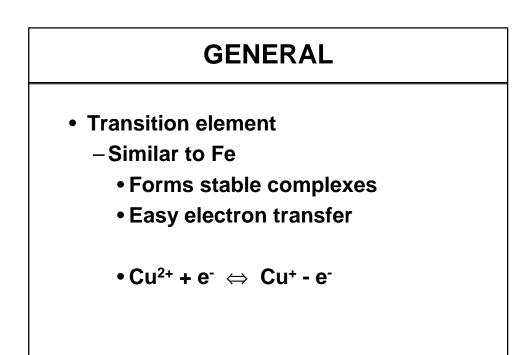
BIOL 695

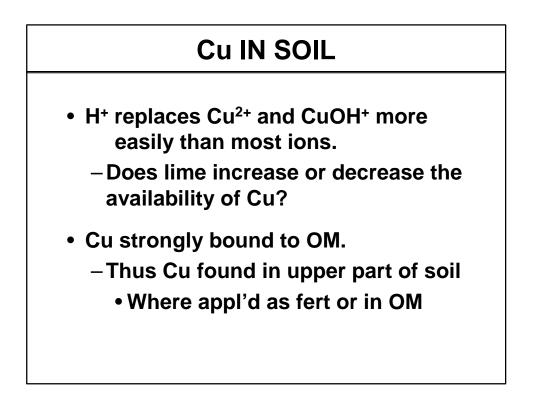
COPPER

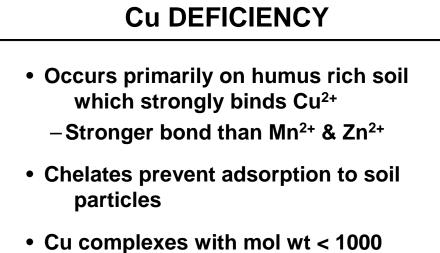
Chapter 16 MENGEL et al, 5th Ed



TERMINAL OXIDATION

- Cu⁺ unstable
- Most Cu functions based on
 - -Enzymatically bound Cu in redox
 - Terminal oxidation in cells catalyzed by Cu not Fe
- Cu has high affinity for peptide & sulfhydryl groups





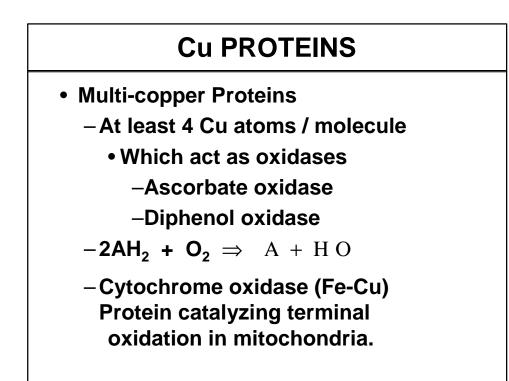
more available than those > 5000

UPTAKE & TRANSLOCATION

- Cu content of plants 2-20 ppm – 1/10 of Mn content
- Active uptake
- Cu & Zn inhibit uptake of each other
- Cu not readily mobile in plant
 - -If plenty of Cu it moves
 - -If Cu deficient it does not move

Cu PROTEINS

- Blue Proteins
 - -Without oxidase activity
 - Plastocyanin
 - One electron transfer
- Non-blue Proteins
 - -Peroxidases
 - Mono and diphenols



PLASTOCYANIN

- 50% of Cu in chloroplasts bound in plastocyanin
 - -1 Cu atom / molecule
 - Component of electron transfer chain of photosystem I
- Cu defic ⇒ PS I drastic reduction
 −Chlorophyll not affected
- PS I more affected by Cu defic than PSII

SUPEROXIDE DISMUTASE

- Detoxification of superoxide radicals O₂⁻
- CuZnSOD Mol Wt. ~32 kDa
 - 1 Cu & 1 Zn atom at active site connected to a histidine N
 - Cu atom involved in detoxification of
 O₂⁻ generated in photosynthesis
- CuZnSOD controls peroxidation of membrane lipids
 - -Thus involved in senescence

ASCORBATE OXIDASE

- Oxidizes ascorbic acid to dehydroascorbic acid
- Contains 4 Cu atoms / molecule – Operates 4-electron red $O_2 \Rightarrow H_2O$
- Ascorbate Oxidase activity (AOA) decreases in Cu defic & sensitive indicator Cu nutritional status.

RAPID FIELD TEST FOR Cu

- Simple colormetric field test for AOA dev for diagnosis of Cu deficiency.
- Results close to Cu cont. of leaves.
- Resupplying Cu to deficient plants – Restores AOA in very young lvs
 - Thus enzyme synthesized only in young leaves

ASCORBATE OXIDASE ACTIVITY

- In contrast to plastocyanin
 - Activity can be restored in mature leaves on resupplying Cu.

DIAMINE OXIDASE (DO)

- Polyamine oxidase are flavoproteins

 Catalyze degradation of polyamines
 e.g.
- Spermidine \Rightarrow Putrescine + H₂O₂ + NH₃ (triamine) (diamine)
- DO in widespread in legumes & other
- Restoration with Cu confined to young leaves.

LIGNIFICATION OF WOUNDS

- DO in apoplasm of epidermis & xylem of mature tissue where funct
 - -H₂O₂- delivery system for peroxidase activity for:
 - Lignification & suberization
 - DO increases in lignification of wounded areas (graft healing)

PHENOL OXIDASES (PhO)

- Two functions
 - Hydroxylate monophenols to diphenols
 - -2) Oxidize diphenols to o-quinone
 - Dihydroxyphenylalanine (DOPA) activity

LIGNIN SYNTHESIS

- Polyphenol oxidases involved in biosynthesis of lignins
 - Formation of brown melanotic substances when tissues wounded
 - -Active as phytoalexins (PLX)
 - Inhibit spore germination & fungal growth

DISEASE RESISTANCE

- Within few hrs post infection:
 - Signal transmitted to non-infected leaves which increase their phenol synthesis
 - Cu & B: profound influence on synthesis & binding of phenols
- Neg corr between inc N & phytolexin
 & Downy Mildew on grapes

Aspergillus niger

- Black spores Ample supply of Cu
- Light brown Mild Cu deficiency
- White spores Severe Cu deficiency
- Obvious deficiency symptom

Chrysanthemum Flowering

- Cu Defic polyphenol oxidase decline

 Delay in flowering & maturation
 IAA oxidase & peroxidase also low
- Regeneration in tissue culture favored in Cu deficient plants. WHY?

POLLEN FORMATION

- Cu deficiency low CHO
 - -Impaired pollen formation & fertiza
 - Depressed nodulation
 - Accumulation of AA & NO₃
 - No evidence for protein synthesis role for Cu
- N appl'n accentuates Cu deficiency
 High N content apply Cu fertilizer

RETRANSLOCATION OF Cu

- N effect on Cu availability & mobility
 - sequesters more Cu to AA & protein in mature leaves
 - decreases rate of retranslocation of Cu from older leaves
- Impaired retranslocation to new leaves (leaf deformation)

LIGNIFICATION

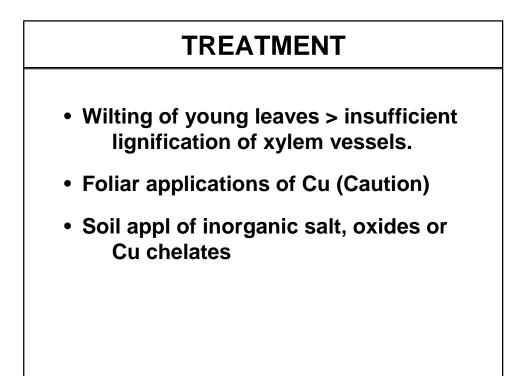
- Impaired lignification of cell walls
 typical anatomical change Cu def
 - -Distortion of young leaves
 - -Twisting of stems & twigs
 - -Increased lodging of cereals
- Decr in lignin with mild Cu defic thus indicator of Cu nutritional status

POLLINATION

- Cu defic affects reproduction more than vegetative growth
- Lack of lignin in anther cell walls causes soft tapetum ⇒ no rupture
 - -Lack of starch in pollen
 - Induced pollen sterility in microsporogenesis

COPPER DEFICIENCY

- Stunted growth
- Distorted young leaves
- Necrosis of apical meristem
- Bleaching of young leaves (White Tip)
- Summer die back in trees
- Auxiliary shoots caused by death of apical meristem



COPPER TOXICITY

- Critical toxicity above 20-30 μg g⁻¹
- May induce Fe deficiency
- Chlorosis result of Tox Cu on lipid peroxidation ⇒ destruction of memb
- High Cu inhibits roots > shoots

 Because roots are site for
 excessive Cu storage

SOURCES OF Cu POLLUTION

- Toxic Cu from fungicides used in grape vineyards
- Air Pollution
- City Waste
- Sewage sludge
- Swine & poultry slurries high in Cu

MECHANISMS OF Cu TOLERANCE

- Exist in *metallphytes* special ecotype
- Ectomycorrhiza may have central role
- Excluder type (no uptake)
- Includer type (tolerance mechanisms)
 - Compartmentation as soluble or insoluble complexes
 - Within cytoplasm or vacuole