Nutrition of tree fruits

✓ Reading assignments: Tree Fruit Nutrition, Chapters 1, 2, 3

✓ Composition of fruit trees
50 -85% may be water
* Leaves and wood: 50 -70% water
* Fruit: 80 -90% water
C based compounds
* Leaves: 20-40%
* Fruit: 10-15%
1/2 -2% are inorganic nutrients

✓ Tree response to nutrients

✓ Nutrient demand
There is competition between the organs of the tree
Organs with the highest metabolic rates will be the strongest sinks

✓ Adequacy range for foliar nutrients

✓ Seasonal changes of nutrient concentration in fruit trees

✓ Requirement for essential nutrients
1 The elements are directly involved in the metabolic processes of the plant; as a constituent of a metabolite or required for action for an enzyme system
2 A deficiency of an essential element results in plant death and an inability of the plant to complete its life cycle
3 A deficiency is specific for an individual element; no element can substitute for another

✓ Nitrogen fertilization
N taken up as Nitrate and ammonium
Most ammonium is incorporated into AA in the roots
Nitrate is mobile in xylem
Nitrate may also be utilized by roots or leaves

Nitrate reductase is found in leaves of apple, apricot, and cherry, but not in peaches

Nitrogen is largely utilized in the root, this requires CHO
Nitrogen uptake by plum trees

<table>
<thead>
<tr>
<th>STAGE</th>
<th>KNO3- NUE (%)</th>
<th>Tot. fertilizer N abs./ tree/10 days</th>
<th>Tot. fertilizer N app. / tree/ 10 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormant</td>
<td>Jan 16-26</td>
<td>4.75</td>
<td></td>
</tr>
<tr>
<td>Bud swell</td>
<td>March 5-15</td>
<td>4.34</td>
<td></td>
</tr>
<tr>
<td>Rapid shoot growth</td>
<td>April-12</td>
<td>30.52</td>
<td></td>
</tr>
<tr>
<td>Shoot growth ceased</td>
<td>May 14-24</td>
<td>39.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>July 9-19</td>
<td>32.73</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aug 6-16</td>
<td>35.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sept 10-20</td>
<td>32.73</td>
<td></td>
</tr>
<tr>
<td>Mid –leaf-fall</td>
<td>Oct 22-Nov 1</td>
<td>16.14</td>
<td></td>
</tr>
<tr>
<td>Dormant</td>
<td>Dec 3-13</td>
<td>3.66</td>
<td></td>
</tr>
</tbody>
</table>

**Responses of fruit trees to N nutrition**

1. Vegetative responses
2. Responses involving fruiting
3. Responses involving fruit characteristics

* The growth of apple trees is directly proportional to the amount of N applied to the maximum growth rate
* Restriction of growth due to N deficiency results in the decrease of top / root ratio
* The formulation of the applied N is important
Points to consider when judging the N status of apples

- Rapid growth of young trees is desirable to develop the fruiting system
- Fruit color is delayed when N levels are too high
- 5% reduction in color by each 0.1% increase in leaf N
- Fruit size and flesh firmness are usually inversely related
- Varietal differences
  - 2 general categories
  - Soft varieties: Cortland, McIntosh, Macoun, and early maturing cultivars (1.8-2.2% leaf N)
  - Hard varieties: Empire, Liberty, Delicious (2.2-2.4)
- Biennial bearing
- Vigor of shoot growth
- General N relationships
  - Leaf N tends to be higher in trees carrying a heavy crop
  - Leaf N is reduced by sod or weed competition
- Rootstock (see table 3 in chapter 4 of Tree Fruit Nutrition)

N application methods

- Soil application
  - Timing
    - Dormant
    - Summer
    - Fall
  - Placement
- Fertigation
- Foliar

Phosphorous

Roles

- Energy transfer
- NA
- Coenzymes
- Phospholipids
- Phytic acid
- Varies according to fruit type and variety
- Soil analysis not a good indicator
  - pH dependent
- Leaf analysis
  - High levels may indicate growth restriction due to deficiencies in Zn and Cu
  - Due to interaction of P and these elements
  - >150 K / 1 Zn indicate that Zn is deficient
  - 50 K / 1 Zn indicate adequate supplies
Attention to P fertilization should be given at pre-plant stage
* Direct responses to P fertilization not commonly seen in orchard situations
* Cultural practice
  Organic matter

✓ Replanted orchards
See table 1, chapter 7 in Tree Fruit Nutrition

✓ Potassium
Roles
* Regulation of water status
* Enzyme activation in Pn and respiration
* Fruit color, size and acidity are positively correlated to K
* Trees low in K are more susceptible to winter injury and spring frost injury to buds and flowers

✓ Points to consider when judging the K status
* Leaf K levels are strongly influenced by crop load
* Level of K for optimum growth depends on N status (1-1.25 N: 1 K for McIntosh and 1.25-1.50)
* Leaf responses generally less sensitive than the fruit
* Soil testing of top and subsoil
* Excessive applications may suppress Ca and Mg uptake
* Most mobile element

✓ Application
* Preplant
* Fertigation
* Foliar

Calcium

Calcium uses in apples: Presentation

* Perhaps the most important mineral element in determining fruit quality, especially fruits that are stored for long periods of time such as apples and pears, and in other fruits because it delays ripening
* Most physiological disorders are triggered by weather conditions that cause moisture or temperature stress
* Ca plays an important role in reducing stress by maintaining cell integrity
* Uptake from soil restricted to area just behind the root tip
* The most immobile mineral element
Uptake passive, but requires photosynthates

Ca-related disorders of apple and pear

<table>
<thead>
<tr>
<th>Apple</th>
<th>Disorder</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cork spot</td>
<td>Abnormal cell division</td>
<td></td>
</tr>
<tr>
<td>Watercore</td>
<td>?sorbitol accumulation</td>
<td></td>
</tr>
<tr>
<td>Bitter pit</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Jonathan spot</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Deep cracking</td>
<td>Influx of water</td>
<td></td>
</tr>
<tr>
<td>Raised lenticels</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Sunburn</td>
<td>Heat exposure</td>
<td></td>
</tr>
<tr>
<td>Early ripening</td>
<td>Premature gene expression</td>
<td></td>
</tr>
</tbody>
</table>

| Pear                | Cork spot         | Abnormal cell division       |
|                     | Black end         | Unknown                      |

**Program to control bitter pit and corking**
Soil conditions
* Moisture
* pH
Balanced nutrition
* Soil test
* Leaf analysis
Moderate tree vigor
Moderate fruit density
foliar Ca sprays
Read chapter 13 in *Tree Fruit Nutrition*

**Postharvest uses of Ca**
Read chapter 15 in *Tree Fruit Nutrition*

* CaC\textsubscript{12} drenches usually include a fungicide and DPA
* CaCl\textsubscript{2} do not improve fruit texture or firmness
One drench may more effective than season long orchard treatments (ground and foliar)
Relative effects of 8 foliar sprays of CaC\textsubscript{12} (total of 74 lb/acre) and a single 2\% CaC\textsubscript{12} post harvest treatment

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>PEEL</th>
<th>OUTER CORTEX</th>
<th>MID CORTEX</th>
<th>INNER CORTEX</th>
<th>CORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>No CaC\textsubscript{12}</td>
<td>695</td>
<td>294</td>
<td>224</td>
<td>312</td>
<td>1234</td>
</tr>
<tr>
<td>foliar sprays</td>
<td>739</td>
<td>259</td>
<td>261</td>
<td>338</td>
<td>1389</td>
</tr>
<tr>
<td>Dip treatment</td>
<td>949</td>
<td>338</td>
<td>309</td>
<td>399</td>
<td>1336</td>
</tr>
</tbody>
</table>

Why not depend on drenches?
1. Ca deficiency problems in the orchard as well as after harvest
2. Post harvest treatments not always feasible
3. Not always applied properly
4. Problems associated with the treatments

✓ **Factors affecting Ca absorption**
* Sites of entry
* Concentration of soluble Ca in solution
* Temperature differential
* Time in solution
* Relative humidity
* Additives to dip solution

**Iron**
Essential constituent of redox systems in plants
* Hemo proteins: cytochrome catalase and proxidase
* Non-hemo: ferrodoxin

Highly immobile
Chlorophyll formation is greatly decreased in Fe deficiency

✓ **Lime induced chlorosis’**
Chlorosis associated with soils high in Ca

Sensitivity
- Peach and pear> sweet cherry> plum> apricot> apple>sour cherry

Correcting Fe deficiencies
- Fe chelate
- Rootstocks
- Soil drainage
**Boron**
Its major role in fruit trees is in fruit set  
Deficiency causes accumulation of phenolic compounds  
Toxicity causes the pentose phosphate

**Integration of nutrition and tree physiology**
Training and pruning to maximize light penetration, interception and distribution

Why?
- Light interception is quantitative related to the productivity of an orchard on a land unit basis
- Poor light distribution, or shading, reduces the ability of a tree to performing both instances it is assumed that light is utilized for the assimilation of C from CO2 via the process of photosynthesis

✓ **Factors determining the photosynthetic potential**
- Internal
- Environmental

Internal
- Leaf structure
- Chlorophyll content
- Water conducting ability
- Osmotic adjustment (K)
- Presence of strong sinks

Environmental
- Availability of light
- High temperatures
- Air humidity

Photosynthesis
30% of the global radiation is absorbed by a modern orchard.  
Of this amount > 70% is converted into heat for transportation and connective heat exchange

PAR flux: photosynthetic active radiation between 400-700nm  
Light saturation occurs at 30-45% of full sun

✓ **Chlorophyll (Chl)**
- A heam molecule with Mg atom at center surrounded by N atoms
- The protein that manufactures Chl is activated by Mn and B ions
- Fe indirectly used in manufacture of the Chl, but used in photosynthesis
- Other minerals : K, P,

✓ **Shade vs. sun leaves**
Shade leaves:
- Larger area
- Larger SLA due to:
• Changes in the palisade layer
• Spongy mesophyll more loosely arranged
• Chloroplasts are oriented horizontally