Lecture

Inhibition of Cell Wall Synthesis

1. General Information

The cell wall distinguishes plant and microbial cells from animal cells. Cell walls provide rigidity and protection to the cell and at the same time allowing diffusion of water and ions into the plasma membrane. A recently discovered mode of action is the inhibition of cell wall synthesis.

Cell walls are primarily composed of cellulose, one of the most abundant organic compounds on earth. Cell division is necessary for plant growth and is active in growing points of shoots and roots. Herbicides with this mode of action prevent new cells from producing cell walls and plant growth ceases.

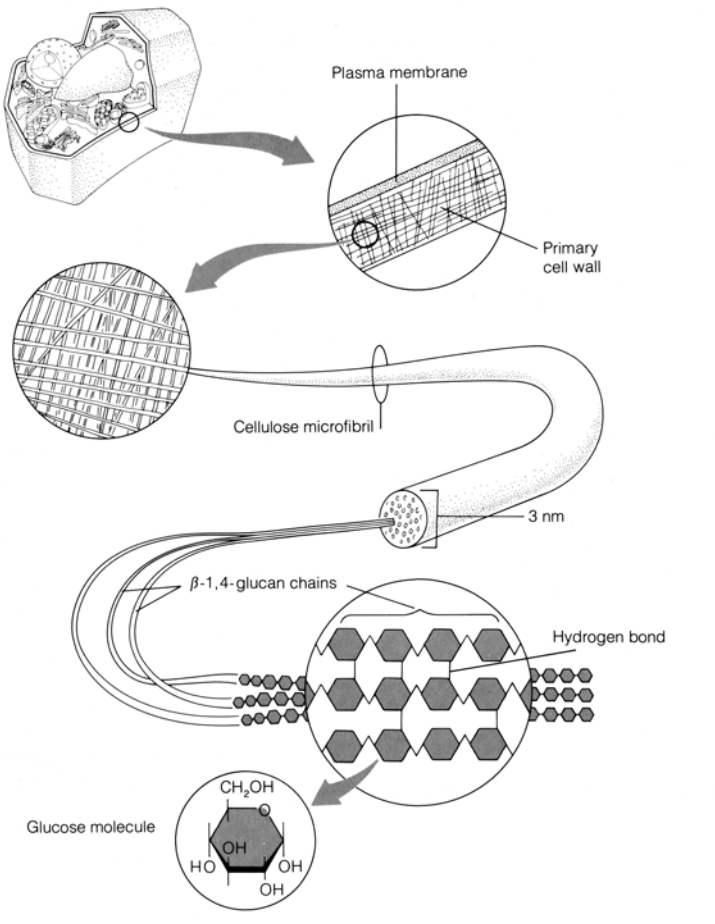


FIGURE 1.21. Cellulose microfibrils in the cell wall are made up of crystalline arrays of β-1, 4-linked glucan chains held together by intermolecular hydrogen bonds.

Source: Plant Physiology. L. Taiz and E. Zeiger. 1991. Benjamin Cummings Publishing, CA

2. Mode of Action

The precise mode of action for this class of herbicides is not known, however, the effects on the plant are certain. Cell wall formation (glucose to cellulose) is inhibited, but synthesis of other polysaccharide polymers is unaffected.

Inhibition likely occurs at some point in the cellulose microfibril crosslinking steps, a mode of action similar to that of many antibiotics (including penicillin) on bacterial cell walls. Inhibition of cell division at meristematic tissue has been proposed as a secondary mode of action.

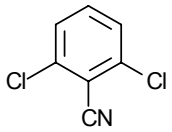
3. Site of Action

The site of action is unknown, but likely at the cell wall synthase complexes on the cell membrane.

4. Symptoms

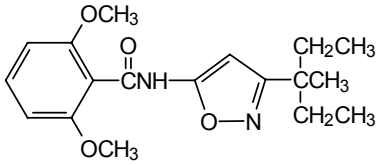
- if applied to soil, most weeds fail to emerge
- those emerging show stunting, reduced root growth, root hair distortions, and root clubbing (similar to symptoms of DNA herbicides)
- blackening of growing points may occur with application of dichlobenil
- foliar application to broadleaf weeds causes growth inhibition, swelling and cracking of stem and petiole within 2 to 3 days

5. Herbicide Families

<table>
<tr><td colspan="3">Nitriles</td></tr>
<tr><td>Example</td><td> 

dichlobenil
(Casoron/Acme/Barrier)</td><td>base structure includes a C-N triple bond off of a benzene ring (see pg 57 for comparison with bromoxynil and ioxynil); herbicides vary by substitutions at other positions on the ring e.g bromoxynil with Br, ioxynil with I, and dichlobenil with Cl</td></tr>
<tr><td>Metabolism</td><td colspan="2">plant – hydroxylation/conjugation; soil – microbial
half-life – dichlobenil 60d (provides 2-6 months of control)</td></tr>
</table>

Absorption & Translocation	absorbed by roots and slowly transported upward in xylem; little to no downward movement in phloem slow basipetal translocation when absorbed by leaves
Selectivity	selective – herbicide placement and rate; seedlings present in the herbicide zone in soil are controlled, but not those outside the zone established plants with shallow roots may be injured or killed
Herbicide Use	controls annual grasses and broadleaf weeds, and some biennials and perennials used PRE with irrigation or soil incorporated due to volatility in fruit and nut orchards, woody ornamentals, forests, vineyards, cranberries, nursery stock containers, under asphalt, industrial sites, noncrop areas, certain aquatic situations; granular formlation widely used (Casoron spreader)

Benzamides		
Example	 isoxaben (Gallery)	characterized as having a benzene ring with an amide group attached; contains a 5-member ring with an O and N
Metabolism	plant – hydroxylation; soil – microbial half-life – isoxaben 50-120d	
Absorption & Translocation	absorbed by roots but leaf absorption is limited; transported upward in xylem	
Selectivity	selective – decreased sensitivity at the target site not differential metabolism	
Herbicide Use	controls broadleaf weeds, and some biennials and perennials used PRE in established turfgrasses, ornamentals, nonbearing fruit and nut crops, nonbearing vineyards, Christmas tree plantations, and noncrop areas	

6. General Comments

Dichlobenil was discovered in the 1950's by Phillips-Dumar in the Netherlands and was first sold in 1960. Isoxaben was discovered much later in 1979 and was first sold in 1984 by Eli Lilly & Company. Isoxaben inhibits cell wall synthesis about 40 times more than dichlobenil.

In contrast to dichlobenil, the nitrile herbicides bromoxynil (Buctril) and ioxynil (Totril/Mate) are inhibitors of photosynthesis at Photosystem II.

The herbicide chlorthiamid, no longer sold in the U.S., is active as a cell wall inhibitor as well. Chlorthiamid is converted to dichlobenil by soil microorganisms as a byproduct of metabolism.

6. References

Ahrens, W. Herbicide Handbook, seventh edition. 1994. Weed Science Society of America, Champaign, IL.

Devine, M.D., S.O. Duke, and C. Fedtke. Physiology of Herbicide Action. 1993. Prentice Hall, NJ.

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Stryer, L. Biochemistry – fourth edition. 1995. W.H. Freeman, NY.