

## Chapter 36 Plant Nutrition

## Nutritional Needs

- Autotrophic does not mean autonomous
  - plants need...
    - sun as an energy source
    - inorganic compounds as raw materials
      - water (H<sub>2</sub>O)
      - CO<sub>2</sub>
      - minerals

## Macronutrients

- Plants require these nutrients in relatively large amounts (at least 1 g/kg of dry matter)
  - C, O, H, N, P, K, Ca, Mg, S

**Table 37.1 Essential Elements in Plants**

Element	Form Available to Plants	% Mass in Dry Tissue	Major Functions
<b>Macronutrients</b>			
Carbon	CO <sub>2</sub>	45%	Major component of plant's organic compounds
Oxygen	CO <sub>2</sub>	45%	Major component of plant's organic compounds
Hydrogen	H <sub>2</sub> O	6%	Major component of plant's organic compounds
Nitrogen	NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup>	1.3%	Component of nucleic acids, proteins, hormones, chlorophyll, coenzymes
Potassium	K <sup>+</sup>	1.0%	Cofactor that functions in protein synthesis; major solute functioning in water balance; operation of stomata
Calcium	Ca <sup>2+</sup>	0.5%	Important in formation and stability of cell walls and in maintenance of membrane structure and permeability; activates some enzymes; regulates many responses of cells to stimuli
Magnesium	Mg <sup>2+</sup>	0.2%	Component of chlorophyll; activates many enzymes
Phosphorus	H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> , HPO <sub>4</sub> <sup>2-</sup>	0.2%	Component of nucleic acids, phospholipids, ATP, several coenzymes
Sulfur	SO <sub>4</sub> <sup>2-</sup>	0.1%	Component of proteins, coenzymes

## For what & from where?

<b>C</b>	synthesis	CO <sub>2</sub>
<b>O</b>	synthesis	CO <sub>2</sub>
<b>H</b>	synthesis	H <sub>2</sub> O
<b>N</b>	protein & nucleic acid synthesis	soil & fertilizer
<b>P</b>	nucleic acids, ATP, phospholipids	soil & fertilizer
<b>K</b>	stomate control, water balance	soil & fertilizer
<b>Ca</b>	cell wall & membrane structure, regulation	soil
<b>Mg</b>	chlorophyll	soil
<b>S</b>	proteins, enzymes	soil

## Micronutrients

- Plants require in very small amounts (less than 100 mg/kg of dry matter)
  - primarily cofactors

**Table 37.1 Essential Elements in Plants**

Element	Form Available to Plants	% Mass in Dry Tissue	Major Functions
<b>Micronutrients</b>			
Chlorine	Cl <sup>-</sup>	0.01%	Required for water-splitting step of photosynthesis; functions in water balance
Iron	Fe <sup>2+</sup> , Fe <sup>3+</sup>	0.01%	Component of cytochromes, activates some enzymes
Manganese	Mn <sup>2+</sup>	0.005%	Active in formation of amino acids; activates some enzymes; required for water-splitting step of photosynthesis
Boron	H <sub>2</sub> BO <sub>3</sub> <sup>-</sup>	0.002%	Cofactor in chlorophyll synthesis; may be involved in carbohydrate transport and nucleic acid synthesis; role in cell wall function
Zinc	Zn <sup>2+</sup>	0.002%	Active in formation of chlorophyll; activates some enzymes
Copper	Cu <sup>+</sup> , Cu <sup>2+</sup>	< 0.001%	Component of many redox and lignin-biosynthetic enzymes
Nickel	Ni <sup>2+</sup>	< 0.001%	Cofactor for an enzyme functioning in nitrogen metabolism
Molybdenum	MoO <sub>4</sub> <sup>2-</sup>	< 0.001%	Essential for symbiotic relationship with nitrogen-fixing bacteria; cofactor that functions in nitrate reduction

## Nutrient Deficiencies

- Lack of essential nutrients
  - exhibit specific symptoms
    - dependent on function of nutrient
    - dependent on solubility of nutrient

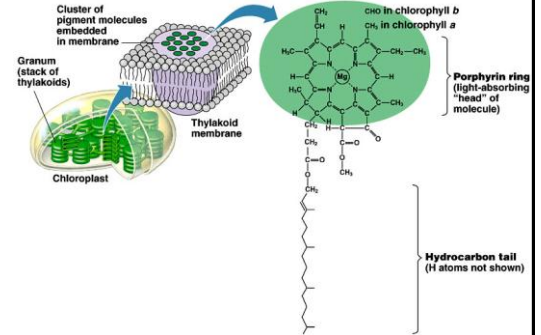
## Magnesium Deficiency

### Symptoms

- ◆ chlorosis = yellowing of leaves
- ◆ what is magnesium's function?



## Chlorophyll



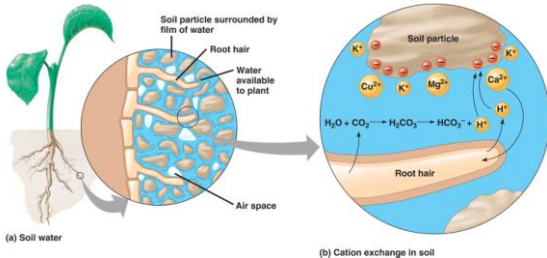
## Water & Mineral Uptake

### Water uptake

- ◆ plants cannot extract all water from soil, only free water
- ◆ osmosis

### Cation uptake

- ◆ cation uptake is aided by  $H^+$  secretion by root cells (proton pump)
- ◆ active transport



## The Role of Soils

### Plants are dependent on soil quality

- ◆ texture / structure
  - relative amounts of various sizes of soil particles
- ◆ composition
  - organic & inorganic chemical components
  - fertility



## Importance of Organic Matter

### Topsoil ('A' Horizon)

- ◆ most important to plant growth
- ◆ rich in **organic matter**
  - humus
    - ◆ decomposing organic material
      - breakdown of dead organisms, feces, fallen leaves & other organic refuse by bacteria & fungi
    - ◆ improves soil texture
    - ◆ reservoir of minerals
- ◆ organisms
  - 1 tsp. of topsoil has ~5 billion bacteria living with fungi, algae, protists, insects, earthworms, nematodes



## Soil Health as a Global Issue

### Not taking care of soil health has far-reaching, damaging consequences

- ◆ 1920's → 1930's Dust Bowl
- ◆ lack of soil conservation
  - growing wheat
  - raising cattle
  - land exposed to wind erosion
  - drought



### Soil Health as a Global Issue

- Soil conservation & sustainable agriculture
  - maintaining healthy environment
  - production of food supply
  - economically viable farming industry

**"A sustainable agriculture does not deplete soils or people."**  
– Wendell Berry

contour plowing      cover crops      crop rotation

### Global Issues

- fertility
- erosion
- irrigation
- forestry destruction



### Fertilizers

- "Organic" fertilizers
  - manure, compost, fishmeal
- "Chemical (Inorganic)" fertilizers
  - commercially manufactured
  - N-P-K (ex. 15-10-5)
    - 15% nitrogen
    - 10% phosphorus
    - 5% potassium

### Nitrogen Uptake

- Nitrates
  - plants can only take up nitrate ( $\text{NO}_3^-$ )
- Nitrogen cycle by bacteria
  - trace path of nitrogen fixation!

### Soybean Root Nodules

- N fixation by *Rhizobium* bacteria
  - symbiotic relationship with bean family (legumes)

(a) Pea plant root. The bumps on this pea plant root are nodules containing *Rhizobium* bacteria. The bacteria fix nitrogen and obtain photosynthetic products supplied by the plant.

(b) Bacteroids in a soybean root nodule. In this TEM, a cell from a root nodule of soybean is filled with bacteroids in vesicles. The cells on the left are uninfected.

### Increasing Soil Fertility

- **Cover crops**
  - ◆ growing a field of plants just to plow them under
    - usually a legume crop
    - taking care of soil's health
      - ◆ puts nitrogen back in soil



### Parasitic Plants

- tap into host plant vascular system



### Plants of Peat Bogs

- **High acid environment**
  - ◆ most minerals & nutrients bound up & are not available to plants
    - must find alternative sources of nutrients



### Carnivorous Plants...



Are they really carnivores?