The Nutrition of Walnut.

Plant Nutrition 101: Understanding the Principles to Optimize the Practices.

Tri-County Walnut Day

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How, Why, When, Where and What of Tree Nutrition

Principles:

- How are nutrients acquired by plants
- Why are they needed and what is their function
- When and where are they required

Practices:

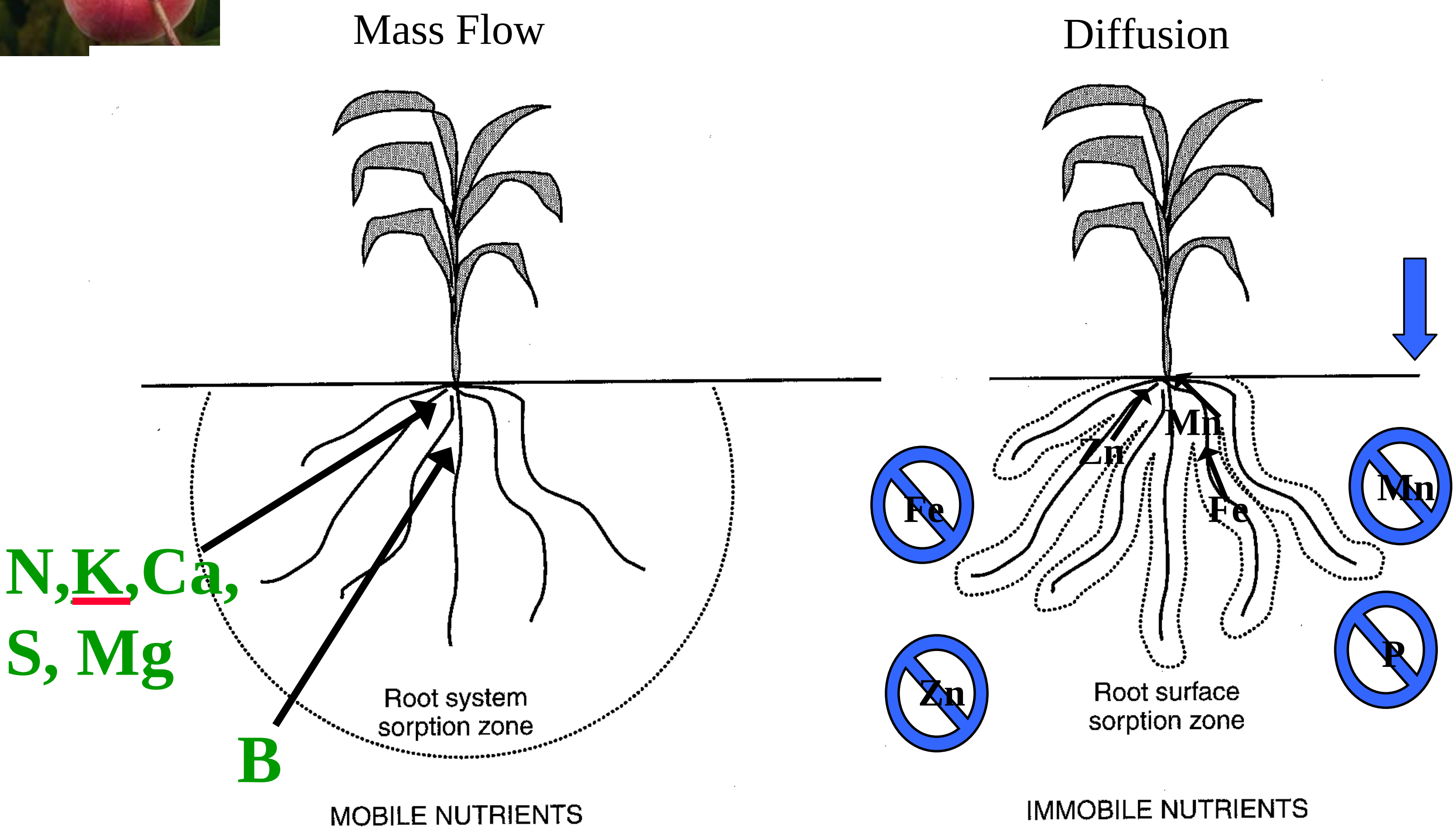
Optimized Nutrient Monitoring, Optimized Fertilizer Management.

How are nutrients obtained?

Soil Science and Plant Nutrient Uptake

- Nutrients are taken up in water only by active roots.
  - Active root growth is required.
  - Water, oxygen, suitable temperatures are required for uptake
  - Leaves are required for nutrient uptake by roots
- N, S, Mg, Ca, B are mobile in most soils
  - Water movement delivers these nutrients to roots
- Mn, Zn, Cu, Ni, Fe have restricted solubility and movement in soils, hence:
  - Active root growth and soil explotration are critical
  - Nutrients and roots must be in the same place
  - Soils that limit root growth can cause Zn, Fe, Cu deficiencies
- K is mobile in some soils but not others
  - Soil tests to determine K-fixation are essential to K management.

Diffusion versus Mass Flow



Micronutrients (excluding B and Cl) are immobile in the soil and can only be obtained from soil in close proximity to the root surface. Root growth and root patterns (fineness, depth etc) influence uptake.

The uptake of micro-nutrients (Zn, Fe, Mn) depends greatly on roots exudation into the soil, soil organic matter and root induced pH changes

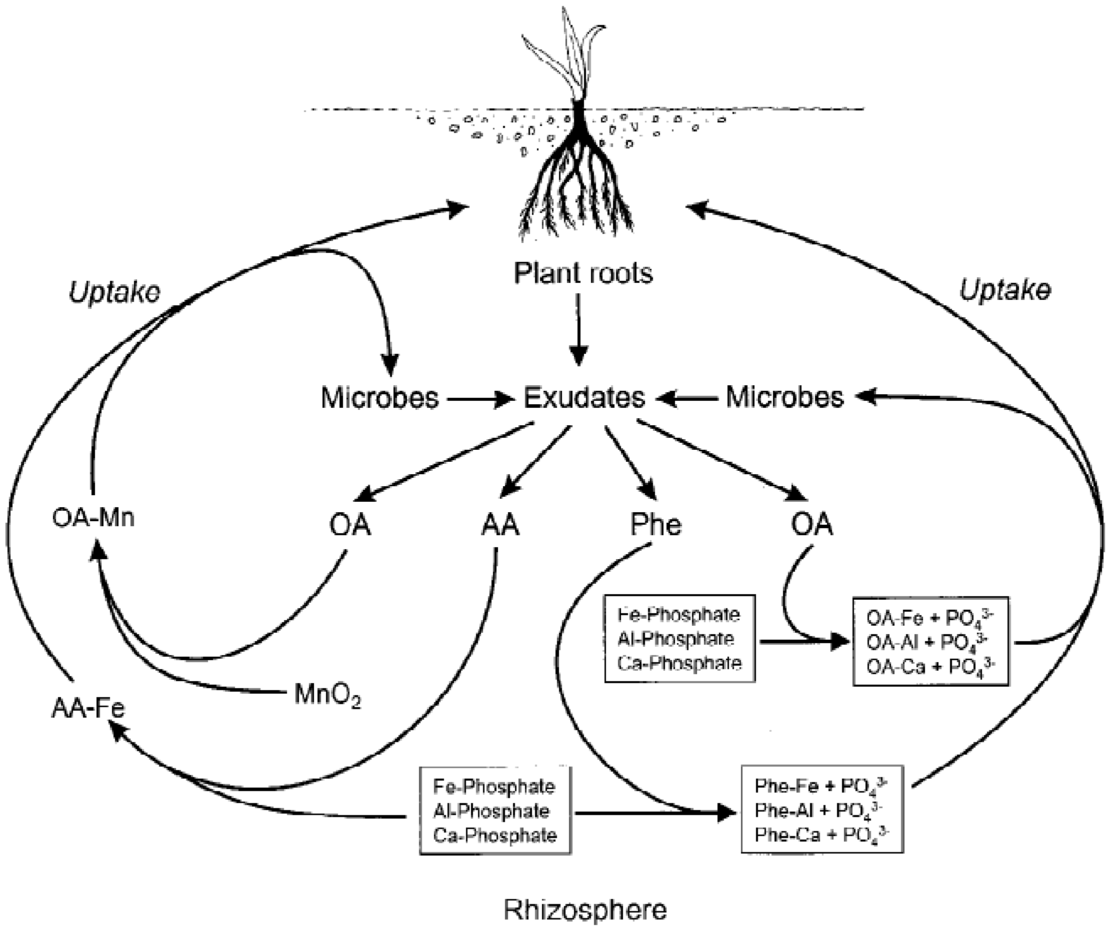
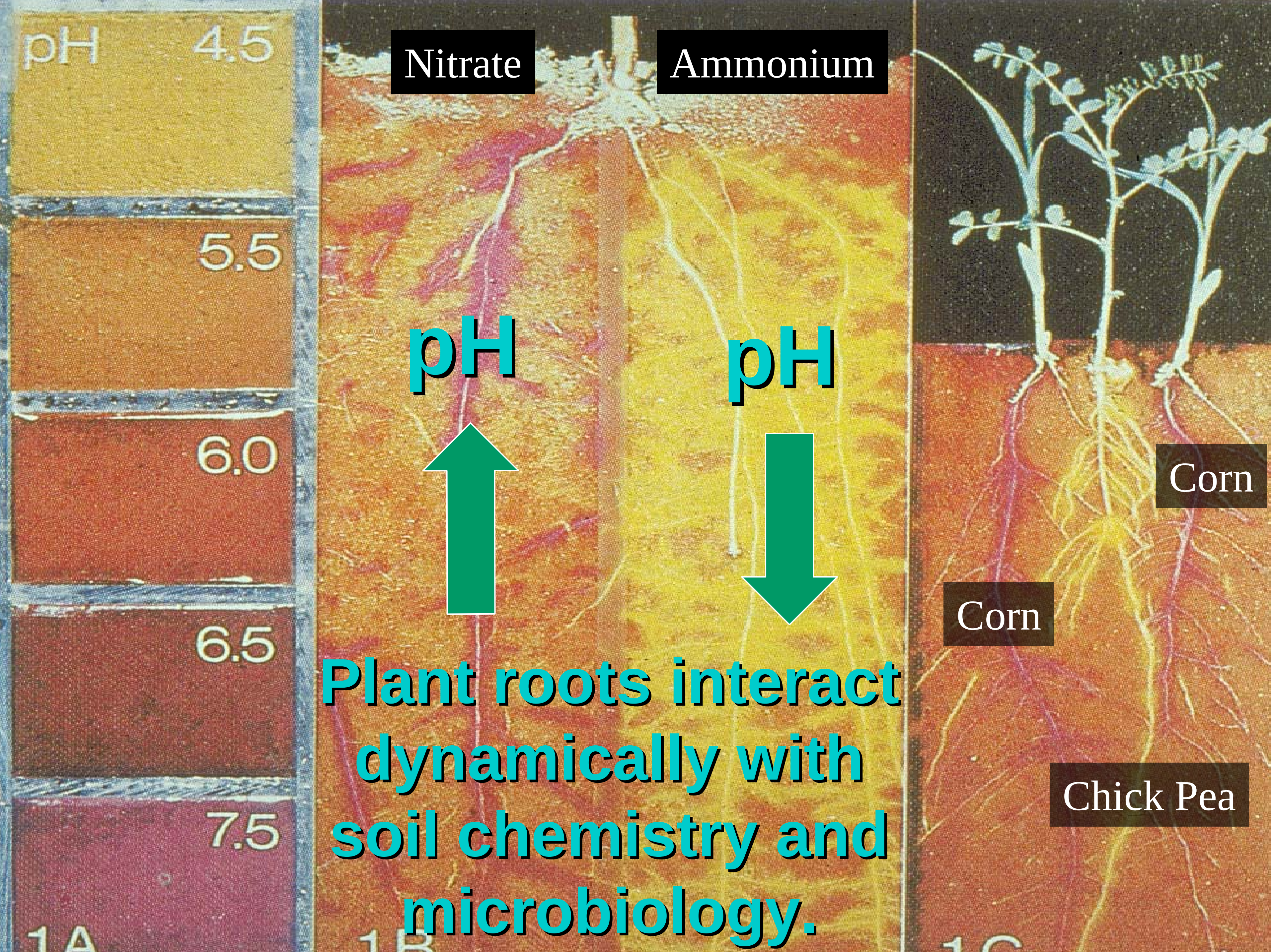


Figure 1. Effects of root exudate components on nutrient availability and uptake by plants and rhizosphere microbes. OA = organic acids; AA = amino acids including phytosiderophores, Phe = phenolic compounds.

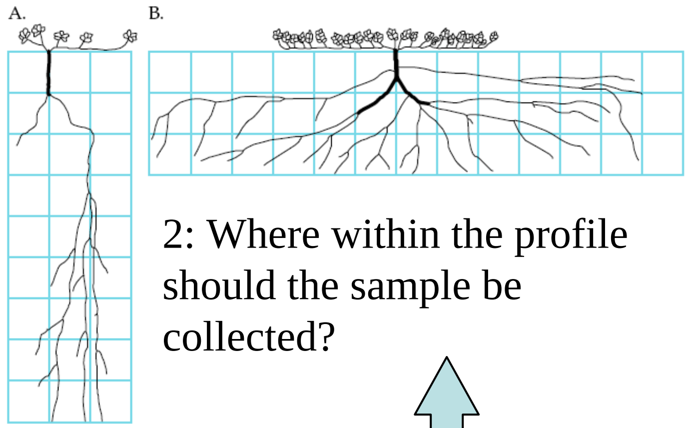
Plant & microbial chelators in the soil dramatically enhance Fe and Mn availability for uptake

Also, microbial activity and enzymatic excretion important for accessing many nutrients held in soil organic matter


pH 4.5
5.5
6.0
6.5
7.5
Nitrate
Ammonium
pH
pH
Plant roots interact dynamically with soil chemistry and microbiology.
Corn
Corn
Chick Pea

CONSTRAINTS OF SOIL TESTING

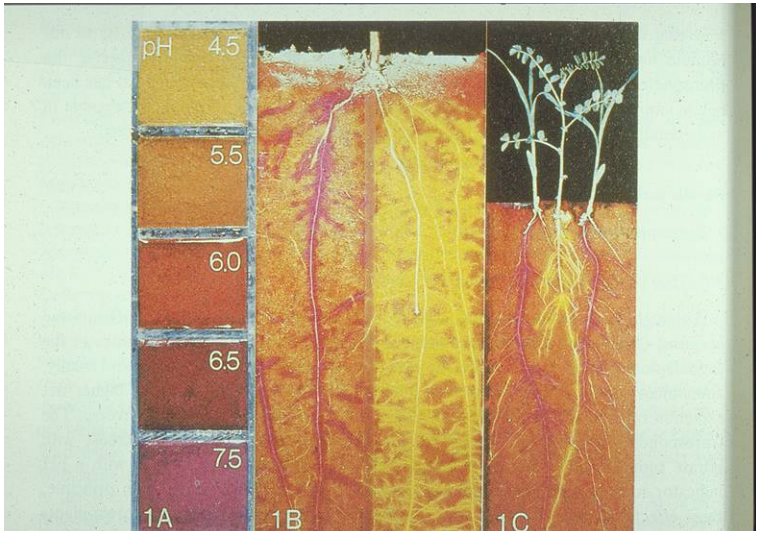
1: A valid soil test must be able to determine the plant available nutrients in the soil.

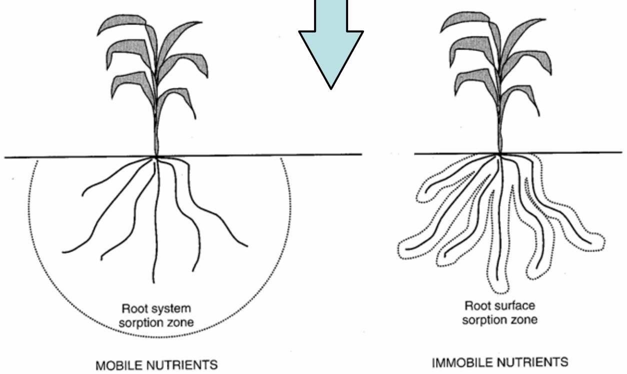


2: Where within the profile should the sample be collected?

3: Plants Can Alter Their Rooting Environment

-Altered soil pH influences micronutrient uptake
-Species vary in their capacity to affect soil pH
-Fe deficiency and Nitrogen source can alter soil pH





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Value of Soil Testing (How and Why)

How:

- Collect soil samples that reflect where roots will be growing
- Collect samples from all parts of the orchard and build a ‘map’ of the whole property. Do it and do it right, most soil characteristics don’t change with time.

What:

- Soil tests that provide background information on general soil physical and chemical characteristics are essential for all orchards.
  - pH, Lime/Bicarbonate - as an index of potential solubility of natural and applied nutrients
  - CEC, OM as a measure of buffering capacity
  - Salinity, Toxic Elements, nutrient imbalances.
- Determine K fixation characteristics.
- For most nutrients (with the exception of K, B), soil analyses of nutrient availability are of limited value.

Why are certain nutrients essential?

Nutrient Function and Mobility

Mobility = Once in the plant, can the nutrient move from place to place in the shoot and can it be ‘stored’ for later use.

Nitrogen, Potassium, Sulfur, Phosphorus, Magnesium, Calcium

Essential for all stages of plant growth.

- N, K and P exported in the crop should be replaced to avoid soil depletion (yield drives fertilization)
- K, S, P, Mg are mobile in plants and can be effectively stored for later use (1 fertilization - prolonged effect)
- K response is highly soil specific
  - Conduct soil tests and follow soils consultant advice
- N is mobile in plant and soil and can be lost to the environment
  - apply only when the tree is growing actively.
- S, Mg, Ca and P are rarely deficient in CA soils
  - S is supplied in K, Ca and Mg sulfate fertilizers, if none of these are used S monitoring is recommended.
- Ca is important for growth and is immobile,
  - some responses to in-season foliar Ca at flowering have been reported.

Zinc

- Nutrient Uptake and Assimilation
  - Walnut (and Pecan) are very sensitive to low Zn.
  - Zn^{2+} is a charged ion easily immobilized ‘fixed’ in the soil
  - Deficient in alkaline (pH>7), bi-carbonate rich soils (co-precipitation of Fe-Oxides), leached acid soils and organic rich soils.
  - Soil fertilizers must overcome this fixation (Chelates, high local concentrations and bands) or foliars.
- Function
  - Key roles in gene regulation and protein synthesis (bud break and shoot extension)
  - Alters stress tolerance (high light, drought, disease?)
- Mobility
  - Phloem immobile or slightly mobile in walnut in the fall and spring.
  - Limited foliar uptake into mature leaves.

Zinc Function in Gene Function

Step 1 in Plant Growth

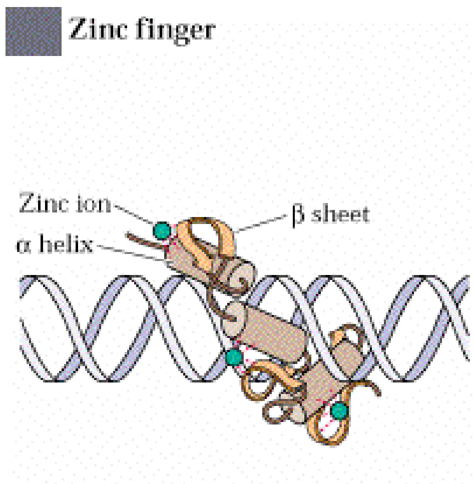
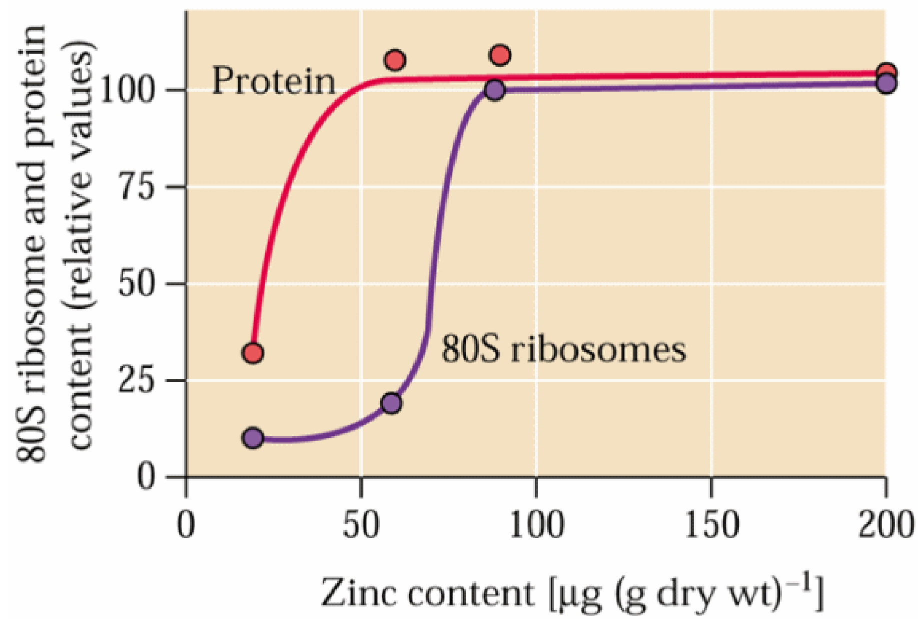


Figure 8.15 Zinc finger-DNA complex from the house mouse (*Mus musculus*). The DNA backbone is the red ribbon, and the base pairs are the red spheres. The Zif 268 zinc finger peptide is the green ribbons and the three associated zinc molecules are the grey spheres. Based on the X-ray diffraction data of Elrod-Eriksen *et al.* (1996)



Zn plays a critical role in regulating transcription through at least 3 processes (Zn-finger, Zn-cluster, Zn-RING finger)

Effect of Zn deficiency on Protein transcription and translation in emerging bud.

February 22, 2005

Zn Deficient

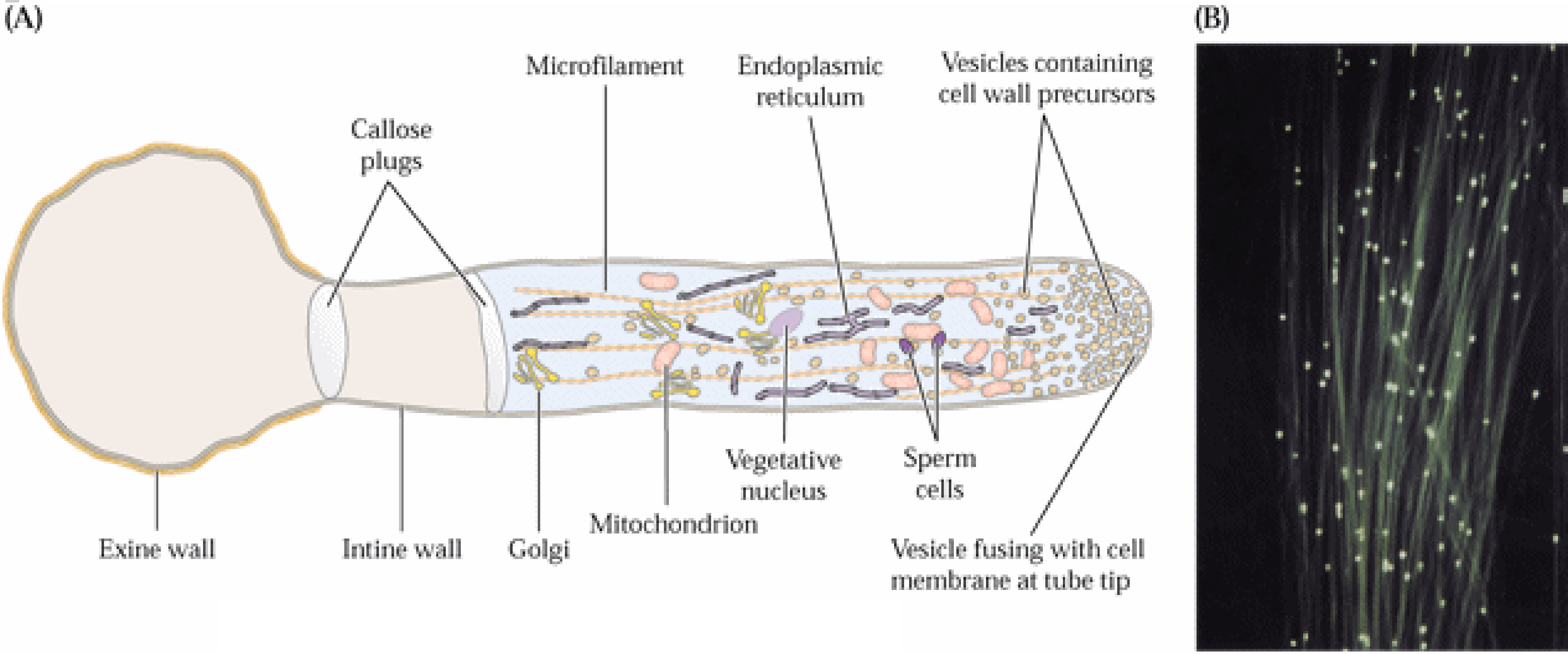
Zn Sufficient

Boron

Boron is a Building Block for the cell wall and hence all Growth, especially flowers and fruits.

- Nutrient Uptake and Assimilation
  - Uncharged element, not fixed in CA Walnut soils. Deficiency can occur in all soils supplied with low B irrigation water.
  - Stored in organic residue.
- Function
  - Cell Wall Construction
  - Pollen formation and fertilization
- Mobility
  - Highly immobile in Walnut
  - Lack of mobility and high demand for reproduction can result in critical short term deficiencies that are hard to detect or predict but are potentially very important.

Boron strongly influences pollen tube germination and growth.



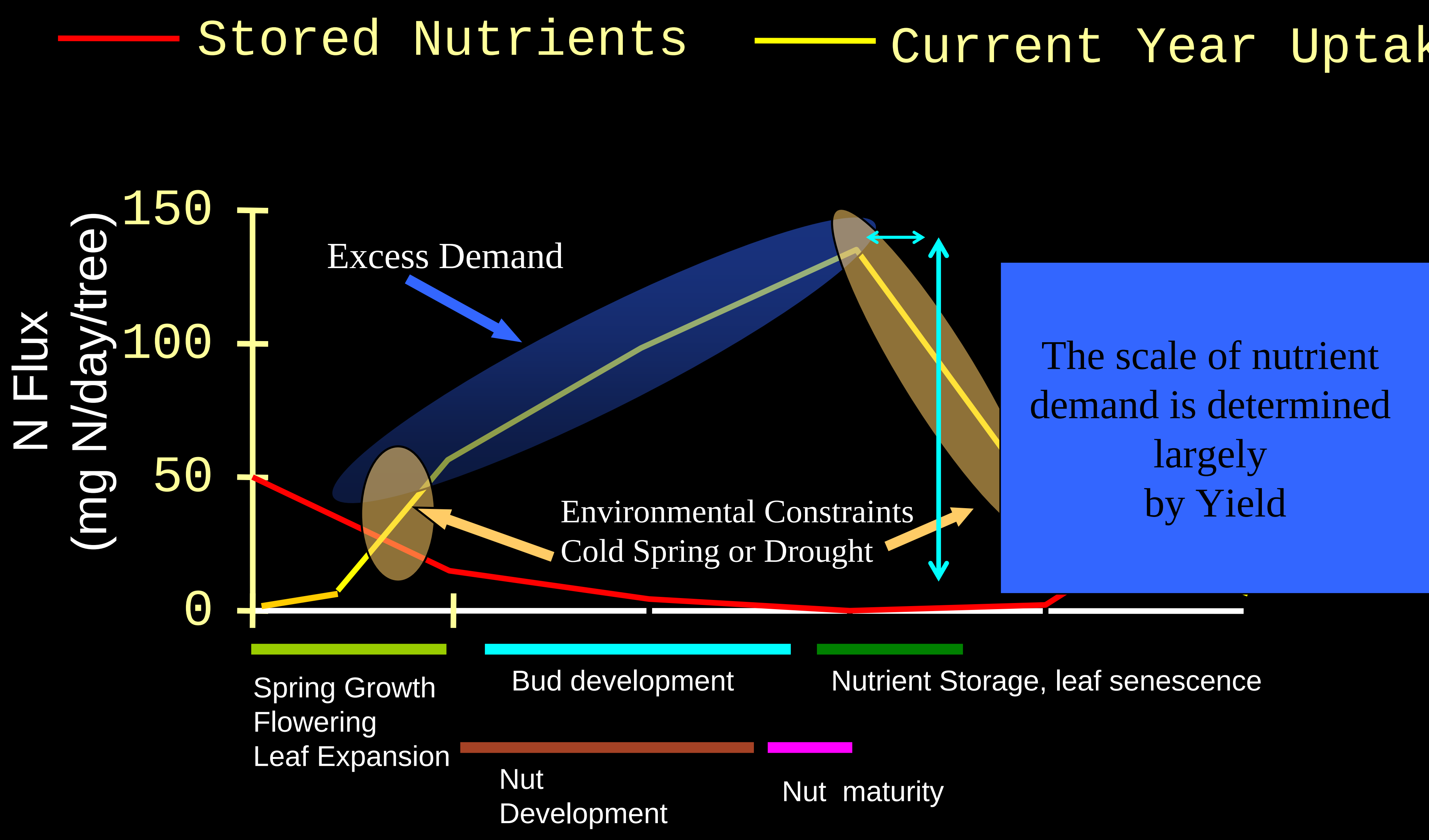
QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

When are nutrients required?

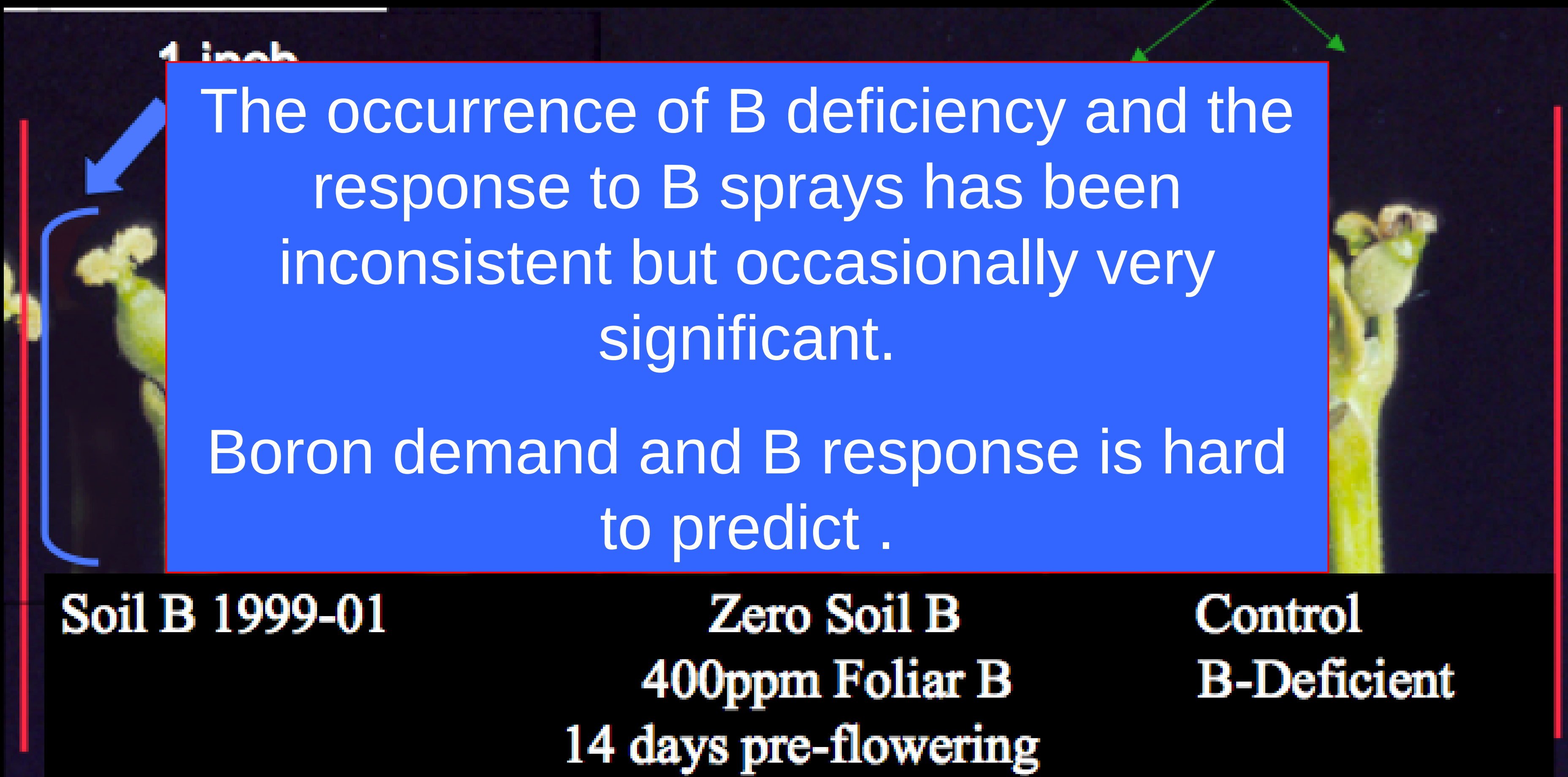
Nutrient Demand Is Not Uniform Through the Year.

- Uptake only occurs in actively growing plants
  - No uptake in fall, winter or before leaf out.
- For N and K yield determines demand
  - The size of the crop determines the demand for N and K
- Short Term Nutrient Deficiencies can be important (transient)
  - During times of High Nutrient Demand
    - Heavy crop, marginal supply.
  - When Environmental Conditions prevent uptake
    - Cold weather at flowering
    - Drought
  - For immobile elements with critical short term demand
    - Zinc during spring growth
    - Boron during flowering

Nutrient Fluxes (N, K, S, P) in Walnut



B Deficiency: Flower Abortion in Walnut



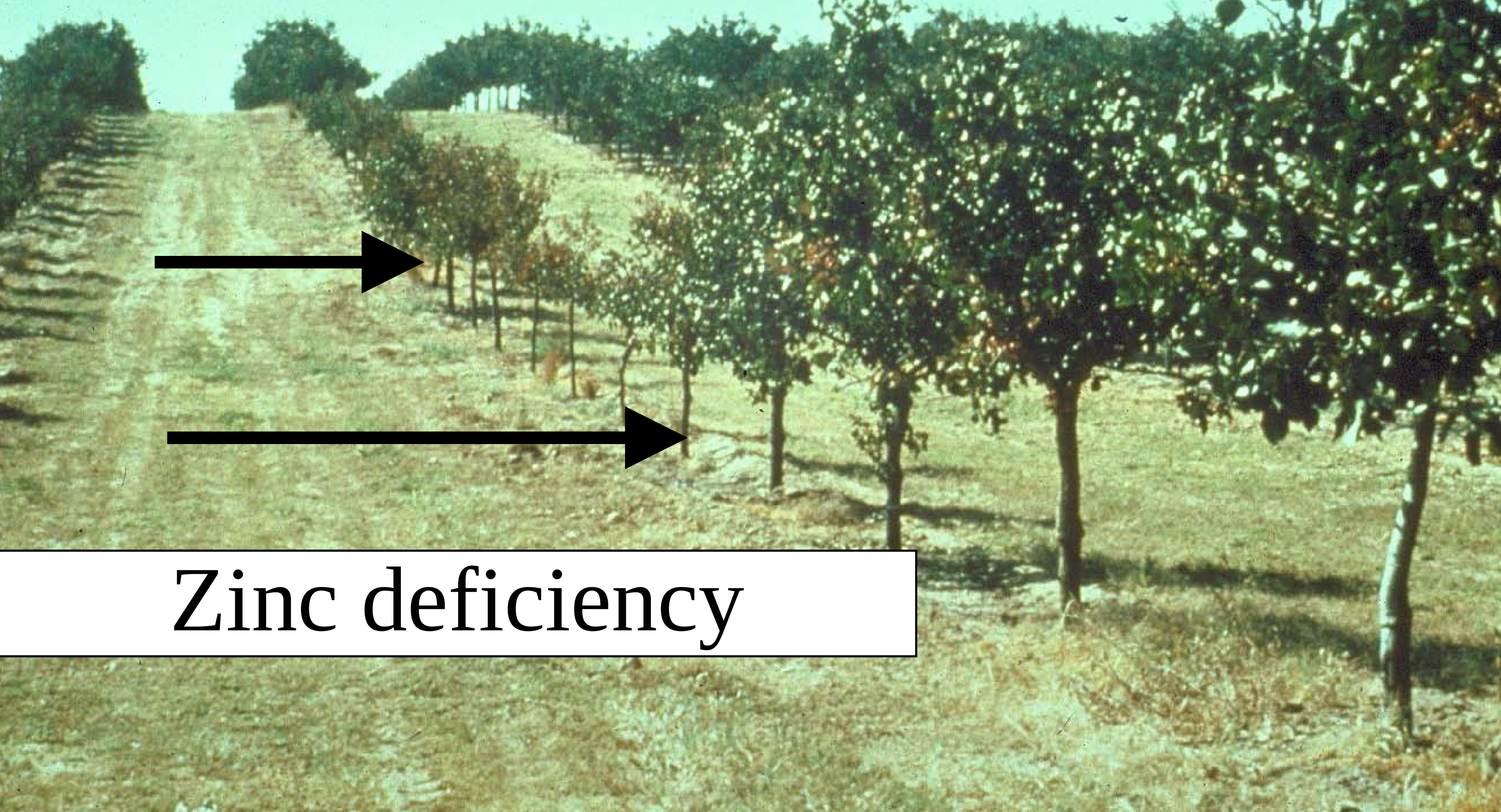
The occurrence of B deficiency and the response to B sprays has been inconsistent but occasionally very significant.

Boron demand and B response is hard to predict .

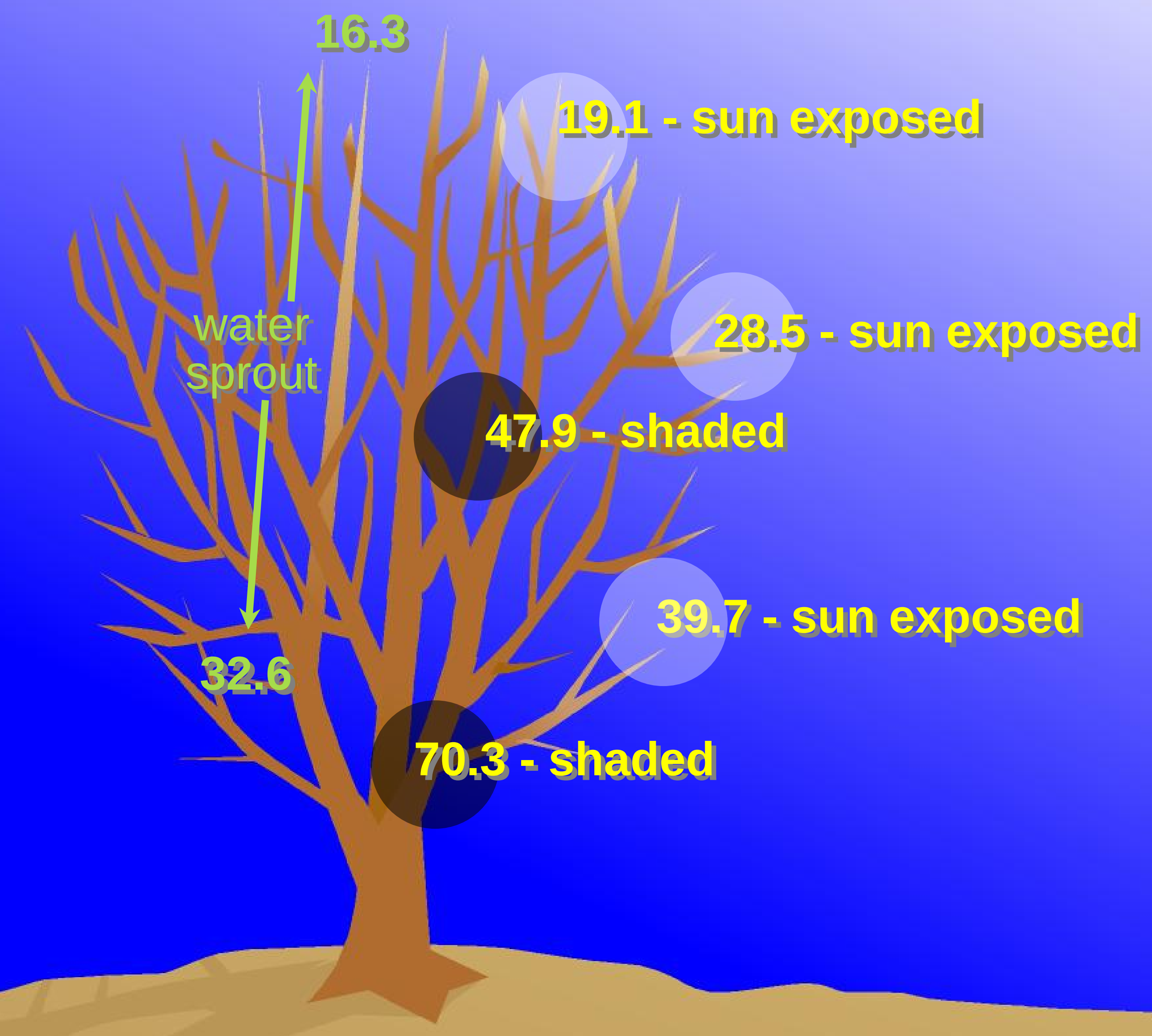
	Soil B 1999-01	Zero Soil B 400ppm Foliar B 14 days pre-flowering	Control B-Deficient
Relative Yield	45%	100%	25%

Where are nutrients needed?

Demand Varies across the orchard, within the tree and through the year.



Shoot Zn Distribution Through A Dormant Peach Tree (ppm)



Zn Deficiency in Tree Crops

Tops of trees on the sunny side will always be the most sensitive to Zn (and K) deficiency).

What approaches do we have to manage and optimize nutrition?

Leaf Samples and Critical Values for Walnut

	Deficient	Adequate	Toxic
Nitrogen	<2.1	2.2 - 3.2	
Potassium	0.9	>1.2	
Zinc	18		
Boron	20	36-300	>300

Concerns:

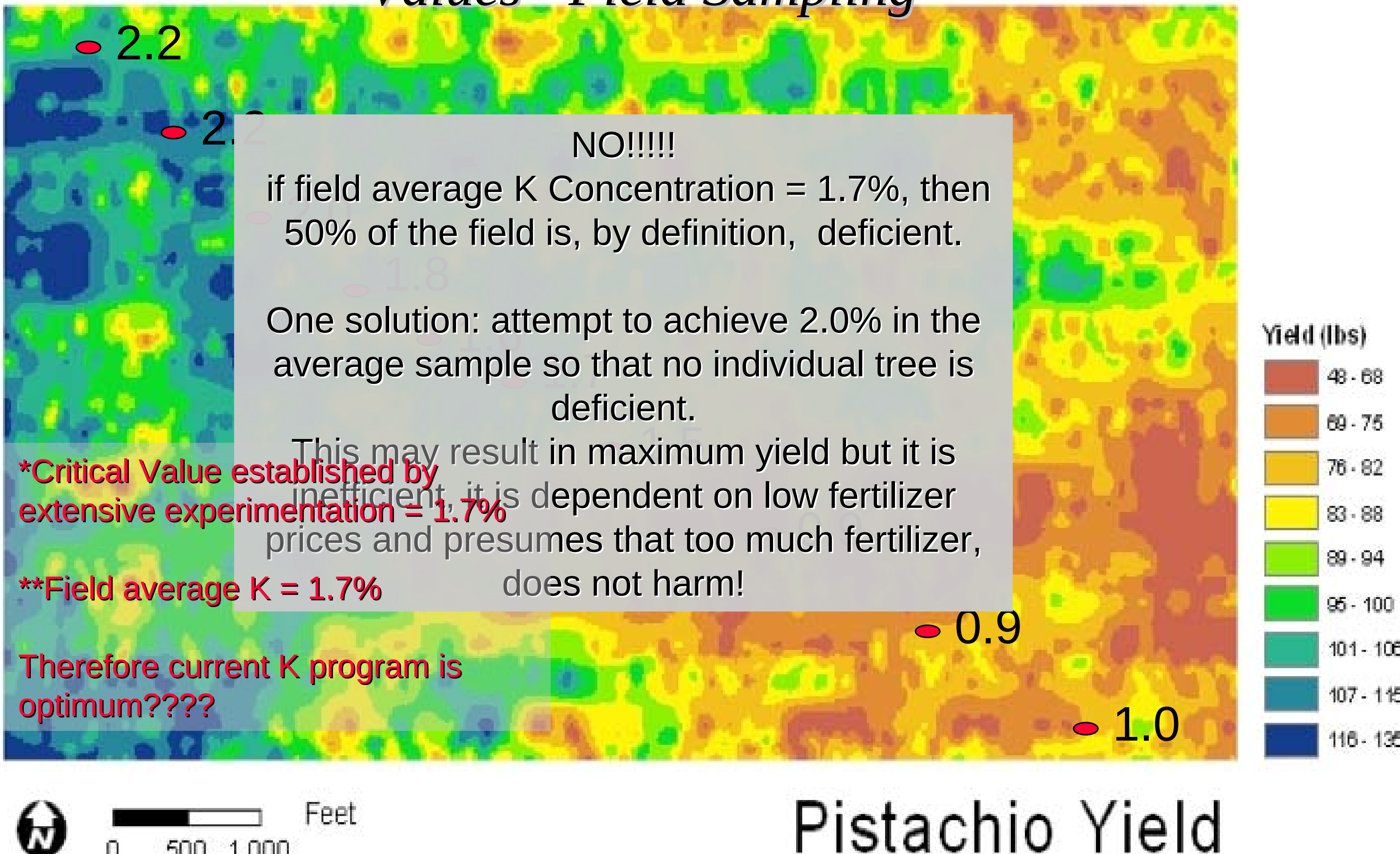
- Validated for mid-summer samples only.
- Limited guidance provided on how to sample effectively or respond appropriately.

Are the UC Critical Values Correct?

- Probably yes, BUT only when taken in context
  - Summer leaf sample only (not an adequate indicator of spring nutrient needs)
    - Limited ability to detect 'transient' deficiencies (B, Zn).
  - Difficult to collect truly representative samples (leaf/orchard)
    - Relevant only for the trees sampled
  - Results are frequently used incorrectly

Leaf sampling and CV's provides no information on the cause and best correction of the problem. This can only be achieved by understanding the how, what, when, where.

The Biggest Problem With Our Use of Critical Values - Field Sampling



NO!!!!!
if field average K Concentration = 1.7%, then 50% of the field is, by definition, deficient.

One solution: attempt to achieve 2.0% in the average sample so that no individual tree is deficient.
This may result in maximum yield but it is inefficient, it is dependent on low fertilizer prices and presumes that too much fertilizer, does not harm!

*Critical Value established by extensive experimentation = 1.7%

**Field average K = 1.7%

Therefore current K program is optimum????

Nitrogen Demand by 20 acre block

Pistachio Yield

Whole Field Average N demand = 150 lbs N

Nutritional Management of Walnut: *Understanding the Principles to Optimize the Practices*

Limits of our current approaches.

- Leaf sampling and critical value analysis are inadequate as the primary tool for managing nutrition and are not integrated with other tools.
- Growers manage as if all trees in an orchard require the same nutrients and have the same constraints
- We do not always ask the how, why, when and where questions.

Ways to improve:

- Greater knowledge of the orchard (more soil samples)
- Greater knowledge of walnut nutrition (my job!)
- Manage at a smaller scale and with more flexibility (adjust fertilizer based on yield, local environment and specific nutrient function)
- Understand the how, why, when and where of plant nutrition.


Thank You