

Plant Nutrition and Soils
Chapter 29

Plant Nutrition

- relatively simple compared to animals
- definition

Essential Elements

- mid-1880's: 10 essential elements
 - C, H, O, K, Ca, Mg, N, P, S, Fe
- early 1900's: Mn
- through 1960's: Zn, Cu, Cl, B, Mo
- recently: Ni
- element is essential if:
- micronutrients (trace elements)
 - concentrations < 100 mg/kg dry matter
- macronutrients
 - concentrations > 1000 mg/kg dry matter
- requirements differ among plant groups and species

Functions of Essential Elements

- many roles
 - structural, enzymatic, regulatory, ionic
- nutrient deficiency symptoms
 - most associated with shoot
 - necrosis
 - chlorosis
 - phloem-mobile elements

The Soil

- soils provide plant with
- rock weathering important for inorganic nutrient supply
 - beginning of succession
- soil horizons
 - A horizon (topsoil)
 - B horizon
 - C horizon
- solid matter
 - sand

- silt
- clay
- pore space
- water potential
 - measured as pressure units in soil, plant, and air
 - indication of amount of water held in soil
 - below minimum threshold, plant will wilt
- soils retain cations, leach anions

Nutrient Cycles

- biogeochemical cycles
- 17 essential elements for plants
- dependent on recycling of nutrients

The Nitrogen Cycle

- Where is most nitrogen on Earth?
- In what form?
- three main processes
 - ammonification
 - nitrification
 - assimilation
- ammonification
 - nitrogen mineralization
 - convert amino acids to ammonium ions (NH_4^+)
- nitrification
 - oxidation of ammonium
 - chemosynthetic autotroph *Nitrosomonas*
 - oxidize ammonium to nitrite ions (NO_2^-)
 - another bacterium *Nitrobacter*
 - oxidizes nitrite to nitrate (NO_3^-)
- denitrification
 - nitrate reduced to nitrogen gas (N_2) and nitrous oxide (N_2O)
 - anaerobic process
- other losses of nitrogen from soil
- nitrogen fixation
 - N_2 reduced to NH_4^+
 - energy expensive reaction
 - nitrogenase requires molybdenum, iron, sulfide
 - only certain bacteria
 - some symbiotic with plants
 - most important fixers

- *Rhizobium* and *Bradyrhizobium*
- legumes (Fabaceae)
- root nodules produced by infection
- very specific associations between bacterial species and plant species
- other microorganisms symbiotic with other plant species
 - » alder and other plants with actinomycetes
 - » *Azolla-Anabaena*
- other nitrogen-fixing bacteria free-living
- nitrogen fixation
 - industrial fixation
 - developed in 1914
- assimilation
 - inorganic nitrogen (nitrates and ammonia) into organic compounds
 - most plants take up N primarily as nitrate
 - evidence that many plants may take up organic compounds directly
 - via roots
 - via mycorrhizae

The Phosphorus Cycle

- Where is most of the phosphorus on Earth?
- localized cycling
- amount of P required by plants small compared with N

Revisit the Carbon Cycle

- each cycle is interconnected with all the others
- What do plants need to photosynthesize?

Human Impacts on Nutrient Cycles and Effects of Pollution

- human population growing exponentially
 - food cultivation has had dramatic effects on some element cycling
- acid rain

Soils and Agriculture

- elements naturally re-cycle in soils
 - patterns altered by agriculture

Plant Nutrition Research

- overcome soil deficiencies and toxicities
 - select and develop varieties of plants rather than amending soil
 - phytoremediation
 - manipulate biological nitrogen fixation

Summary

- micronutrients and macronutrients
 - recycled globally and locally

- inorganic nutrients
- characteristics of soils
- nitrogen cycle
- phosphorus cycle
- human activities
- plant nutrition research