BIOL 695

ZINC

Chapter 15
MENGEL et al, 5th Ed
(Handout: Sec 9.4
Marschner, 1995)

SOIL Zn

- **Soil concentration ~È10 - 300 ppm**
- **Much related to Zn in PM**
- **Ionic radius similar to Fe^{+2} & Mg^{+2}**
  - **may occur in sim minerals**
  - **includes clay minerals**
- **Sorbed as Zn^{+2}, $ZnOH^{+}$, $ZnCl^{+}$**
- **Low conc'ns in soil solution**
- **Forms complexes with OM**

UPTAKE

- Taken up as a divalent cation (Zn^{2+})
  - At high pH taken up as $ZnOH^{+}$
- Xylem transport
  - bound to organic acids
  - in free divalent form
- High conc in phloem sap
  - Complexed with low molecular organic solutes

FORM IN PLANT

- Exists as divalent cation
  - Does Zn enter into redox reactions?
- Metabolic function
  - Forms tetrahedral complexes with
    - N, O, S ligands
      - Both structural & catalytic

ENZYMES WITH CATALYTIC FUNCTIONS

- Carbonic anhydrase, carboxypeptidase
- Example - 4 points of ligand
  - Water
  - Histidine (most frequent)
  - Glutamine
  - Asparagine (Model I pp 348, Marschner)

ENZYMES WITH STRUCTURAL Zn FUNCTIONS

- Alcohol dehydrogenase & proteins involved in DNA replication & gene expression
  - Structural Zn atoms coordinated to S-groups of 4 cysteine residues
    - Highly stable tertiary structure
      - Model II pp 348, Marschner

ALCOHOL DEHYDROGENASE

- 2 Zn atoms / molecule
  - 1 catalytic
  - 1 structural
  - pp 348, Marschner

CARBONIC ANHYDRASE

- Single Zn atom catalyzes
  - Hydration of CO_2

    $CO_2 + H_2O \Leftrightarrow HCO_3^- + H^+$
- Lack of relationship between PS & CA in C_3 plants.
- In C_4 plant, high CA activity needed in mesophyll chloroplasts to shift to HCO_3^- from CO_2 (Fig. 9.14 & 9.15, Marschner)

CuZn SUPEROXIDE DISMUTASE

- Cu is catalytic metal
- Zn structural metal
- SOD decreases with Zn deficiency
  - Increase in O_2^- (Table 9.16, Marshner)
    - Causes peroxidation of membrane lipids
    - Increase in membrane permeability

REGULATION OF GENE EXPRESSION

- Zinc metalloproteins
  - Polypeptide chain forms a loop of
    - 11-13 amino acids which binds
      - Specific DNA sequences
      - Zn directly involved in translation step of gene expression (Fig. 9.16, Marschner)

PROTEIN SYNTHESIS

- Protein content of Zn-def plants
  - Decreases (Table 9.17, Marschner)
  - Amino acids accumulate
- Resupply Zn & proteins increase
- Zn structural component of ribosomal RNA
  - Zn defic - ribosomes disintegrate

SHOOT MERISTEMS REQUIRE Zn

- Requires 100μg g^{-1} for maintenance of protein synthesis
- Leaf blades require much less Zn
- Most root-supplied Zn preferentially translocated to apex to meet high req
- Increase in RNase activity observed before Zn def symptoms appear

CHO METABOLISM

- Zn-dependent enzymes in CHO meta
  - Fructose 1,6-bisphophatase
    - Key in partitioning C_6 sugars
  - Aldolase transfer of C_3 photosynth from chlorop to glycolytic pathway
  - (Model pp 354, Marschner)
- Both located in chloroplasts & cytoplsm

CHO METABOLISM

- Zn deficient leaves
  - Decline in carbonic anhydrase most sensitive change
- Despite decrease in enzyme activity & PS (Hill Reaction) sugars & starch accumulate in Zn deficient plants
- Zn-def change in CHO metab not prim responsible for growth retardation or Zn deficiency symptoms

TRYPTOPHAN & IAA SYNTHESIS

- Rosettes & Little Leaf are related to disturbances in IAA metabolism
- Model pp 355, Marschner
- Zn $\Rightarrow$ IAA $\Rightarrow$ Growth
- Lower IAA in Zn defic plants
  - Could be result of oxidative degradation of IAA

Summary of Fig. 9.18

- Zn deficiency $\Rightarrow$ O_2^- generation $\Rightarrow$ Less IAA $\Rightarrow$ growth inhibition
- Zn sufficiency $\Rightarrow$ O_2^- destruction $\Rightarrow$ More IAA $\Rightarrow$ growth (shoot elongation)

Zn REQUIRED FOR MEMBRANE INTEGRITY

- Binds to phospholipids & sulfhydryl gps to form tetrahedral complexes with cysteine & polypeptide chains
  - Thus protects lipid membranes & proteins from oxidative damage
- Prevents oxidation of NADPH

AS A RESULT OF Zn DEF PLANTS

- Increase in PM permeability
- Decrease in phospholipids
- Decrease in degree of unsaturation of fatty acids.

P - Zn INTERACTIONS

- **Large appl of P in soils low in available Zn $\Rightarrow$ Zn deficiency**
- **High P supply**
  - **Reduces root growth**
  - **Less infection with VA mycorrhizae**
  - **Might reduce solubility of Zn**
- **Pecan Zn defic cleared up by alfalfa**