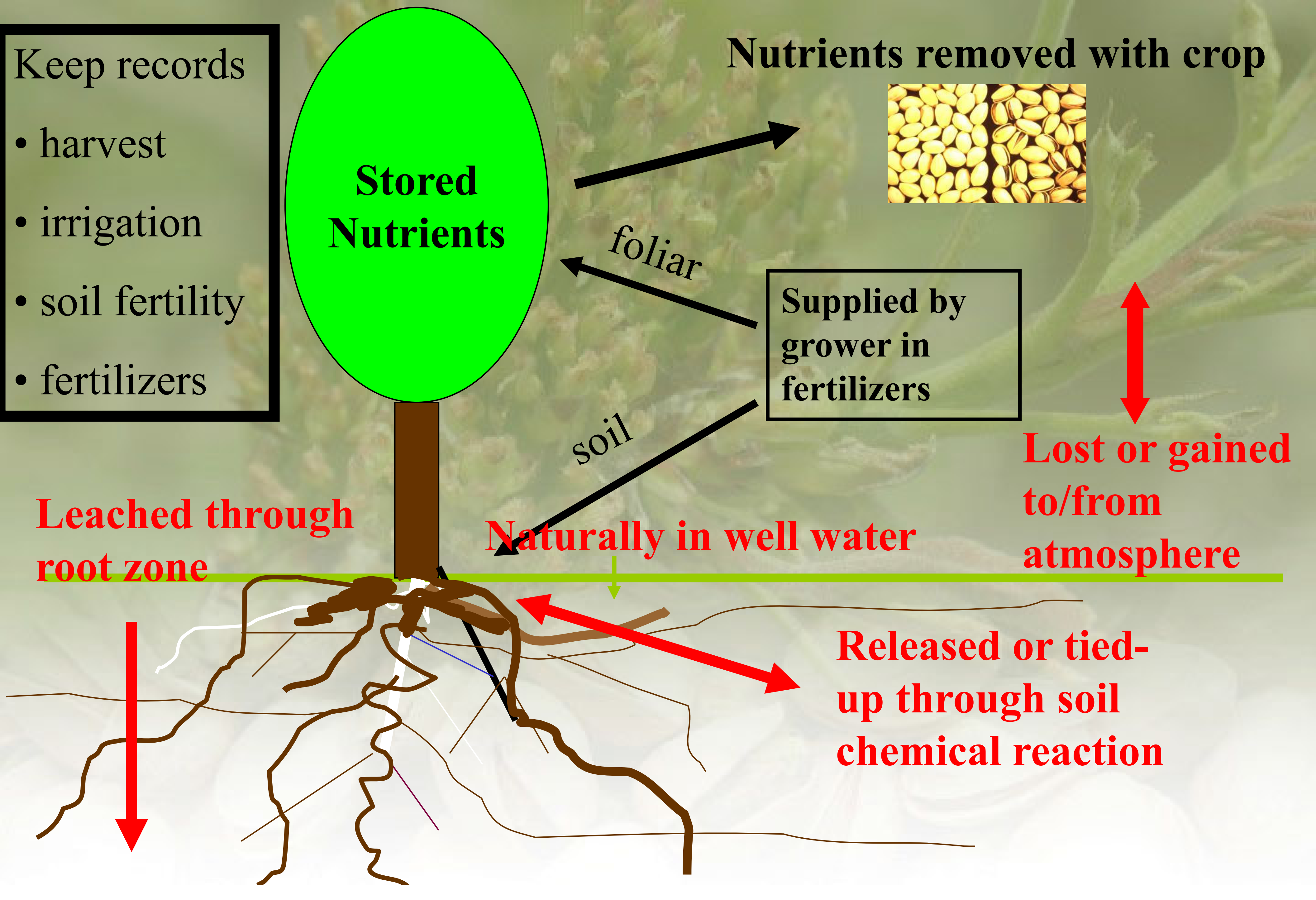


Photosynthesis supplies CHO…

- sunlight
- temperature
- water
- **nutrients**

Nutrient pools in soil and tree

Nutrient Cycle



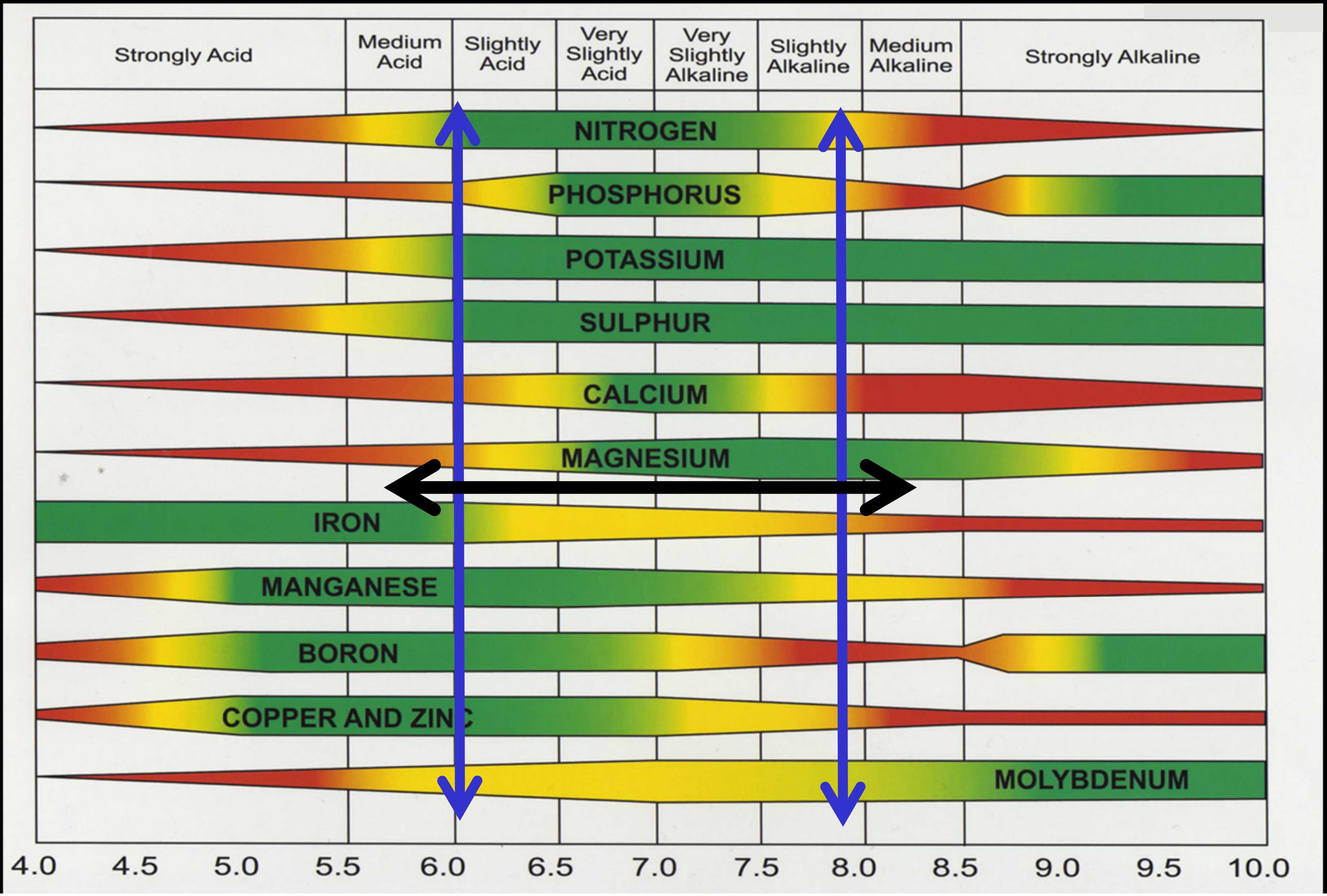
Symbols for the Macro and micronutrients

Macronutrient	Symbol	Secondary Nutrient	Symbol	Micronutrient	Symbol
carbon	C	calcium	Ca	zinc	Zn
oxygen	O	magnesium	Mg	boron	B
hydrogen	H	sulfur	S	copper	Cu
nitrogen	N			manganese	Mn
phosphorous	P			chlorine	Cl
potassium	K			iron	Fe
				nickel	Ni
				molybdenum	Mo

Soil Supply Processes

- Nutrients move to roots in soil moisture
- Nutrient supply from a soil depends:
  - nutrient 'pool' size = amount
  - solubility of nutrients = availability
- Soil chemistry determines solubility
  - minerals, pH, CEC, lime, organic matter content
- Texture: for root exploration
  - structure for penetration, available water and oxygenation

Soil pH and Mineralogy determines Nutrient Availability



Soil Science and Plant Nutrient Uptake

- Nutrients are taken up in water only by active roots on trees with leaves.
  - Active root growth is required.
  - Water and oxygen are required for uptake
  - Leaves are required for nutrient uptake by roots

Soil Science and Plant Nutrient Uptake

- N, S, Mg, Ca are mobile and soluble in most soils
  - Water movement delivers these nutrients to roots
  - Nutrients can be leached or displaced.

Soil Science and Plant Nutrient Uptake

- K is mobile/available in some soils but not others
  - Soil tests to determine K-fixation are essential to K management
  - K, Mg and Ca can interact

Soil Science and Plant Nutrient Uptake

- P has restricted solubility and movement in soils, hence:
  - Root exploration and 'soil health' is critical
  - Nutrients and roots must be in the same place

Mass Flow of soluble nutrients
versus
Dissolution/Diffusion of insoluble elements

Mass Flow Diffusion

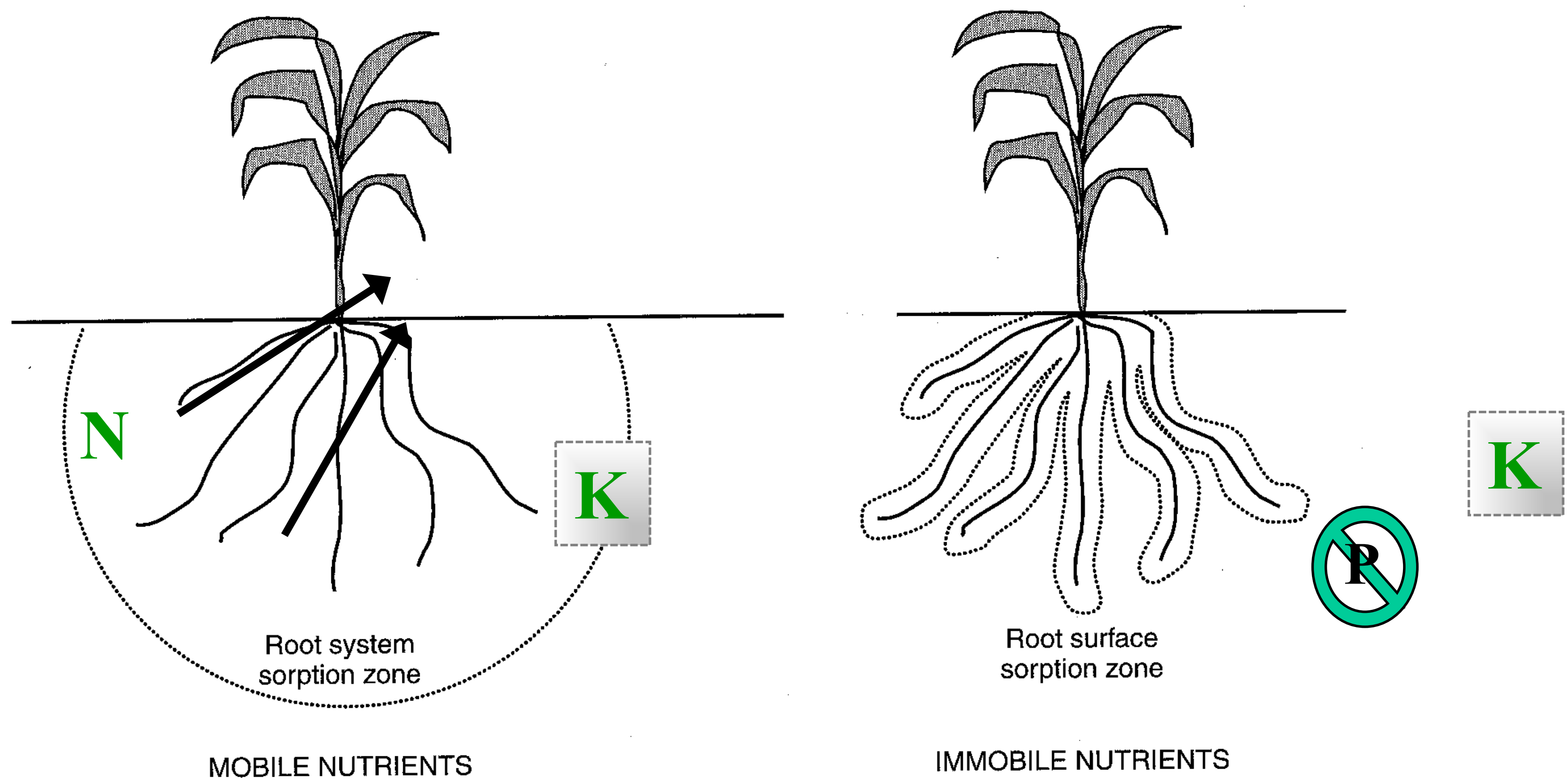


FIGURE 9.44 Difference in nutrient extraction zones between mobile and immobile nutrients in the soil. For mobile nutrients, the soil test must estimate the total nutrient available in the root zone. For immobile nutrients, the soil test is an index of the quantity available to the plant. *Courtesy R. Raun and G. Johnson, Oklahoma State Univ.*

Factors affecting Nutrient Uptake and Utilization

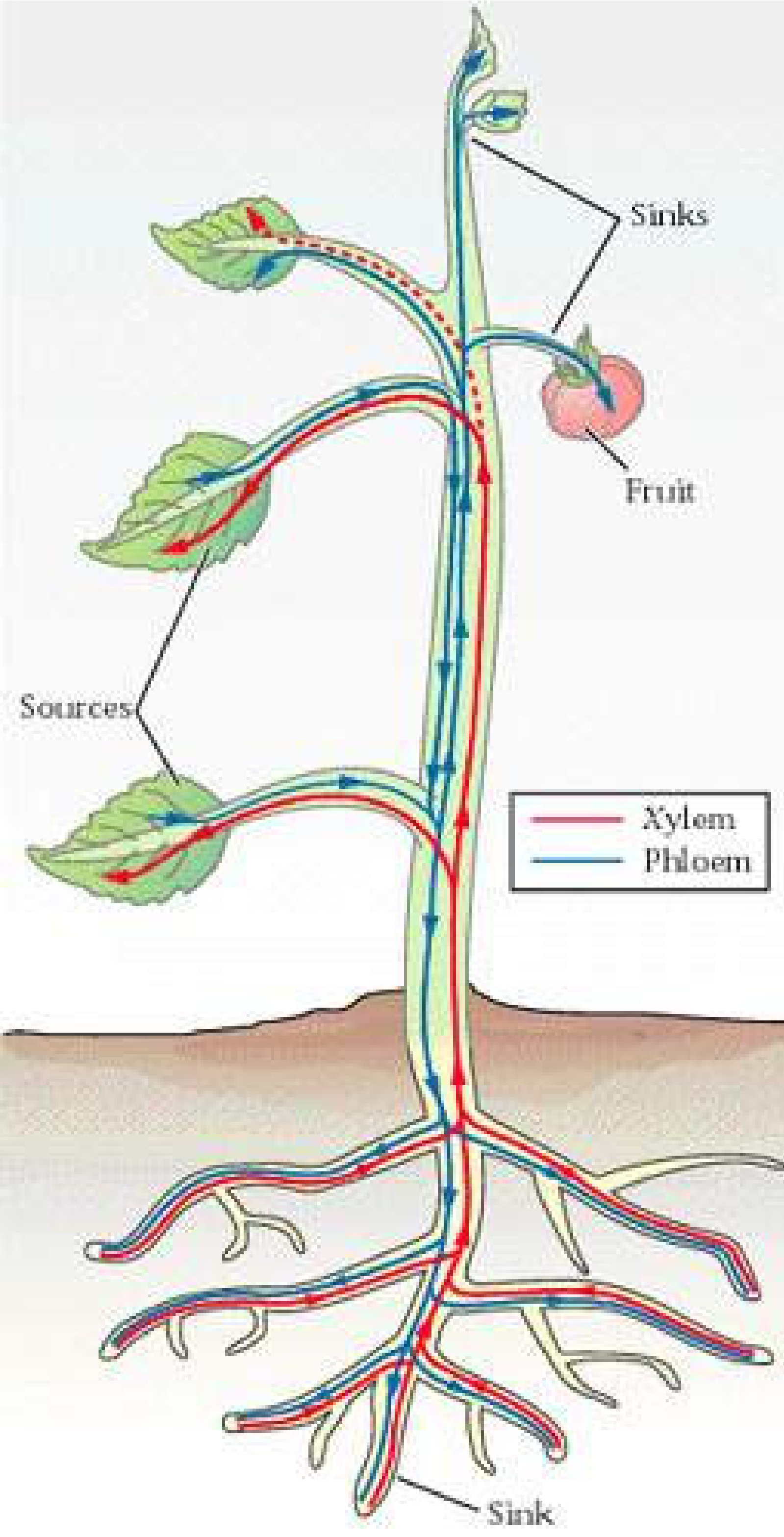
- poor irrigation system design and scheduling
- weed competition
- presence of hardpans, poor water infiltration, perched water tables, alkali spots
- salinity (soil or water), pH, nutrient fixation
- low soil temperature (microbial activity, root activity)
- weather/climate, limitations of tree uptake and transport
- low or high native soil fertility for one or more nutrients
- root disease (i.e. Verticillium wilt affects K uptake)

Nutrient Mobility in Plants

- Nutrients taken can move about in plant
- Can be stored in plant
- Determines when and where deficiencies and toxicities will appear
- Indicates how and when to fertilize

Nutrient Mobility in Plants

Freely Mobile **(nutrient moves from mature leaves to all plant parts)**	**Low Mobility** **(a very small amount of nutrient moves from mature leaves to other plant parts)**	**Immobile** **(No movement.)**
Nitrogen	Zinc	Manganese
Potassium	Molybdenum	Iron
Phosphorus, Sulfur	Copper	Calcium
Magnesium	Nickel	Boron
Chlorine, Molybdenum		



Mobile Elements move in:

- Xylem (one way)
- Phloem (two way)
- N, P, K, Mg, S

Movement is driven by demand for growth.

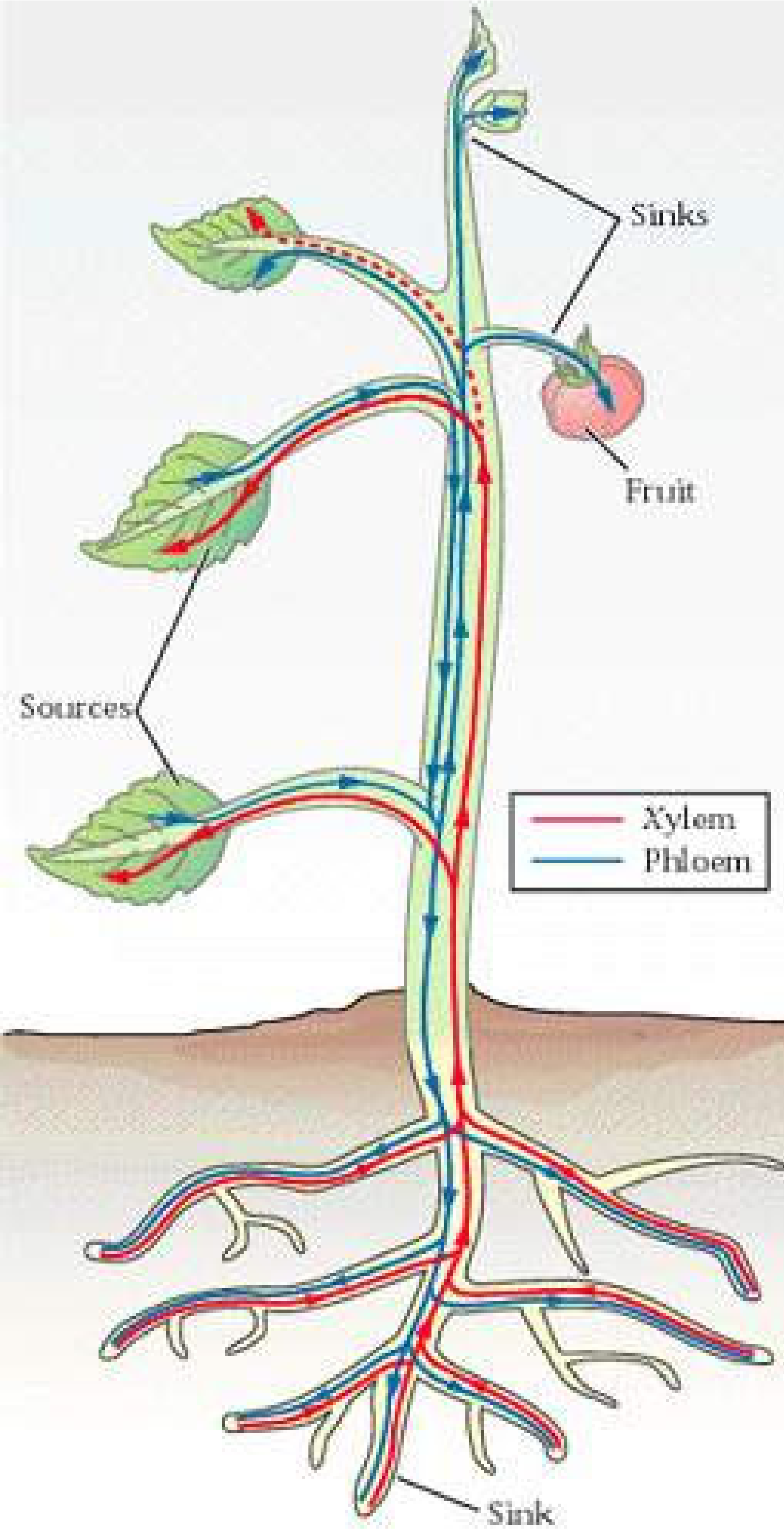
Fertilization has longer term benefits

Nutrients can be stored

Foliar fertilizers can supply current and developing tissues

Older plant parts develop deficiencies first

Photosynthesis and growth drives movement



Immobile Elements: move in:
- Xylem
Ca

Delivered by one-way flow of water in xylem.

Driving force is the transport of water:
- decreased water flow = decreased transport
- tissues that don't transpire more likely to be deficient

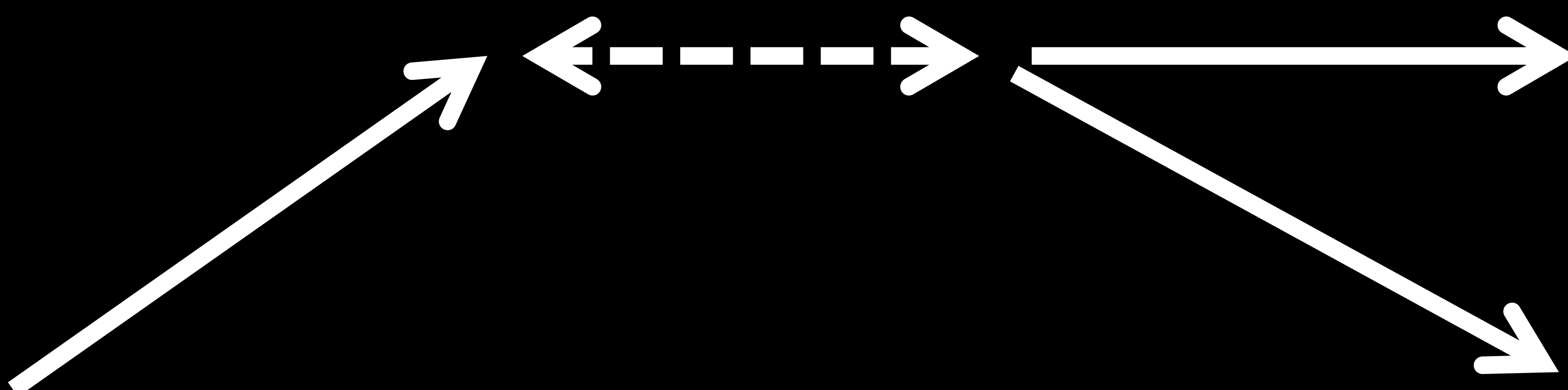
Management Implications:
- supply required through growth and reproduction
- fertilizers have limited long term effectiveness
  - foliar fertilizers benefit only the tissues sprayed
  - cannot benefit tissues developed after application.

Pistachios Tree Macronutrient Storage

Cropping Status	N	P	K	Ca	Mg
ON	16	0	53	41	9
OFF	113	14	92	0	16

Total stored nutrients end of the season in kg/hectae

Element	Critical Value	Suggested Range	Reference
Nitrogen (N)	1.8%[1]	2.2 -2.5%	Weinbaum, et al. 1988, 1995
Phosphorus (P)	0.14%	0.14-0.17%	
Potassium (K)	1.6%	1.8 - 2.2%	Brown, et.al. 1999
Calcium (Ca)	-[3]	1.3-4.0%	
Magnesium (Mg)	-	0.4-1.2%	
Sodium (Na)	-	-	
Chlorine (Cl)	-	0.1-0.3%	
Manganese (Mn)	30 ppm	30-80 ppm	
Boron (B)	90 ppm	150-250 ppm	Uriu, 1984; Brown, et al.1993
Zinc (Zn)	7 ppm	10-15 ppm	Uriu and Pearson 1981, 1983, 1984, 1986
Copper (Cu)	4 ppm	6-10 ppm	Uriu, et al. 1989



Established Pistachio Nutrient Values

Macronutrient Diagnosis

- Visual: when, where and what
- Leaf sample
- Soil
- Water

Macronutrient Diagnosis

- Leaf sampling:
  - The most commonly used production monitoring tool..after visual observation

Macronutrient Diagnosis

- Visual: when, where and what
  - mobile elements; older leaves first
    - more pronounced later in the season
  - Immobile: new leaves first
    - can be evident in spring
  - Deficiencies are specific to nutrient function

Macronutrient Diagnosis

- Visual: when,where and what
- Leaf sampling: tree status integrator

Macronutrient Diagnosis

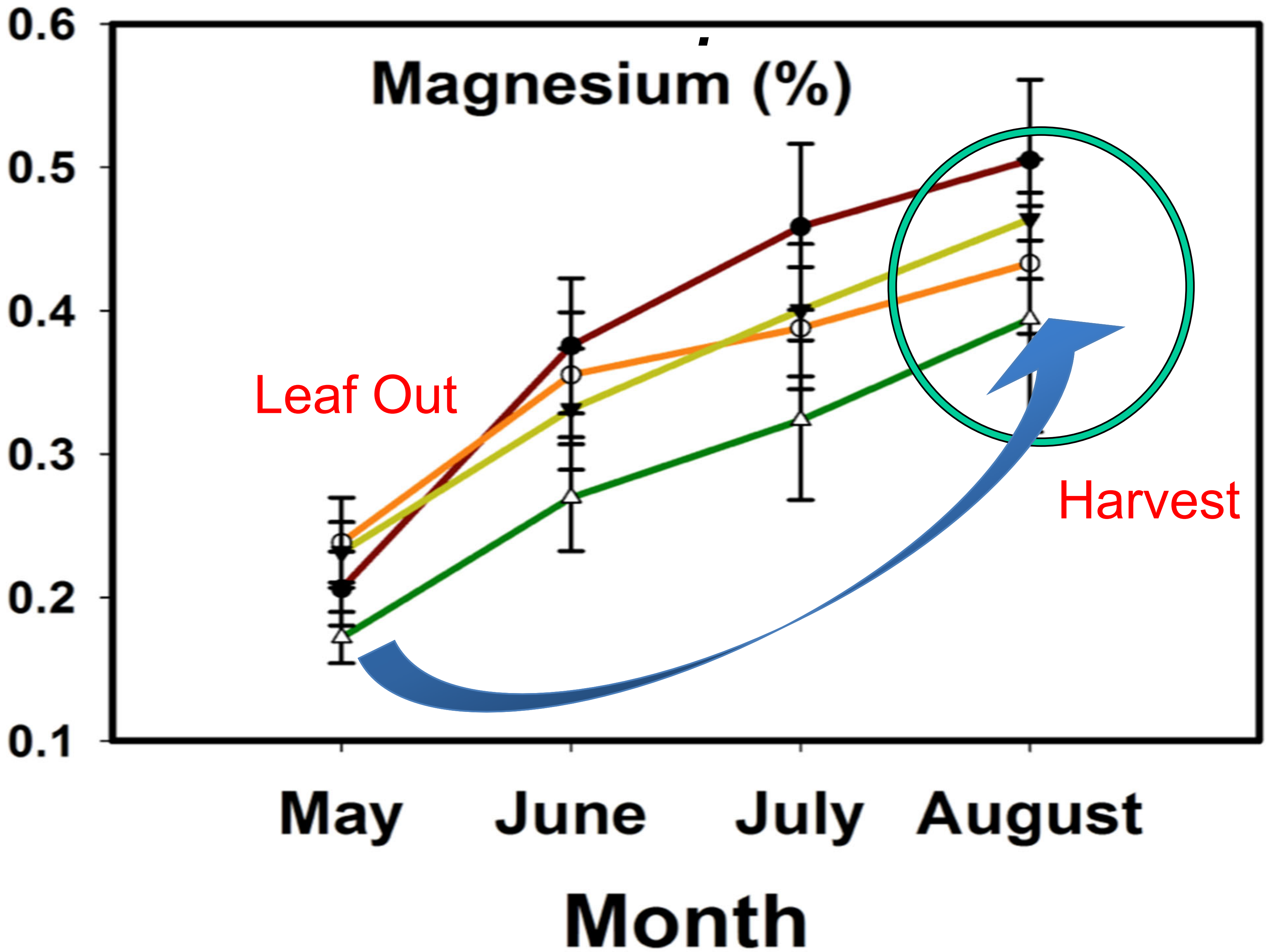
- Leaf sample = net integrator of tree status:
  - fraction by weight of nutrients in
    - non-terminal leaflets
    - non-fruiting leaflets
    - 30-50 DAFB
    - in late July and August

is correlated to orchard nutritional status

Macronutrient Diagnosis

- Visual: when, where and what
- Leaf sampling: tree status integrator
  - recent change
    - now sampling twice in-season

Can late summer nutrient status be predicted with a spring leaf sample?



YES: Spring samples can predict summer values.

Site	Year	July Nitrogen Predicted	July Nitrogen Observed
Arbuckle	8	2.4	2.3
Belridge	8	2.4	2.4
Madera	8	2.5	2.4
Modesto	8	2.4	2.4
Arbuckle	9	2.4	2.6
Belridge	9	2.4	2.4
Madera	9	2.6	2.4
Modesto	9	2.6	2.7
Arbuckle	10	2.4	2.5
Belridge	10	2.3	2.7
Madera	10	2.3	2.3
Modesto	10	2.4	2.5

Average Orchard: 4-8 hectare acre block.

Spring or Summer Sampling

- **Collect sub terminal leaves from non-fruiting branches.**
- **Minimum of 13 trees each tree sampled at least 25 meterss apart.**
- **In each tree collect 10 leaves around the canopy from well exposed branches located between 1.5-2 meters from the ground.**
  - **If cost is a constraint, samples can be pooled into a single sample for analysis to guide an individual orchards management**
  - **Analyze for the N, P, K, S, Ca, Mg, Cu, Zn, Fe, B**
- **In spring, collect samples soon after full leaf expansion:(approx. 30-50 days after full bloom (DAFB), for standard sample collect in late July.**

Non-Uniform Orchard:

- **Repeat this process in each orchard zone of similar performance.**

Recommended Sampling Criteria

Sub-terminal Leaf on non-fruiting branch

13 trees at leas 30 meters apart. 10 leaves per tree. Pooled

In non-uniform orchards sample each soil or productivity zone separately.

Macronutrient Diagnosis

- Soil
- Water
  - diagnosing a site
  - monitoring changes; salinity
  - answering a question

Nitrogen

- **<u>Leaf Levels:</u>**
  - **% N in leaf dry matter of leaves indicates N tree storage**
  - **1.8%is critical value**
  - **2.2 – 2.5% is optimal range**

Nitrogen

- **Deficiency Symptoms**
  - Mobile: new leaves mobilize N at expense of old leaves
  - new leaves pale
  - old leaves yellow and drop
  - Reduced shoot growth; shorter and thinner
  - Reddish bark if severe

Not a Problem

Potassium

- **<u>Leaf Levels:</u>**
  - **% K in leaf dry matter of leaves indicates K tree storage**
  - **1.6% is critical value**
  - **1.8 – 2.2% is optimal range**

Potassium

- **Leaf Symptoms:**
  - Symptoms appear early to mid summer
  - Small leaves without chlorosis and scorched margins
  - Worst on older leaves of current shoots
  - Sparse foliage with pronounced dieback
  - Yields decline as K declines

Phosphorus

- **Leaf Levels:**
  - % P in leaf dry matter of leaves indicates P tree storage
  - 0.14% is critical value
  - 0.14 – 0.17% is optimal range

Phosphorus

- **Leaf Symptoms:**
  - initially interveinal chlorosis then older leaves became bright yellow, dessicate and drop
  - first on nuts next to clusters

Update on July Critical Leaf Values
Calcium and Magnesium

Element	Critical Value	Suggested Range	Reference
Nitrogen (N)	1.8%	2.2 -2.5%	Weinbaum, et.al. 1988, 1995
Phosphorus (P)	0.14%	0.14-0.17%	
Potassium (K)	1.6%	1.8 - 2.0 %	Brown, et.al. 1999
Calcium (Ca)	1.3% (?)	1.3-4.0%	2.0%
Magnesium (Mg)	0.6% (?)	0.6-1.2%	0.4%
Sodium (Na)	(?)	(?)	
Chlorine (Cl)	(?)	0.1-0.3%	
Manganese (Mn)	30 ppm	30-80 ppm	
Boron (Bo)	90 ppm	150-250 ppm	Uriu,1984; Brown, et.al.,1993
Zinc (Zn)	7 ppm	10-15 ppm	Uriu and Pearson.1981, 1983,1984,1986
Copper (Cu)	4 ppm	6-10 ppm	Uriu, et.al. 1989

ppm = parts per million or milligrams/kilogram dry weight.
% = parts per hundred or grams/kilogram dry weight

Conclusions: Managing Nitrogen

Base your fertilization rate on realistic, orchard specific yield and adjust in response to spring nutrient and yield estimates.

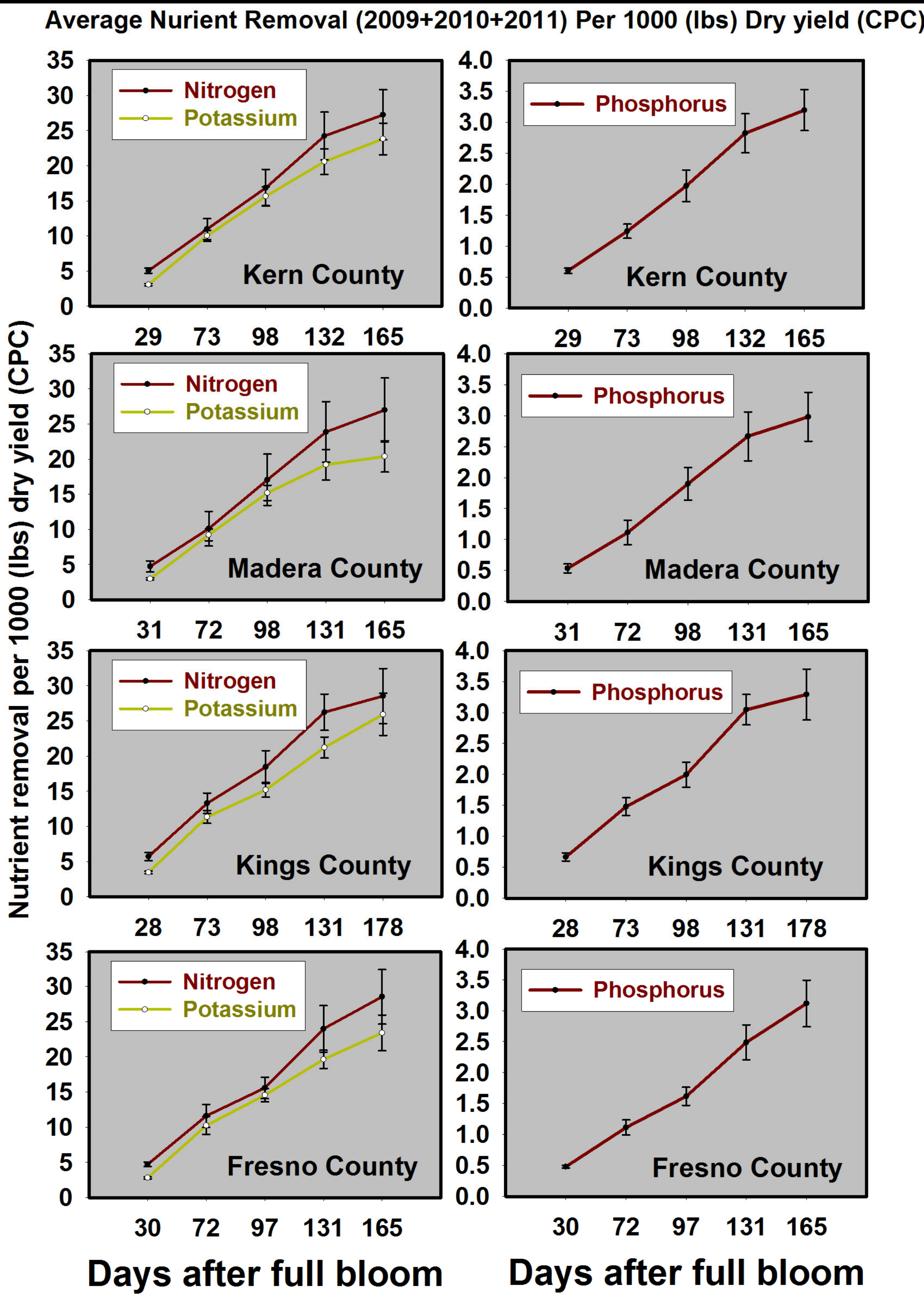
- **Make a preseason fertilizer plan based on expected yield.**
    - **Every1000 kg. pistachio crop removes 29 kg N, 25 kg K and 3 kg P…and 25kg is given to the tree.**
- **Conduct leaf analysis following full leaf out.**
- **Using leaf analysis and updated yield estimate, adjust fertilization for remainder of season.**
    - **Uptake of N, K, P occurs uniformly from leaf out to harvest.**
    - **Apply up to 20% immediately post harvest, corrected for actual yield - but only if trees are healthy.**
- **Every field and every year is a unique decision, adjust fertilization accordingly.**

Conclusions: Managing Nitrogen

•*Leaf analysis is useful for monitoring orchards but it is NOT adequate to make fertilizer decisions.*

Follow the sampling rules!

- **13 trees/one bag/each 30 meters apart. You can sample in spring to estimate summer.**
- **Use leaf analysis in conjunction with yield estimate to adjust in-season fertilization.**
- **Keep good records and sample consistently and correctly over the years.**
- **Every field and every year is a unique decision, adjust fertilization accordingly.**



Nutrient removal Per 1000 lb
(CPC Yield)

- Nutrients removed in all fruit components and accounts for losses in non-marketable fruit.
  - N removal 29 kg per 1000
  - K removal 25 kg per 1000
  - P removal   3 kg per 1000
  - Mg, S, Ca are abundant in most soils and not removed in large quantities.
- 28 N per hectare, per year is required for tree growth (averaged over 20 years – Rosecrance et al 1998)
- 4000 CPC kg yield 'removes'
  - 116 kg N (+25 for growth)
  - 100 kg K (+22 for growth)
  - 12 kg P

Conclusions

- Apply the Right Rate
  - Match demand with supply (all inputs- fertilizer, organic N, water, soil).
  - Nutrient demand changes as yield changes. Fertilizer rates should vary, year to year.
  - Conduct Tissue Sampling to monitor your progress, but do it correctly!

Conclusions

At Right Time

- **Time fertilizations with demand.**
- **Uptake occurs only when healthy leaves are on the tree.**

Conclusions

- In the Right Place
  - Ensure delivery to the active roots.
  - Minimize movement of nutrients beyond the root zone
  - Pay attention to variability within a field and between fields

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