After completing this Lecture, students will be able

1. to identify and diagnose common plant nutrient deficiency symptoms
2. to know potential limitations of visual diagnosis
3. to understand how to use a key for identifying deficiency symptoms
4. to distinguish between mobile and immobile nutrient deficiencies
LECTURE OUTLINE

- LECTURE OUTCOMES
- INTRODUCTION
- VISUAL DIAGNOSIS
- NUTRIENT DEFICIENCY TERMINOLOGY
- NUTRIENT DEFICIENCY SYMPTOMS
  - N, P, K, S, Mg, Ca deficiency
  - Fe, Mn, Zn, B, Mo & Cl deficiency

INTRODUCTION

BASIC CONCEPT

1. All nutrients must be present in optimum quantities for the proper growth and development of plants or crops.
2. The crop plants may reveal their hunger for the nutrient/s through certain symptoms when the soil does not provide the needed quantities of nutrient/s.

3. These symptoms may vary between nutrients, plant species or crop cultivars and environments.

4. It should be realized that any symptoms observed in the crop is a secondary effect and may be the result of more than one cause.

5. The symptoms observed have to be carefully identified and confirmed for their cause as some symptoms are clear and others or not.

6. Systematic visual inspection should be applied to find the primary cause or at least narrow down to one or two of the most likely possibilities.

7. The diagnosis for the plant symptoms can best be made on the individual plant in the field.

DIAGNOSTIC TOOLS FOR PLANT NUTRIENT STATUS

- Visual Diagnosis
- Tissue testing
  - Plant Analysis
- Soil testing
  - Challenge is to get the plant-available fraction and find a test that correlates well with yield
- Enzyme assays?
  - Peroxidase for Fe deficiency, citrus (deficiency ↓’s activity)
  - Carbonic anhydrase- Zn def., citrus, sugarcane, rice
  - Alcohol dehydrogenase- Zn def., rice
VISUAL DIAGNOSIS

PRINCIPLES

1. **Accurate diagnosis** is essential if nutritional problems are to be dealt with effectively.

2. **Visual symptoms** of nutrient deficiencies and toxicities often play an important part in diagnosis under field conditions, and the visual method has the advantage that it is not directly dependent on costly equipment or laboratory support services.

- However, because different nutritional disorders may sometimes produce rather similar visual symptoms, it is always wise to seek confirmation of the diagnosis by means of plant analysis, soil analysis, or both.
- Unfortunately, clearly recognizable symptoms in many plants are usually only associated with rather severe nutritional disorders.

*(Edwards et al., 1980)*
PRECAUTIONS IN DIAGNOSIS

- Interpreting visual nutrient deficiency and toxicity symptoms in plants can be difficult and plant analysis or soil testing is necessary to confirm nutrient stress.
- Precautions in identifying nutrient stress symptoms include the following:
  1. Many symptoms appear similar
  2. Multiple deficiencies and/or toxicities
  3. Crop species
  4. Pseudo (false) deficiency symptoms
  5. Hidden hunger
  6. Field symptoms

<table>
<thead>
<tr>
<th>Many symptoms appear similar</th>
<th>For instance, nitrogen (N) and sulfur (S) deficiency symptoms can be very alike, depending upon placement, growth stage, and severity of deficiencies.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple deficiencies and/or toxicities</td>
<td>More than one deficiency or toxicity can produce symptoms, or possibly a deficiency of one nutrient can induce the excessiveness of another (i.e., excessive P causing Zn deficiency).</td>
</tr>
<tr>
<td>Crop species</td>
<td>Crop species and even some cultivars of the same species, differ in their ability to adapt to nutrient deficiencies and toxicities. For example, corn is typically more sensitive to a Zn deficiency than barley (NM 7).</td>
</tr>
<tr>
<td>Pseudo (false) deficiency symptoms</td>
<td>Pseudo (false) deficiency symptoms (visual symptoms appearing similar to nutrient deficiency symptoms). Potential factors causing pseudo deficiency include, but are not limited to, disease, drought, excess water, genetic abnormalities, herbicide and pesticide residues, insects, and soil compaction.</td>
</tr>
<tr>
<td>Hidden hunger</td>
<td>Plants may be nutrient deficient without showing visual clues.</td>
</tr>
<tr>
<td>Field symptoms</td>
<td>Field symptoms appear different than 'ideal' symptoms. Many of the plants shown in this module as photographs were grown under controlled nutrient conditions, and deficiency/toxicity symptoms observed in the field may or may not appear as they do here.</td>
</tr>
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### NUTRIENT DEFICIENCY TERMINOLOGY

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>Burning</td>
<td>Severe localized yellowing; scorched appearance.</td>
</tr>
<tr>
<td>Chlorosis (yellowing)</td>
<td>General yellowing of the plant tissue; lack of chlorophyll. Uniform (N) vs. interveinal (K,Mg)</td>
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<tr>
<td>Generalized</td>
<td>Symptoms not limited to one area of a plant, but rather spread over the entire plant.</td>
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<tr>
<td>Immobile</td>
<td>Not able to be moved from one part of the plant to another.</td>
</tr>
<tr>
<td>Intervernal Chlorosis</td>
<td>Yellowing in between leaf veins, yet veins remain green.</td>
</tr>
<tr>
<td>Localized</td>
<td>Symptoms limited to one leaf or one section of the leaf or plant.</td>
</tr>
<tr>
<td>Mobile</td>
<td>Able to be moved from one plant part to another.</td>
</tr>
<tr>
<td>Mottling</td>
<td>Spotted, irregular, inconsistent pattern.</td>
</tr>
<tr>
<td>Necrosis (brown/black)</td>
<td>Death of plant tissue; tissue browns and dies. Leaf tips/margins (B toxicity) vs. interveinal (K, Zn)</td>
</tr>
<tr>
<td>Stunting</td>
<td>Decreased growth; shorter height of the affected plants. Shorter stature (N or P)</td>
</tr>
<tr>
<td>Lack of new growth</td>
<td>Death of terminal (Ca) axillary buds, and leaves. Leaf rosetting (Zn)</td>
</tr>
<tr>
<td>Anthocyanin accumulation</td>
<td>Base of stem (P), interveinal ~(Mg)</td>
</tr>
</tbody>
</table>

### MOBILE AND IMMOBILE NUTRIENTS

![Diagram of mobile and immobile nutrients](image)
1. N Deficiency

- Nitrogen is needed by plants for the production of proteins, nucleic acids (DNA and RNA), and chlorophyll.
- Symptoms of N deficiency are general chlorosis of lower leaves (light green to yellow), stunted and slow growth, and necrosis of older leaves in severe cases.
Nitrogen deficiency in corn

Iowa State University

Older leaves are affected first and may acquire a purplish discoloration due to the accumulation of sugars in P deficient plants which favor anthocyanin synthesis.

2. P Deficiency

- Plants require P for the development of ATP (energy), sugars, and nucleic acids. P deficiency symptoms are usually more noticeable in young plants, which have a greater relative demand for P than more mature plants.
- Older leaves are affected first and may acquire a purplish discoloration due to the accumulation of sugars in P deficient plants which favor anthocyanin synthesis.

Phosphorus deficiency

Iowa State University
3. K Deficiency

- Potassium is utilized by plants in the activation of enzymes and co-enzymes (specialized proteins serving as catalysts and co-factors), photosynthesis, protein formation, and sugar transport.

- Affected older leaves will show localized mottled or chlorotic areas with leaf burn at margins.

- Chlorotic symptoms typically begin on the leaf tip, but unlike the ‘V’ effect caused by N deficiency, K deficient chlorosis will advance along the leaf margins towards the base, usually leaving the midrib alive and green.
4. S Deficiency

- As S is an essential constituent of certain amino acids and proteins, S deficiency results in the inhibition of protein and chlorophyll synthesis.

- S deficiency symptoms can be difficult to diagnose as effects can resemble symptoms of N and Mo deficiencies.

- In contrast to N or Mo deficiency, however, S deficiency symptoms initially occur in younger leaves, causing them to turn light green to yellow.
5. Mg Deficiency

- Magnesium is the central molecule in chlorophyll and is an important cofactor for the production of ATP.
- Mg deficiencies are not common.
- Symptoms of Mg deficiency include interveinal chlorosis of older leaves, and leaf margins becoming yellow or reddish-purple while the midrib remains green.
6. Ca Deficiency

- Calcium is commonly the major cation of the middle lamella of cell wall, of which calcium pectate is the major constituent.
- Consequently calcium has an important bearing on the mechanical strength of tissues. In addition, calcium appears to play an important role in the organization of cell membranes by maintaining their selectivity towards various ions.
- Due to the role of Ca in structural material, it is very immobile in plants and deficiency symptoms show up in the new growth. In some cases the older plant tissues may contain “luxury” quantities of Ca whilst the new growth is deficient.

- Although all growing points are sensitive Ca deficiency, those of the roots are affected most severely. These cease growing, become disorganized, seen as a twisting and bending of the growing points, and, under severe deficiency die
- In corn the early foliar symptoms appear as a diffused yellow to white area about one-third of the distance from the tip of the youngest leaf. The next leaf formed may be chlorotic and rolled. Finally the growing apex becomes destorted and growth ceases.
Ca Deficiency

7. Fe Deficiency
- Iron plays an important role in plant respiratory and photosynthetic reactions. Fe deficiency reduces chlorophyll production and is characterized by interveinal chlorosis with a sharp distinction between veins and Chlorotic areas in young leaves.
- As the deficiency develops, the entire leaf will become whitish-yellow and progress to necrosis.
Iron deficiency in soybean

Iron deficiency in cassava
8. Mn Deficiency

- Manganese is needed by plants for the activity of some enzymes, and also involved with photosynthetic O₂ evolution.
- Chloroplasts are the most sensitive of cell organelles to Mn deficiency (Mengel and Kirkby, 2001). As a result, a common symptom of Mn deficiency is interveinal chlorosis in young leaves.

- However, unlike Fe, there is no sharp distinction between veins and interveinal areas, but rather a more diffuse chlorotic effect.
- The early stages of the chlorosis induced by manganese deficiency are somewhat similar to iron deficiency.
- It begins with a light chlorosis of the young leaves and netted veins of the mature leaves especially when they are viewed through transmitted light.
9. Zn Deficiency

- Zinc is needed by plants for growth hormone production and is particularly important for internode elongation.

- Zn has intermediate mobility in the plant and symptoms will initially show up in middle leaves.

- Zn deficient leaves display interveinal chlorosis, especially midway between the margin and midrib, producing a striping effect; some mottling may also occur.

- Chlorotic areas can be pale green, yellow, or even white. Severe Zn deficiencies will cause leaves to turn gray white and fall prematurely or die.

- Because Zn plays a prominent role in internode elongation, Zn deficient plants generally exhibit severe stunting.
10. Cu Deficiency

- Copper is needed for **chlorophyll production**, **respiration**, and **protein synthesis**.
- Cu deficient plants display chlorosis in younger leaves, stunted growth, delayed maturity (excessively late tillering in grain crops), lodging, and, in some cases, **melanosis** (brown discoloration).
- In cereals, grain production and fill is often poor, and under severe deficiency, grain heads may not even form.
11. B Deficiency

- Primary functions of B in plants are related to cell wall formation and reproductive tissue.
- Plants suffering from B deficiency exhibit chlorotic young leaves and death of the main growing point (terminal bud).
- Leaves may develop dark brown, irregular lesions that will progress to leaf necrosis in severe cases. Whitish-yellow spots may also form at the bases of leaves.
- Due to disturbances in cell wall growth, leaves and stems of B deficient plants will become brittle and distorted and leaf tips tend to thicken and curl.
- Affected plants will grow slowly and appear stunted as a result of shortened internodes (stem segment between points where leaves are attached).
12. Mo Deficiency
- Molybdenum is needed for enzyme activity in the plant and for nitrogen fixation in legumes.
- Due to this interrelationship, Mo deficiency symptoms often resemble N deficiency symptoms with stunted growth and chlorosis occurring in legumes.
- Other symptoms of Mo deficiency include pale leaves that may be scorched, cupped, or rolled.
- Leaves may also appear thick or brittle, and will eventually wither, leaving only the midrib.
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13. CI deficiency

- Plants require relatively high chlorine concentration in their tissues for leaf turgor and photosynthesis. Chlorine is very abundant in soils, and reaches high concentrations in saline areas, but it can be deficient in highly leached inland areas.

- The most common symptoms of chlorine deficiency are chlorosis and wilting of the young leaves. The chlorosis occurs on smooth flat depressions in the interveinal area of the leaf blade.

- Wilting of leaves at margins and highly branched root systems are also typical Cl deficient symptoms, found mainly in cereal crops (Mengel and Kirkby, 2001).
- Chlorotic and necrotic spotting may be found along leaves with abrupt boundaries between dead and live tissue.
- In more advanced cases there often appears a characteristic bronzing on the upper side of the mature leaves.
- Plants are generally tolerant of chloride, but some species such as avocados, stone fruits, and grapevines are sensitive to chlorine and can show toxicity even at low chloride concentrations in the soil.

CL deficiency in hydroponically grown WB881 durum wheat. (From R. Engel)

- CI deficiencies are highly cultivar specific and can be easily mistaken for leaf diseases, and were often misdiagnosed as physiological leaf spot (Engel et al., 2001).
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Спасибо
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