

BIOL 695

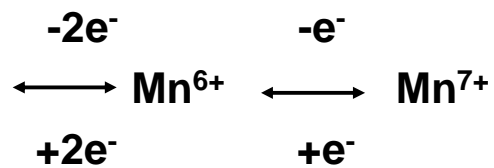
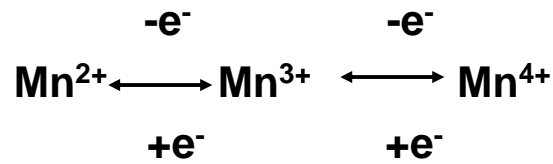
MANGANESE

Chapter 14
MENGEL et al, 5th Ed

Mn OXIDATION STATES IN SOIL

- **Mn can exist in the oxidation states:**
 - **Mn⁰⁺ Mn²⁺ Mn³⁺ Mn⁴⁺ Mn⁶⁺ Mn⁷⁺**
 - **Mn²⁺ and Mn⁴⁺ are most common**
- **Mn²⁺ soluble and can be toxic**
 - **Low pH**
 - **Water logged soil ⇒ anaerobic**
 - **Steam sterilization kills Mn oxidizing microorg ⇒ Mn tox**

Mn NODULES



Influenced by microbes & anaerobic soil conditions

TETRAVALENT Mn INSOLUBLE

- Mn^{4+} is insoluble \Rightarrow Mn deficiency
 - High pH
 - Soil aeration
 - Microbial activity
- Mn plays important role in redox rea'ns
- Fig. 14.1 text Oxid'n - Red'n Cycle for Mn

UPTAKE

- **Mn²⁺ lower uptake than Ca²⁺ & Mg²⁺**
- **Active**
- **Mg²⁺ depresses Mn²⁺ uptake**
- **Mn²⁺ depresses Fe²⁺ uptake**
- **Plants supplied with NH₄-N took up more Mn²⁺ than NO₃-N fed plant**

Mn RELATION TO OTHER IONS

- **Ionic radius of**
 - **Mg²⁺ 0.065 nm**
 - **Mn²⁺ 0.075 nm**
 - **Ca²⁺ 0.099 nm**
- **Mn²⁺ can substitute or compete with these ions.**

Mn CONTAINING ENZYMES

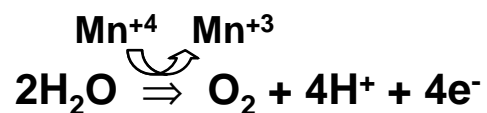
- Mn^{2+} activates IAA Oxidase

IAA Oxidase

- Reduced IAA \longrightarrow Oxidized IAA
(Active) (Inactive)
- Mn deficient plants have toxic levels of IAA
- “Mn toxicity may relate to IAA defic”

WATER SPLITTING

- Mn protein in Photosystem II
- Role in water splitting system
– Fig 14.3 on page 578 text

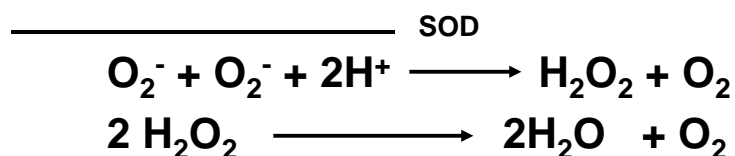


NITRATE REDUCTASE

- Mn cofactor for NR (1970)
- $\text{NO}_2^- \longrightarrow \text{NH}_4^+$
- Evidence - NO_3^- Accum in Mn^{2+} def pl
- BUT due to shortage of red equiv in chloroplasts and neg feedback reg'n resulting in lower demand for red'd N in new growth of Mn def plant, then NO_3^- accum. No evidence of direct Mn^{2+} role (1985)

ELIMINATION OF SUPEROXIDES

- Superoxide dismutase (MnSOD)
 - Present in all aerobic organisms
 - Plays essential role in survival of organ if presence of oxygen
- $\text{O}_2 + e^- \Rightarrow \text{O}_2^-$ (Superoxide)



Mg CAN SUBSTITUTE FOR Mn

- Mg^{2+} 50 - 100 times $>$ Mn^{2+} in cell
- Mn^{2+} necessary in cases where more effective than Mg^{2+}
- Activation of chloroplast RNA polymerase req's 10 x greater Mg^{2+} than Mn^{2+}

ABSOLUTE REQ'MT FOR Mn^{2+}

- Bundle sheath chloroplasts of C4 plants where oxaloacetate acts as carbon shuttle.
 - Decarboxylation catalyzed by
 - PEP carboxykinase which has absolute requirement for Mn^{2+}

Mn²⁺ ROLE IN O₂ EVOLUTION

- **Decrease in Mn²⁺ only small effect on chlorophyll or leaf dry wt.**
- **But O₂ evolution drops by 50%**
- **When Mn def becomes more severe**
 - **Chlorophyll content decreases & not reversible.**
 - **Caused by inhib of lipid synthesis**

CHO & LIPIDS

- **Mn deficiency has severe effect on non structural CHO**
 - **Largest effect in roots**
- **Depress of lipid content in chloroplasts**
 - **Role of Mn in synthesis of lipids**
 - **Coupling of C₂ units**
 - **Mn increases lipids, reduces protein**
 - **Shift from linoelic to oleic**

CELL DIVISION & EXTENSION

- **Cell elongation responds better to Mn than cell division**
 - **Mn def plant roots have small nonvacuolated cells**
- **Inhibition of root growth in Mn defic plants caused by lack of CHO**
- **Mn essential to root growth**

Mn DEFICIENCY

- **Soils derived from material low in Mn**
- **Highly leached tropical soils**
- **Common in high pH soil**
- **Containing free carbonates**
 - **Soils high in OM esp prone to defic**
- **Corrected by soil or foliar MnSO_4 app**
 - **Soil treatment is best**

Mn DEFICIENCY SYMPTOMS

- Soaking seed in MnSO_4 improves growth in Mn deficient soils.
- Peaches are susceptible to low Mn
- Critical Mn conc 10 - 20 ppm leaves
- Interveinal chlorosis in younger leaves of dicots
- “Gray speck” on older cereal leaves

Mn TOXICITY

- Wide range of concentrations
- Symptoms are brown speckles on mature leaves
 - Less distance in high light vs low It
 - Brown specks contain oxidized polyphenols + MnO_2
 - Preceded by callous indicating toxic Mn^{2+} on Plasma Membrane & + Ca^{2+} influx

Mn TOXICITY INDUCES DEFIC

- **Beans - interveinal chlor & necrosis**
 - **Combined with deformed young leaves, typical of Ca deficiency**
 - **Induced deficiencies of Fe, Mg, Ca**
 - **Mn toxicity countered by**
 - **High supply of Mg**

INDUCED Ca DEFICIENCY

- **Acropetal Ca transport mediated by basipetal IAA transport.**
- **Toxic Mn levels \Rightarrow IAA oxidase \Rightarrow Less IAA \Rightarrow Less Ca transport**
- **Aggravated by high light intensity**
 - **Loss of apical Dominance**
 - **“Witches broom”**

STEAM STERILIZATION

- **Of media is opposite reaction**
 - **It is a reducing reaction**
 - **Steam kills oxidizing bacteria**
 - **Media under water as steam condenses & oxygen is lost**
 - **Decaying OM Sucks up the O₂**
 - **Mn analysis: 80 ppm in greenhouse media. Mn²⁺ in media highly toxic**