Nutrient deficiencies and their symptoms in selected crops

Modified from Mike Stewart
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Potash & Phosphate Institute
www.ppi-ppic.org
Some good sources of information

Western Fertilizer Handbook

Nutrient Deficiencies & Toxicities In Crop Plants
Edited by William F. Bennett

Nutrient Deficiency Symptoms

Prepared by Potash & Phosphate Institute
Potash & Phosphate Institute of Canada
Nocross, GA 30092
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Essential and Beneficial Elements in Higher Plants

- Essential Mineral Element
- Beneficial Mineral Element
- Essential Nonmineral Element
Five general types of nutrient deficiency symptoms

- **Chlorosis** - yellowing due to reduction in chlorophyll
  - Uniform or interveinal
- **Necrosis** - death of plant tissue
- **Lack of new growth or terminal growth** resulting in resetting
- **Anthocyanin accumulation** (when metabolic processes are disrupted) resulting in reddish color
- **Stunting** with either normal or dark green color or yellowing

Bennett, 1993.
Several factors can affect occurrence of deficiency symptoms

- Soil test level
  - also consider texture, CEC, OM, pH, etc.
- Soil conditions, e.g.,
  - temperature
  - compaction
  - moisture
  - Salinity
- Tillage practices
- Root pruning
- Nutrient interactions
  - P-Zn
- Herbicide, disease, or insect damage
Soil pH and availability of nutrients
The Hills and Valleys of Phosphorus Fixation

Hill No. 1, greatest fixation:
- P fixation by iron

Valley No. 1:
- P fixation due to aluminum

Hill No. 2, high fixation:
- Range for highest P availability

Valley No. 2:
- P fixation by calcium

Hill No. 3, medium fixation:
- Acid soils
- Neutral
- Alkaline soils

Amount of phosphorus fixation in soil vs pH:
- pH3
- pH4
- pH5
- pH6
- pH7
- pH8
- pH9
- V. High
- High
- Medium
- Low
Soil pH and the secondary and micronutrients

- Soil pH influences
  - solubility of compounds, hence nutrient availability
  - cations on exchange sites
- Common deficiencies on **acid soils**
  - Ca, Mg, S, Mo
- Common deficiencies on **alkaline soils**
  - B, Cu, Fe, Mn, Zn
Nutrient deficiency symptoms and mobility within plants

- **Mobility** - The ease with which an element is transported to new plant parts.
  - The extent of mobility affects the appearance of deficiency symptoms.
Nutrient Mobility in the Plant

<table>
<thead>
<tr>
<th>Translocated</th>
<th>Not translocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms appear in older leaves</td>
<td>Symptoms appear in younger leaves first</td>
</tr>
<tr>
<td>first</td>
<td></td>
</tr>
<tr>
<td>• nitrogen</td>
<td>• sulfur</td>
</tr>
<tr>
<td>• phosphorus</td>
<td>• calcium</td>
</tr>
<tr>
<td>• potassium</td>
<td>• boron, iron, manganese, zinc, copper, molybdenum,</td>
</tr>
<tr>
<td>• magnesium</td>
<td>chloride</td>
</tr>
</tbody>
</table>
General symptoms - nitrogen

- Deficiency usually appears on older leaves first.
- Because N is a part of the chlorophyll molecule, a major deficiency symptom is chlorosis.
- Slow growth and stunted plants
- Lower protein, fewer leaves, and early maturity
- In corn yellowing begins at leaf tip and extends along midribs.
- Less tillering in small grains and other grasses
- Reduced yield potential
General symptoms- phosphorus

- Symptoms will generally appear on older leaves first.
- Purple or reddish color
- Overall stunting
- Reduced tillering in small grains
- Reduced yield potential
- In many crops symptoms can be aggravated by conditions that restrict root growth (e.g., cool, moist, and/or compacted soils).
General symptoms- potassium

- Symptoms will generally appear on older leaves first.
- Yellowing and/or scorching along leaf margins
- Weakened stalks (lodging)
- Decreased disease resistance
- Slow growth and poorly developed root system
- Small and shriveled grain or fruit
- Reduced yield potential
- In many crops symptoms can be aggravated by conditions that restrict root growth (e.g., cool, moist, and/or compacted soils).
Cotton
N management of cotton

- Uptake may reach 2-4 lb/A/day during mid boll fill
- Approximately 20% of seasonal needs should be supplied pre-bloom
- Supply remainder of N should be supplied during boll development period
- Soil N should be depleted as bolls begin to open to avoid delayed maturity
Dry Matter Accumulation, and Nitrogen and Phosphorus Uptake of Cotton

D. Krieg
N deficient cotton

Early and mid season
• Yellowish-green leaf color and small young leaves
• Stunted plants
• Shortened fruiting branches
• Many bolls shed in the first 10-12 days after flowering

Late season
• Reddening in the middle of the canopy
• Reduced boll retention at late fruiting positions
• Shorter flowering period, accelerated leaf senescence, and early cut-out
Functions of Phosphorus in Cotton Production

- Promotes early boll development and hastens maturity
- Essential for vigorous root and shoot growth
- Helps overcome the effects of compaction
- Increases water use efficiency
- A 2 bale crop can take up more than 50 lb P$_2$O$_5$/A
P deficient cotton

Symptoms are not distinct in cotton,

- Stunting
- Dark leaves
- Flowering delayed
- Poor boll retention
- Premature leaf senescence
Potassium in Cotton Production

- Bolls are major sinks for K, uptake may peak at as much as 3-4 lb K$_2$O/A/day during boll development.
- About 70% of total uptake occurs after first bloom.
- Affects quality (micronaire, length, and strength)
- Increases water use efficiency
- Reduces the incidence and severity of wilt diseases
- A 2 bale crop will take-up about 170 lb K$_2$O
Potassium deficient cotton

- Affects older leaves first in early season
- Begins as scorching of leaf margin
- Affects both yield and quality
- Late season affects younger leaves
Late season K deficiency of cotton
Foliar K on Cotton

• The foundation of K fertility program should be soil applications.

• Response to mid-season foliar K is likely when
  – soil K is low (low soil test level or fixation)
  – root uptake is compromised
  – petiole analysis indicates a pending shortage

• Applications at 2 week intervals should begin at or soon after 1st flower
  – 5 lb K$_2$O/A per application
Sulfur deficient cotton

- Symptoms similar to N but occur on younger leaves in upper canopy first
- Leaf veins tend to remain green
Mg deficiency in cotton

- Appears on older leaves first
- Distinct interveinal reddish purple color
Corn
Phosphorus deficiency in corn

- Purple or reddish color in older leaves
- Most often occur in young plants
- Overall stunting that may persist throughout season
- Lower yield
Effect of P on hastening corn maturity
K deficiency in corn

- Scorching (necrosis) along leaf margins of lower leaves first
- Weakened stalks that may result in lodging
- Decreased disease resistance
- Slow growth
- Reduced yield potential
K shortages can weaken stalks and result in lodging
Sulfur deficiency in corn

- Chlorosis similar to N but occurring on younger leaves first
- Delayed maturity
- Stunting
- Favored in sandy, acid soils low in OM, and cold wet soils.
Magnesium deficiency in corn

- Yellow to white intervienal chlorosis on older leaves first
- Leaves may become reddish-purple
- In severe cases leaf tips and edges may die
- Favored by sandy, acid soils where Mg has been leached
- Deficiency can be induced by imbalance with K
Zn deficiency due to P-Zn interaction
EFFECTS OF P IN ABSENCE OF SUFFICIENT Zn
80 lb P$_2$O$_5$ as 15-60-0

80 lb P$_2$O$_5$-Banded 0 Zn

80 lb P$_2$O$_5$-Broadcast 0 Zn
Wheat
**P deficiency in wheat**

- Slow growth and reduced tillering
- Late maturity and reduced yields
- Increased disease susceptibility
P deficiency in wheat...
reduces tillering, delays maturity, and lowers yield
S deficient wheat

- Brightly chlorotic, yellow-green and stunted plants.
- Most common on coarse, well-drained soils low in organic matter.
- In season deficiency best treated with sulfate source and not elemental S
## Some micronutrient symptoms

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Corn</th>
<th>Cotton</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zinc (Zn)</strong></td>
<td>Broad white to yellow bands on each side of midrib.</td>
<td>Interverinal yellowing with distinct green veins.</td>
<td>Stunted stems and chlorotic interveinal areas. Slowed maturity and reduced seed number.</td>
</tr>
<tr>
<td><strong>Iron (Fe)</strong></td>
<td>Interverinal areas become pale green to white.</td>
<td>Interverinal yellowing with distinct green veins.</td>
<td>Yellowing of interveinal areas. Whole leaf finally turns white. May be induced by liming.</td>
</tr>
<tr>
<td><strong>Manganese (Mn)</strong></td>
<td>Rarely occurs. Symptoms are not clear-cut.</td>
<td>Rarely occurs. Leaf cupping and interveinal chlorosis.</td>
<td>Interverinal areas become light green to white. Veins remain prominently green.</td>
</tr>
<tr>
<td><strong>Boron (B)</strong></td>
<td>Rarely occurs. Leaves are brittle with small dead spots.</td>
<td>Short, thick petioles with dark concentric bands along their length. Distorted flower shape. Flower and boll shedding.</td>
<td>Shortened internodes and yellowing or reddening of upper leaves. Death of terminal growth. Flowers fail to develop.</td>
</tr>
</tbody>
</table>

Bennett, 1993.
Zinc deficiency symptoms
Iron deficiency symptoms
Manganese deficiency symptoms

Cotton

Soybean

Soybean
Summary

• The ability to accurately diagnose nutrient deficiencies is an important skill.

• Deficiency symptoms are often not clearly defined. Masking effects can hinder diagnosis.

• The entire system should be evaluated before making a diagnosis and recommendation.

• Use soil, irrigation water, and plant analyses to aid in diagnostic efforts.
Summary

- Visual symptoms indicate severe starvation. Most crops start losing yields well before deficiency symptoms occur.
- In most cases in-season corrective applications can avoid further yield loss.
- A well-planned, complete and balanced fertility program can prevent in-season yield robbing nutrient deficiencies.
- Improving soil quality improves crop quality