BIOL 695

BORON

Chapter 18 MENGEL et al, 5th Ed

SOIL BORON

- Occurs in soil as H₃BO₃
- Fluorine borosilicate B containing soil mineral
- B level in soils ~ 7- 80 ppm
- Adsorption decreases as soil pH lowered
 - Thus Borate availability lowest in alkaline soils. Lowest pH 7- 9

GENERAL

- B is a metalloid (intermediate properties between metals & nonmetals.
- Has 3 valences
- Best idea of role of B is -cell wall biosynthesis & structure
 - -plasma membrane integrity

B COMPLEXES

- Forms stable with cis-diols
- Polyhydroxil compds with adjacent cis-diol config required for formation
 - -of mannitol, mannan, &
 - -polymannuronic acid
 - const of hemicellulose fraction of cell walls

MORE B IN DICOTS THAN MONOCOTS

- o-phenolics (caffeic acid)

 precursor to lignin synthesis in diocots (has cis-diol config)
- Large portion of B complexed in cell walls as cis-borate esters.
- Dicots have higher B requirements than monocots because more cisdiol compds in cell walls of dicots.

DICOTS and MONOCOTS, con't

- Complexed B in wheat roots: 3-5 μ g
- Complexed B in sunflower roots 30 μg g $^{-1}\,dw$
- Assumed that B similar to Ca in stabilizing cell wall constituents including plasma membrane

CELL ELONGATION

- B deficient plants have stubby roots
 - Inhibition of root growth within 3 hrs of B cut off.
 - -Complete stop in 24 hrs
 - -Growth begins 12 hrs after B resupply
- B cut off \Rightarrow 6-12 hrs later IAA increases

CELL WALL SYNTHESIS

- B def plants exhibit:
 - -cracked stems
 - -stem corkiness
 - -hollow stem disorder
 - -Thicker cell walls, greater dry wt
 - –Celery cell walls 1 μ m B sufficient
 - –Celery cell walls 4 μ m B deficient

CALLOSE

- Large portion of B-1,3-glucan (the main component of callose
 - Accumulates in sieve tubes of B deficient plants
 - -Impairs phloem transport

B IS IMMOBILE

- Historically
 - -Plants with adequate B supply
 - B conc higher in old leaves compared to young leaves
 - -B defic sym typically in meristems
 - B tox sym in margins of oldest lvs at end of transpiration stream
 - -Conclusion: B is immobile

MORE EVIDENCE

- Squash & tomato developed B def sym:
 - -When transferred from B sufficient to B deficient conditions
 - B established in leaves did not decrease even when apical tissues were completely inhibited.
 - Conclusion: B almost completely immobile

B IS MOBILE

- Prunus, Pyrus, Malus are exceptions

 1944 work noted no B toxicity sym in stone fruit trees
 - These spp do not accumulate high B levels in leaves
 - But develop twig die back & gum exudation as result of B toxicity
 - No marginal leaf burn of old leaves

MORE EVIDENCE

- Prunus exposed to high B
 - B accumulation in fruit, young stems, apical areas; also as ¹⁰B
 - -NOT in mature leaves
- Not consistent with view that distrib of B related to B transl in xylem to areas of greatest water loss.

WHY Prunus?

- Sorbitol is a major CHO in *Prunus, Pyrus,* and *Malus*
- Sorbitol forms complexes with B resulting in stoichiometric shift in pH and conductivity.
- Sorbitol-borate ester formation (fact)

HYPOTHESIS

 B is mobile in species that transport significant amts of sorbitol in phloem and that movement of B in these plants will be determined by the movement of sorbitol. "Pat Brown, UC Davis"

THOSE ON THE OUTSIDE

- Ficus, Pisticia, Juglans are sorbitol poor .
 - -B is not mobile in these genera.

IAA & PHENOL METABOLISM

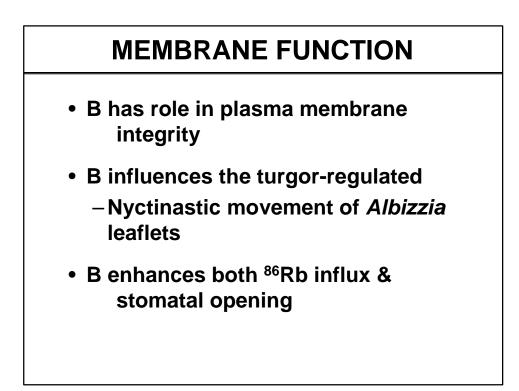
- Confused situation
 - High IAA only in species that in response to B def accum phenolics (caffeic acid) which inhibits IAA oxidase act.
 - -Phenols dependent on light
 - Accumulation of phenols typical in B deficient plants

SHIFT TO PENTOSE-P CYCLE

- Under B defic substrate flux shifted
 - -Toward pentose-P cycle
 - Enhancing phenol biosynthesis
 - -Formation of borate complexes
 - That regulate phenols in lignin synthesis

SHIFT TO PENTOSE-P CYCLE

- Under B def -
 - Phenols accumulate
 - -Polyphenol oxidase act. increased
 - Leads to highly reactive intermediates (caffeic quinone) in cell walls ⇒ superoxide radicals
 - Can damage membranes by lipid peroxidation



B-ENHANCED UPTAKE OF P

- P lower in root tips of B defic plants
 - Uptake increased only 1 hr after B treatment
 - Membrane-bound ATPase restored same level as that in B sufficient tr
- Effect of B on uptake mediated by direct effect on plasma membranebound H⁺ pumping of ATPase

EFFECT OF B ON H+ATPASE

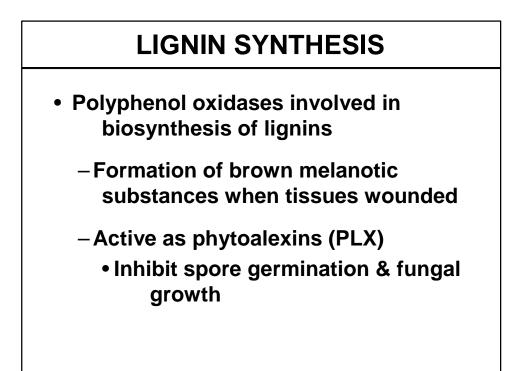
- Effect of B on H⁺ATPase requires presence of IAA & vice versa.
- Supported by evidence of K efflux in expanding sunflower leaves
 - Leaves immersed in B-def or distilled water
- Conclusion: B exerts primary infl in cell wall at PM-Cell wall interface

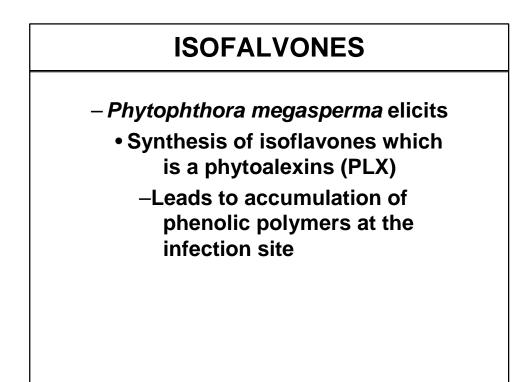
POLLEN GERMINATION & TUBE GROWTH

- Close relation between B supply &
 - Pollen producing cap of anthers
 - -Viability of pollen grains
- B stimulates pollen tube growth
- Sugar leakage from pollen decreases with increasing B

POLLEN TUBE GROWTH

- High B in stigma & style req for inactivation of callose from pollen tube walls
 - By formation of borate-callose complexes
 - When B low, callose syn inc & induces phytoalexins in stigma & style as defense similar to resp to microbial infection





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

B DEFICIENCY

- Sym noticeable at apex become discolored & may die
- Internode shorter rosette
- Increase diameter of petiole & stem
- Bud, flowers, dev fruit drop common
- Lettuce may have black heart
- Failure of seed & fruit to set
- Fruit malformed internal cork

B TOXICITY May be problem in semiarid areas where high B in irrigation water B conc 1 - 10 ppm for sensitive to

- B conc 1 10 ppm for sensitive to tolerant crops
- Symptoms
 - -Marginal or tip chlorosis necrosis
 - Symptoms reflect dist of B following transpiration stream

SUSCEPTIBILITY TO B

- Sensitive peaches, pecans, grapes, kidney beans, figs
- Semi-tolerant peas, potato, Lucerne, tomato, pistachio
- Tolerant Turnips

B TREATMENT

- Deficiency in:
 - Acid sandy soils low in B may ` need regular treatment
 - -Treat when lime applied
 - -High clay inc Borate adsorption
 - 1 ppm too low, 5 ppm too high in water soluble B soil solution

MORE TREATMENT

- More noticeable in dry soil following wet spring
- Apply Na₂B₄O₇·10H₂O to soil
- Apply H₃BO₃ as foliar spray
- Foliar Solubor at 15 60 mg B/tree
- Slow release Boro-silicate to maintain narrow range