Fruit Crops Nutrition

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Getting the best return from your fertilizer dollar

- Establish & maintain optimum soil pH
- Time of fertilizer application:
  - Preplant
  - Postplant (N – when trees can actively take it up)
- Know what you need (tissue analysis)
- Method of application
- Maximize resorption of nutrients in fall
- Reduce competition

Components of a Good Fertility Program:

- Soil testing – pre & post-plant
- Tissue analysis
- Records on yields & quality
- Tree growth & leaf color observations

Preplant Soil Testing

- Integral part of site preparation
- Goal is to provide a nutritionally favorable environment for tree growth & fruiting
  - Adjust soil pH to 6.5 in the upper 16 inches
    - Surface broadcast lime may move down at about 1 inch/year
  - Adjust phosphorus & potassium to desirable levels
    - Phosphorus will not move down in the soil
    - Potassium moves down slowly

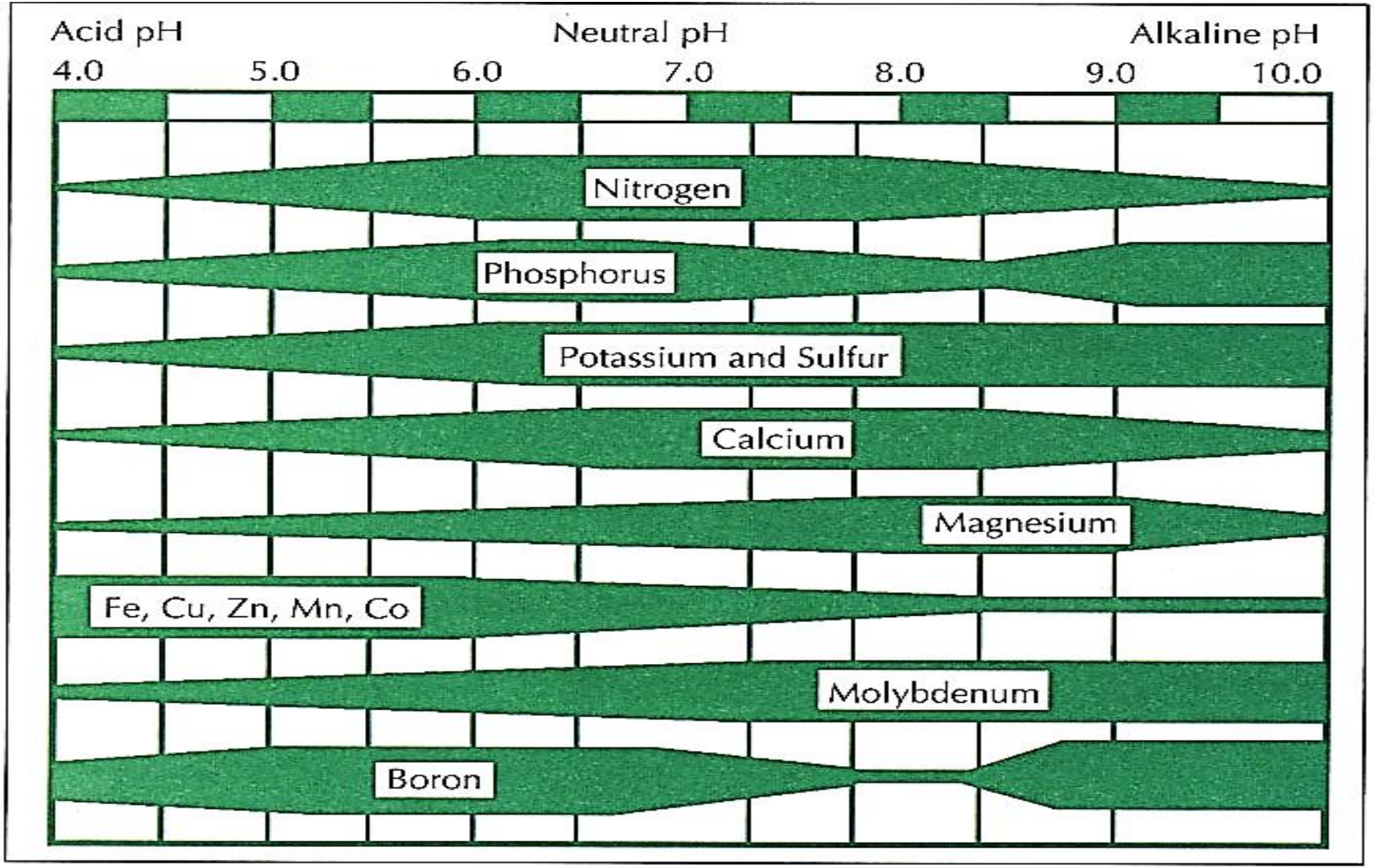
Taking Soil Samples

- **What to Test For:**
  - pH – affects availability of nutrients
  - Phosphorus – only opportunity to adjust P levels in soils (preplant)
  - Potassium – can impact uptake of certain nutrients (Ca, Mg, N)
  - Calcium – calcitic limestone?
  - Magnesium – dolomitic limestone?
  - Organic Matter – can help to determine nitrogen fertilization rates

Sample at 2 depths:
- Upper 8 inches
- 8 to 16 inches

- **What NOT to Test For:**
  - Nitrogen – N levels in soil can change too quickly to be of value
  - Micronutrients – soil testing is of questionable value
  - Macronutrients other than P, K, Ca of Mg unless you have strong reason to suspect a problem

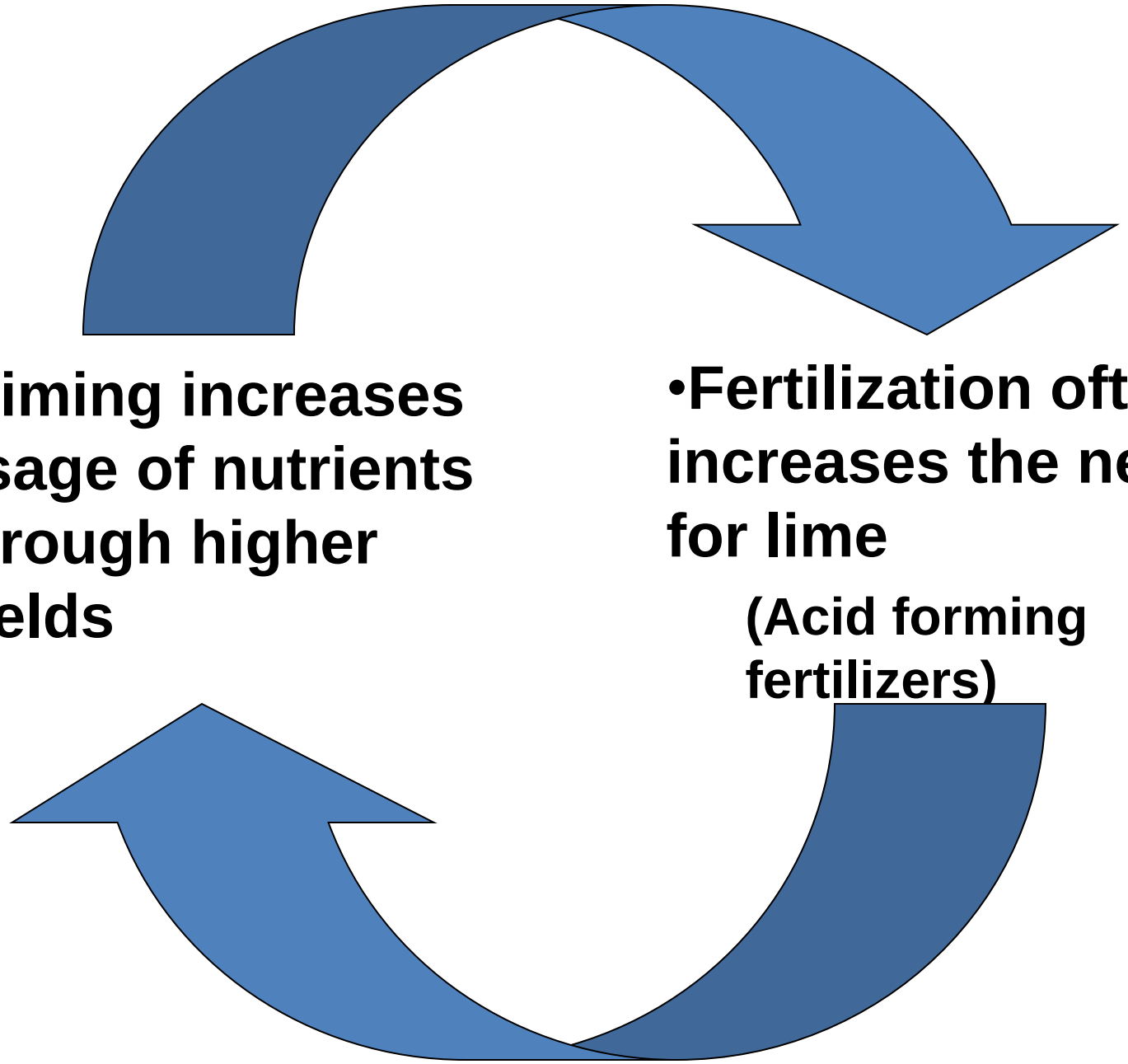
Effects of Soil pH on Nutrient Availability



No other soil characteristic is more important in determining the chemical environment of higher plants and soil microbes than pH.

Benefits of Liming

- **Improve soil pH:**
  - Provides better soil environment for plant growth
  - Prevents toxicity due to excess Al & Mn
  - Increases availability of P & Mo
  - microbiological processes such as nitrification and nitrogen fixation
    - may also indirectly improve the physical condition of the soil



•**Liming increases usage of nutrients through higher yields**

•**Fertilization often increases the need for lime**

(Acid forming fertilizers)

Liming Increases Fertility Efficiency and Decreases Soil Acids

Soil Acidity	Nitrogen	Phosphate	Potash	Fertilizer Wasted
Extremely Acid – 4.5 pH	30%	23%	33%	71.34%
Very Strong Acid –5.0 pH	53%	34%	52%	53.67%
Strongly Acid – 5.5 pH	77%	48%	77%	32.69%
Medium Acid – 6.0 pH	89%	52%	100%	19.67%
Neutral – 7.0 pH	100%	100%	100%	0.00%

Source: The Mosaic Company, 2016. Soil pH

Liming

- Preplant application & deep incorporation of lime is the only economically feasible & effective way to affect subsoil pH.
- Postplant liming considerations:
  - Lime moves down slowly (1 to 2”/year)
    - May only move down the depth of disturbed soil
  - Reacidification is due to
    - Acid rain
    - Breakdown of organic matter
    - Acid-forming nitrogen fertilizers
  - Reacidification may exceed liming effects within 2 to 3 years of lime application
- Postplant applications of gypsum may be superior to lime for subsoil
  - Will not impact soil pH
  - Will prevent aluminum and/or manganese toxicity

Liming Soils

Rate for upper 8”

+

Rate for 8 – 16” depth

= **Amt. to apply**

Disk or rototill (mixes lime with soil in upper 4 – 6”)

Plow to put amended soil at the bottom of the furrow

(for high lime rates, apply ~ 2/3 of total & incorporate, apply remaining amount & disk into topsoil)

PREPLANT APPLICATION OF P & K

PHOSPHORUS

- Amount to apply:
  - Recommendation for upper 8 inches
  - +
  - Recommendation for lower 8 inches
- Application:
  - Disk or rototill in upper few inches
  - Deep plow

POTASSIUM

- Amount to apply:
  - (recommendation for upper 8 inches minus actual content of upper 8 inches)

    +

    (recommendation for lower 8 inches minus actual content of lower 8 inches)

Application:

Disk or rototill in upper few inches

Deep plow

Successful management in any high-density planting depends on maintaining a balance between vegetative growth and fruiting

- Vigor too low:
  - Excessive fruiting, reduced fruit size, biennial bearing, trees fail to fill their allocated space soon enough to make the orchard profitable
- Vigor too high:
  - Flowering & fruiting reduced, shading reduces fruit quality, containing tree in allocated space becomes difficult

Tools to achieve a balance between vigor & fruiting (“calm” trees”)

- Pruning
- Crop load management
- **Fertilization, Fertigation & Irrigation**

- The above variables are affected by :
  - Planting density
  - Tree quality
  - Training strategies

16 Essential Mineral Nutrients

Macronutrients
(major elements)

Nitrogen (N)
Phosphorus (P)
Potassium (K)
Magnesium (Mg)
Calcium (Ca)
Sulfur)S)

Micronutrients
(minor elements)

Iron (Fe)
Manganese (Mn)
Copper (Cu)
Zinc (Zn)
Boron (B)
Molybdenum (Mo)
Chlorine(Cl)

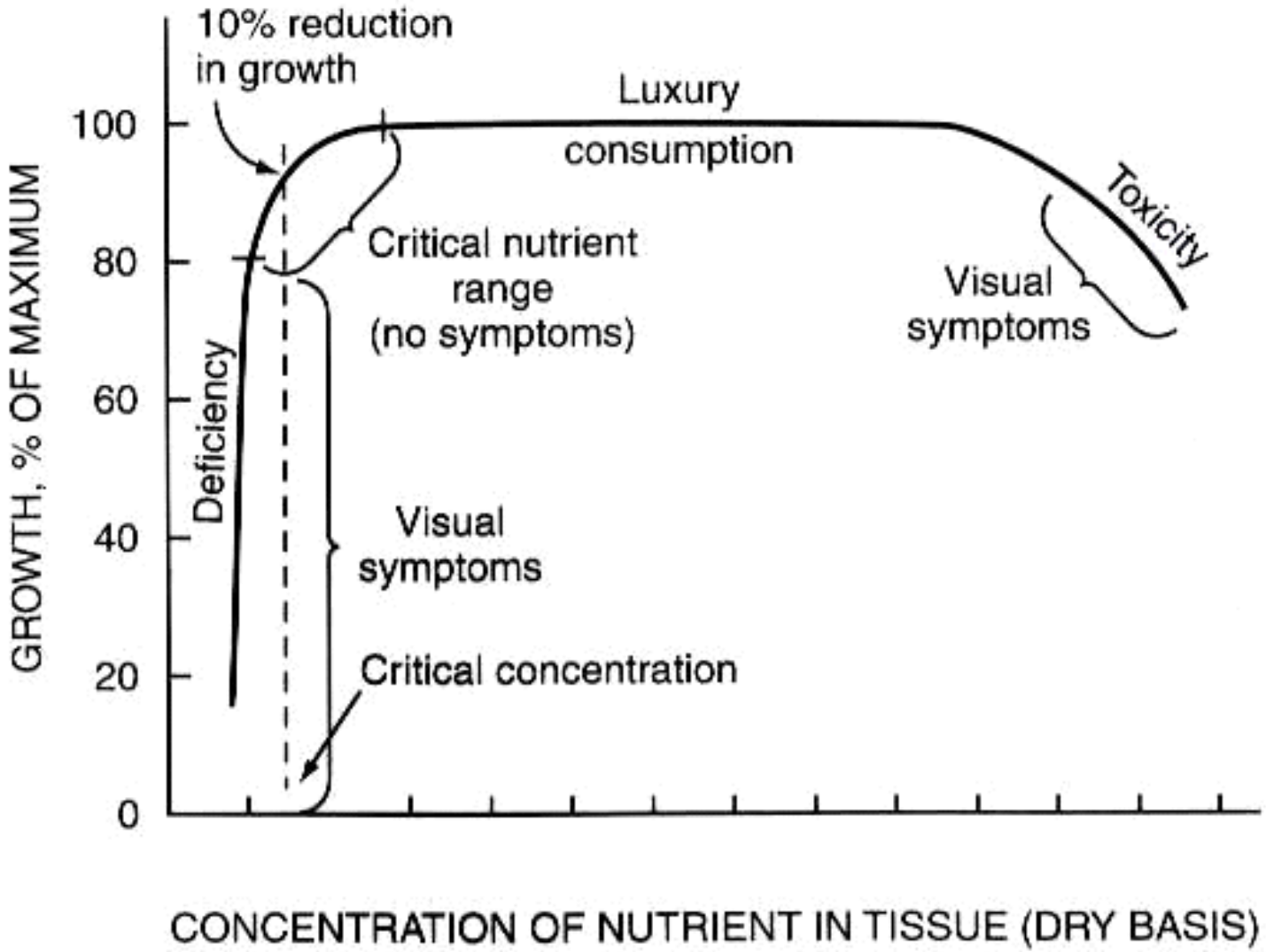
Carbon, hydrogen and oxygen are gotten from the atmosphere

Most of the essential elements do not need to be supplied in a regular fertilizer program because:

1. Most soils can provide an adequate supply.
2. A substantial portion of some nutrients is recycled from the leaves back into the tree structure before leaf fall
3. For some nutrients (i.e. phosphorus), very little is removed in the crop, leaves & prunings

- Annual:
  - N,B (if using foliar applications) – replace what is removed
- Periodic:
  - Ca, Mg to adjust soil pH
  - K on an as needed basis (indicated by tissue analysis)
- Special:
  - Zn, Ca, N – foliar application

Relationship between essential nutrient concentration and yield



Nutrient Disorders

- Deficiencies
- Toxicities
- Imbalances
  - Nitrogen/potassium ratio
    1 – 1.25/1
  - Potassium/magnesium ratio
    - 4/1
  - Calcium/Magnesium ratio
    - 3/1


Soil conditions
and other growth factors
YIELD
Sodium
Oxygen
Boron
Carbon Dioxide
Warmth
Light
Water
Nitrogen
Phosphorus
Potassium
Calcium
Magnesium
Sulphur
Iron
Chlorine

What to Use?

Determining the Nutrient Status of Plants

- **Soil testing**
  - preplant – pH, phosphorus, potassium, organic matter
  - postplant – monitor soil pH only (correlation between soil test results and the actual nutrient status is poor)
- **Plant tissue testing**
  - Except for nitrogen, amendments will be for next year's crop
- **Field observations:** leaf color, shoot growth, crop status
- **Records** from previous year

Soil analysis results in established plantings may correlate poorly with leaf tissue analysis and plant response

therefore

the primary benefit of **postplant** soil testing is pH determination

How Much to Use?

Nitrogen Needed to Grow a Crop of Apples: (semi-dwarf & standard)

<u>Only element needing to be applied annually</u>

- ~ 100 lbs./acre/yr
  - 30 to 35 lbs./acre/yr removed in the crop
  - 65 to 70 lbs./acre/yr used in leaves & woody tissue (recycle)

Potassium Needed to Grow a Crop of Apples – (Semi-dwarf /standard trees)

- ~120 to 200# K/acre/yr
  - 150 -240 # K_2O
- ~ ½ is permanently removed in the crop
- Leaching of soils varies among soils in the S. E.

Nitrogen & Potassium Needed to Grow a Crop of Peaches

Nitrogen

~ 200 lbs./acre/yr

- 30 to 35 lbs./acre/yr removed in the crop
- 65 to 70 lbs./acre/yr used in leaves & woody tissue (recycle)

Potassium

- ~200# K/acre/yr
  - 150 -240 # K_2O
- ~ ½ is permanently removed in the crop
- Leaching of soils varies among soils in the S. E.

Nitrogen

- Only nutrient needed to be applied annually
  - Used in greater amounts than any other nutrient except potassium with some crops
  - Losses from the soil
    - Leaching beyond the root zone of the plant (NO_3)
    - Volatilization: loss to the atmosphere
      - All NH_4 & NH_3-based fertilizers have the ability *to* volatilize
    - Denitrification: $NO_3 \longrightarrow N_2O \longrightarrow N_2$ (lost to atmosphere)
      - Occurs under anerobic conditions (waterlogged soils)

Recycling Prunings

Resorption

- Movement of nutrients from leaves back into the tree in fall for storage in buds and woody tissues
- Maintain a healthy leaf canopy until natural leaf drop
- In a ***healthy*** tree the rate of resorption is generally sufficient to satisfy the needs of the tree for the initial flush of growth in spring

Reducing Nitrogen Losses

- Apply:
  - Modest amounts (consider split applications)
  - When plants need it (when they are leafed out)
    - In peach, all growth for the 1st 30 days following bud break is dependent on stored reserves from the previous year
    - Stored reserves play a decreasing role in plant growth & fruiting for the 1st 75 days following bud break

Phosphorus

- Focus on preplant amendments
  - Incorporate similar to lime
- Postplant:
  - Maintain proper soil pH to increase P availability
  - Consider P application only if tissue testing shows a need
    - Band, not broadcast, in a 4 – 6 inch strip on each side of tree row & about 24 inches out from the tree

Potassium

- K requirements of tree fruits often greater than N requirements
  - Total use in tree crops: 120 – 200# K (150 – 240# K20)
    - about ½ removed in fruit crop
- Form of K to apply determined by
  - Amt. of K required
  - Available soil Mg
    - Muriate of potash when Mg is high
    - Sulfate of potash-magnesia when K & Mg are low

Potasssium

- If muriate of potash is applied, put it down in the fall (Peach)
- Recent research suggests:
  - Do not use a foliar application of potassium nitrate during the 2nd half of the growing season
    - nitrate nitrogen has a large adverse effect on K uptake

Uses of Tissue Analysis

- To *confirm or deny* a suspected nutrient problem
  - Sample “normal” vs “affected” trees
    - Same cultivar
    - Close proximity
    - Can be done at any time during growing season

- To *monitor* nutrient status of orchard & detect trends (deficiencies, toxicities, imbalances) before they become yield/quality limiting
  - Conduct over a period of years
  - Graph results to detect trends
  - Soil test to monitor pH

Collecting a Valid Sample

- One cultivar/rootstock per sample
- Trees approximately the same age
- Not over 10 acres per sample
  - (maybe less in non-uniform orchards)
- Sample non-representative trees separately
- Collect samples before applying a spray
- Wash samples with pesticide residues according to directions if needed
- Air dry in clean paper bags & store in a clean area to avoid contamination
- Provide results from a recent soil test (within 3 years)

- What to sample: mid-terminal leaves on current season's growth
- When to sample: last two weeks in

Leaf Sampling

- What to sample: mid-terminal leaves on current season’s growth
- When to sample: last two weeks in July

Tissue Sampling Tips

- The reliability of the results is only as good as the quality of the sample(s) submitted for analysis
  - Sample should contain 25 – 100 individual leaves
    - Same leaf (physiological age & position) taken from each plant
      - Avoid plants damaged by insects, diseases or chemicals
  - For confirmation or denial of a suspected nutrient problem,
    - Sample both affected and normal plants of the same variety, age and growing in the same general area of the field
  - Sample before a spray application to lessen contamination
  - Include a soil sample

Detection of micronutrient problems

- Do not rely exclusively on visible symptoms
  - Same symptoms may occur with:
    - Other elements
    - Weather stress
    - Herbicide damage
- **By the time symptoms are visible, damage has already occurred**
- Use tissue analysis plus soil testing to head off problems
- Consider foliar applications
  - Application directed where needed
  - Mobility in plant may be limited

“Shotgun” mixtures of micronutrients

- Not recommended
  - Seldom see over one deficiency problem at a time
  - Difference between deficiency and toxicity is small
  - Should not be applied unless tissue analysis demonstrates a need
    - Exception: Solubor for boron deficiency corking
  - Often contains a small amount of nitrogen which is usually responsible for any visible effects of application
    - Very expensive way to apply N

Sufficiency Ranges for Apples

Macronutrients (%)

N: 1.80 – 2.10 (for Golden delicious) 1.90 – 2.30 for other varieties

P: 0.15 – 0.50

K: 1.25 – 1.80

Ca: 1.00 – 2.00

Mg: 0.20 – 0.50

Micronutrients (ppm)

Fe: 50 – 400

Mn: 25 – 200

Zn: 20 – 50

Cu: 5 – 20

B: 25 - 60

Sufficiency Ranges for Peaches

Macronutrients (%)

N: 2.7 – 3.5
P: 0.1 - 0.3
K: 1.2 – 3.0
Ca: 1.00 – 2.5
Mg: 0.25 – 0.50
S: 0.2 – 0.4

Micronutrients (ppm)

Fe: 120 – 200
Mn: 20 – 200
Zn: 20 – 50
Cu: 4 - 16
B: 20 - 80

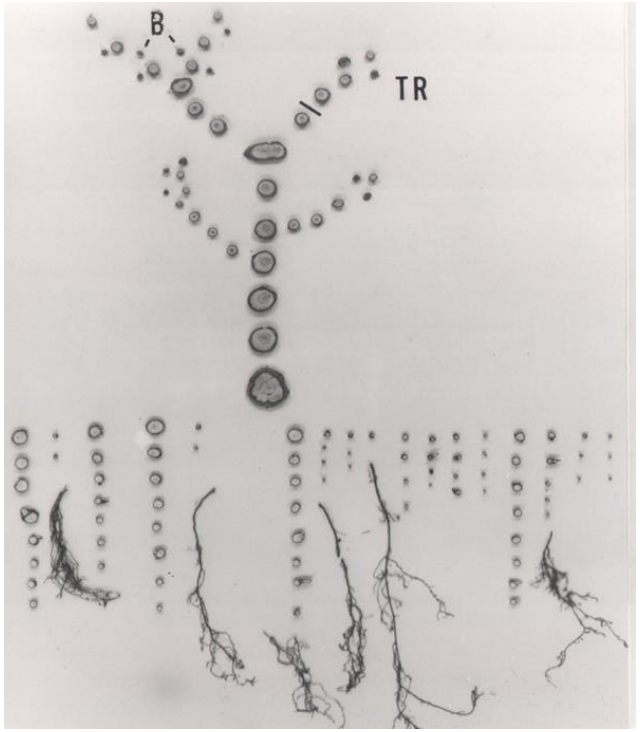
Nitrogen: Application Timing

- Early season growth supported by N remobilized from previous-year reserves. (Neilsen et al, 1997)
- Apply nitrogen fertilizers as early in the spring (bloom +/- 2 weeks)
  - N taken up by the roots & partitioned equally between spur leaves, shoot leaves & fruit
- N applied during active shoot growth is taken up rapidly to support mainly shoot growth:
  - Can contribute to greater bitter pit problems
- Apply N post-harvest when tree will take up Ca & store it for use the following season
  - Will not stimulate growth
  - Foliar applications of urea will increase tree reserves & strengthen spurs for next season

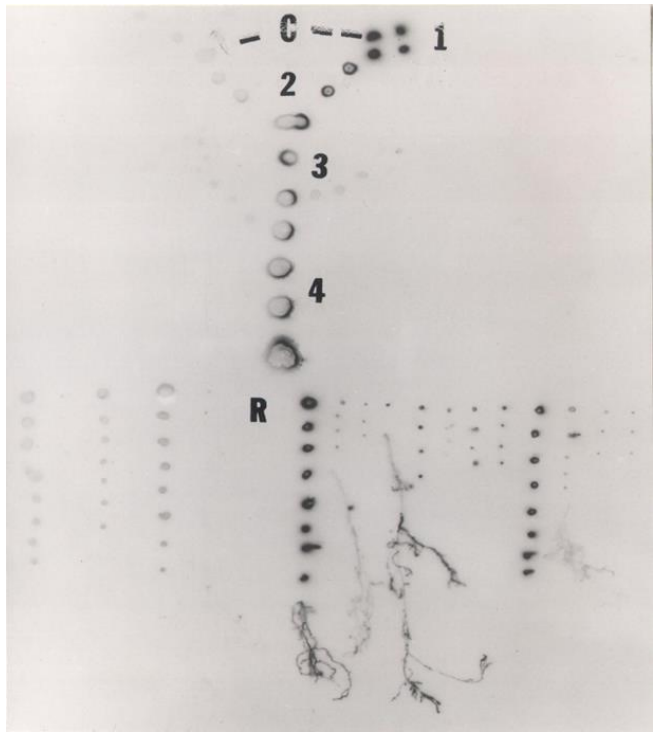
Redistribution of C^{14} in Stuart Pecan

Dormant

Specimen



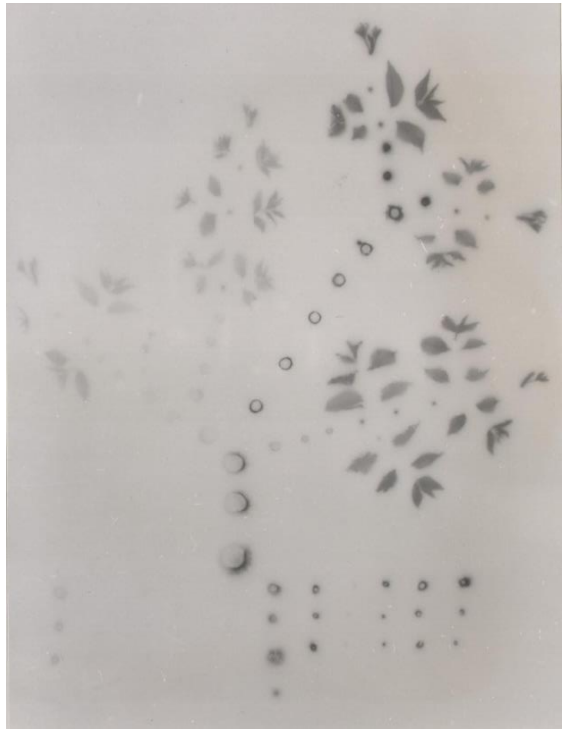
Autoradiograph



Rapid Shoot Elongation

Specimen

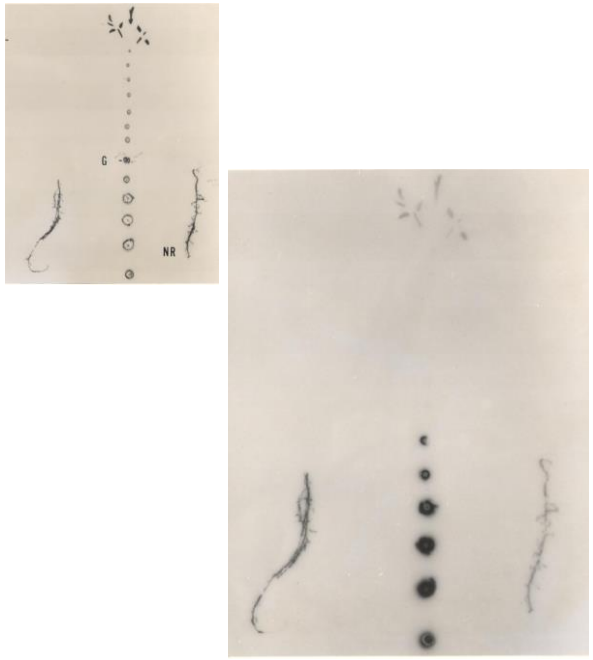
Autoradiograph



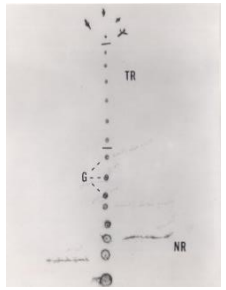
When to Apply:

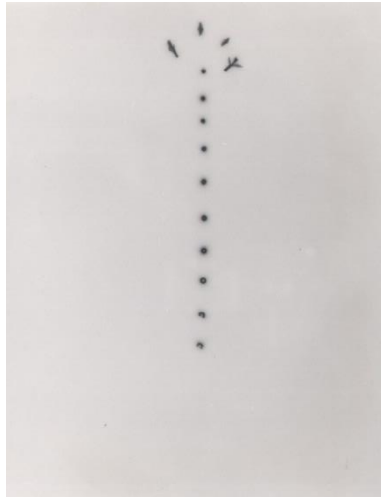
Redistribution of 14C in Grafted Pecan Seedling @ Initial Leaf Expansion vs. Elongation Ceased

C/H specimen **autoradiograph**



H/C specimen autoradiograph





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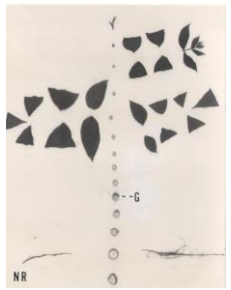

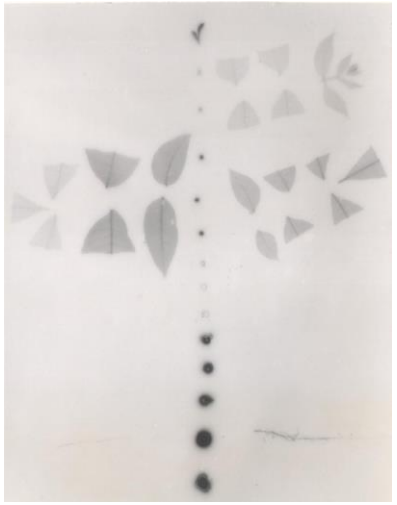

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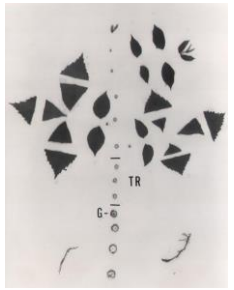


Methods of Nutrient Application

- **Preplant:**
  - **Broadcast,** deep incorporation of lime, P & K
- **Postplant:**
  - **Broadcast** in weed-free strip down the tree row – N & possibly K
  - **Banding** (4 – 6” band 2 to 3’ each side of trunk for postplant P, and possibly K
  - **Fertigation** (microsprinklers or drip) down tree row (reduced rates, control destiny of fertilizer)
  - **Foliar** – best for most micronutrients, supplemental Ca, N - especially late in the growing season

Nutrient	Mobility in Soil	Mobility in Plants
Nitrogen (N)	Mobile as NO_3, Immobile as NH_4	Mobile
Phosphorus (P)	Immobile	Somewhat mobile
Potassium (K)	Somewhat mobile	Very mobile
Calcium (Ca)	Somewhat mobile	Immobile
Magnesium (Mg)	Immobile	Somewhat mobile
Sulfur (S)	Mobile	Mobile
Boron (B)	Very mobile	Immobile
Copper (Cu)	Immobile	Immobile
Iron (Fe)	Immobile	Immobile
Manganese (Mn)	Mobile	Immobile
Zinc (Zn)	Immobile	Immobile
Molybdenum ((Mo)	Somewhat mobile	Immobile
Chlorine (Cl)	Mobile	Mobile

Spreader Types

- Drop-Type Spreaders
  - precise application & pattern
  - Less chance of drift, more control of pattern
- Pendulum Spreaders
  - Ability to spread to either side, or both sides,
  - with or without spreading directly behind applic
- Spinner-Type Spreader
  - Wider swath of coverage, faster application
  - Less uniform distribution, drift can be a problem
- Air-Boom Spreaders
  - Used mainly in larger acreages,
  - very uniform distribution pattern

Calibration: What is it & why do we do it?

- Calibration = process of determining the exact amount of fertilizer that is applied to a given area when the spreader is opened to a particular setting and operated under given conditions

- Factors which can influence application rates include:
  - Type (formulation) and physical properties of the fertilizer used
  - Speed of application
  - Mechanical differences of each spreader

Fertigation

Application of dissolved nutrients through the irrigation system

- Advantages:
  - Rapidly applying precise amounts of essential plant nutrients directly to the root zone
  - Applying nutrients at the exact time that the tree needs them
  - Limiting nutrient leaching to ground water & nutrient runoff
  - Saves labor
  - Less expensive than ground application

Why Consider Foliar Applications?

- Best for most micronutrients
- Provides an opportunity to:
  - Supply essential elements directly to the foliage, flowers or fruit at times when a rapid response may be required (overcome short-term deficiencies)
    - Cold weather during bloom or cold soils in spring may limit the availability of nutrients while increasing plant requirements
    - Pink or petal-fall
      - Rate of 5 to 10# urea per acre

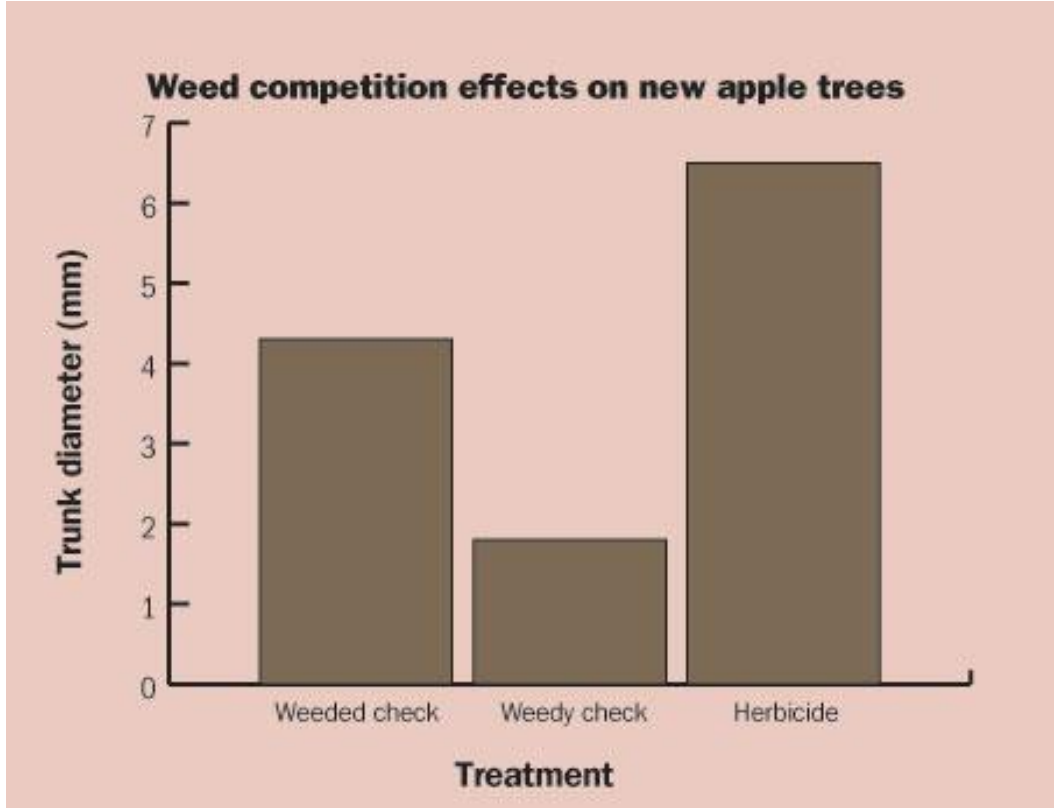
Foliar Applications of Macronutrients (N, P, K, Ca, Mg) are NOT Recommended as the Primary Method of Application

- Use as a supplement to soil-applied nutrients
- Adequate supplies are usually taken up by roots
- Not enough would be absorbed through leaves to correct a deficiency for very long

Annual growth in dwarf apple trees

- Early spring growth is supported primarily by N remobilized from storage in woody tissues & is largely completed by the start of shoot extension
- Little N uptake by roots occurred before shoot development started

Critical weed-free period for bearing trees



Weeds competing with newly planted apple trees cause severe growth reduction in only three months (Unpublished, Harrow 1990)

- For bearing apple trees, the effects of weed competition are the greatest from bud break until terminal bud set, i.e. spring until early July. This corresponds with four stages of crop development:

- flowering
- fruit set
- fruit enlargement
- flower bud initiation

Maximizing Returns from Your Fertilizer Dollar

- Fertilizer applications
  - Fertigation may reduce needs by up to 40%
  - Multiple N applications using smaller quantities
    - Post-harvest ground applications
    - Foliar application in fall prior to leaf drop
    - Delay spring applications until bloom or later
    - Use the least expensive form of nitrogen