BIOL 695

MAGNESIUM

Chapter 12
MENGEL et al, 5th Ed

SOIL Mg

- **Mg soil content**
  - **Sand 0.05%**
  - **Clay 0.5%**
- **Mg present in easily weatherable minerals**
  - **Biotite (mica)**
  - **Olivine, hornblende & others**

SECONDARY CLAY MINERALS

- **Clay minerals (reserve Mg)**
  - **Vermiculite**
  - **Illite**
  - **Montmorillonite**
- **Chemical form of Mg**
  - **$MgCO_3$ - magnesite**
  - **Dolomite - $CaMg(CO_3)_2$**
  - **$MgSO_4$ - kieserite**

SOIL DISTRIBUTION

- **Same situation as with K**

  A $\Leftrightarrow$ B $\Leftrightarrow$ X

Where:

A = Soluble Mg^{2+}

B = Exchangeable Mg^{2+}

X = Non-Exchangeable Mg^{2+} (largest portion of Mg^{2+} in soil)

CATION EXCHANGE CAPACITY

- **Percentage of CEC**
  - **Ca - 80%**
  - **Mg - 2 to 20%**
  - **K - 5%**
- **Mg is leached similarly to Ca, rates related to soil type**

UPTAKE

- **Small divalent cation**
  - **Mg^{2+} hydrated ionic radius = 0.428 nm**
  - **more or less 0.5% in plant tissue**
- **Roots have less ability to uptake Mg in comparison to K**
- **Relatively high conc's of Mg in soil solution**
- **Threshold values are published for many plants**

COMPETITION

- Competition between NH_4^+ & Mg^{2+} dependent on:
  - – H^+ release from NH_4^+ incorporation
  - – Mg^{2+} direct effect
  - – Mg^{2+} deficiency induced by competing cations is common
- High K^+ in soil $\Rightarrow$ Mg^{2+} deficiency in apple leaves

MORE COMPETITION

- Low levels of K^+ $\Rightarrow$ Higher Mg^{2+} uptake
- Low levels of Ca^{2+} $\Rightarrow$ Higher Mg^{2+} up
- Increase of Mg^{2+} fertilization
  - – Reduces Mn^{2+} toxicity
- K^+ promotes transl of Mg^{2+} from leaves to fruit & storage tissue
- Mg^{2+} mobile in phloem; Ca^{2+} is NOT.

Mg IN CHLOROPHYLL

- Mg^{2+} central ion in chlorophyll (Fig. 1.3)
- Proportion of total Mg bound in chlorophyll depends on Mg supply.
  - 6 - 25% of total Mg in chlorophyll
  - 5 - 10% in cell wall pectates
  - Small amount in vacuoles
  - Remainder of Mg is water extractable

CHLOROPHYLL TAKES PRECEDENCE

- Mg^{2+} bound in chlorophyll might be as high as 50% in low light.
- Chlorophyll takes precedence
  - Content depends on availability of Mg^{2+}

CHLOROPHYLL BIOSYNTHESIS

- **Insertion of Mg^{2+} into porphyrin struc**
  - **First step in chlorophyll synthesis**
  - **Catalyzed by Mg-chelastase + ATP**
- **Mg essential as bridging element for aggregation of ribosome subunits**
  - **Necessary for protein synthesis**
    - **Doesn't happen when Mg^{2+} low or K^{+} is high**

DNA

- **Mg req in RNA polymerase**
  - **For formation of RNA in nucleus**
    - **Related to bridging between DNA strands**
    - **Neutralizing acid proteins in nuclear matrix**
    - **Important in formation of ribozymes (ribozome)**

Mg IS DIFFUSIBLE

- 70% Mg diffusible & assoc'd with
  - Inorganic anions
  - Organic anions (citric & malate)
- Mg activates phosphorylation
  - Forms bridge between phosphorylation structure of ATP & enzyme molecule

Mg Required in CO_2 Assimilation

- Mg^{2+} & Mn^{2+} can replace each other
- Mg^{2+} resembles K^{+} and Ca^{2+} in soil
  - Much different role in plant
- Why are potatoes low grade when grown in Mg-deficient soil?
- Stabilizes ribosomal particles in config necessary for protein synthesis

Mg DEFICIENCY

- Mg^{2+} req'd in plant is optimum at
  - 0.15 - 0.35% Dry Weight Basis
- Protein N down
  - Non-protein N up in deficient leaves
- Mg^{2+} mobile thus deficiency where?
  - Enhances protein degradation
  - Other pigments also affected
- Starch accumu In Mg deficient chloroplasts
  - Responsible for increase in dry matter of Mg deficient leaves

DEFICIENCY SYMPTOMS

- Interveinal yellowing - chlorosis
- Confused with virus yellowing
- May appear withered as in K deficiency
- Stiff & brittle leaves
- Abscise prematurely
- See Mg Deficiency slides in BIOL 695 Deficiency Symptom CD-1

CROP REQUIREMENTS

- **Applying Mg beyond growth-limiting level results in Mg being stored in vacuoles**
  - **Acting as buffer in metabolic pool**
  - **Charge compensation & osmoregulation in vacuole**

TOO MUCH Mg IN DROUGHT

- **High Mg in leaves (1.5%) critical under drought stress**
  - **As leaf water potential drops**
  - **Mg conc increases from 3 to 5 mM to 8 - 13 mM**
  - **Such high concentration in stroma of chloroplasts inhibits PS**

COMPARATIVE USE OF Mg

Crop	Kg of Mg / Ha
• Potatoes	7
• Tomatoes	12
• Cabbage	9
• Oil Palm	38
• Coconut	12
• Tea	3

FERTILIZERS TODAY

- Mg was an impurity in many fertilizers in past
  - No longer true today
  - K^+ and NH_4^+ restricts Mg^{2+} uptake
- pH influence
  - Higher - Ca^{2+} competes $\Rightarrow$ Mg^{2+} defic
  - Acid - H^+ & Al^{3+} competes $\Rightarrow$ Mg defic

Mg FERTILIZERS

- **Applied as:**
  - **$MgCO_3$ - magnesite**
  - **dolomite best to lime acid soils - Ca & Mg (dolomitic limestone reacts more slowly)**
  - **MgO**
  - **$MgSO_4$ - More effective & expensive**
    - **Epsom salt effective as foliar spray**
- **See list of Mg fertilizers in Table 12.4**