Photosystem II Inhibitors

- Many different chemical groups
- Many of our most important herbicides
- Uses in crop and non-crop situations
- Applied PPI, Pre, Post, Post-directed
- Introduced many years ago (e.g., simazine – 1956)
- High use rate due to high number of binding sites

Photosystem II Inhibitors

- All compounds absorbed by roots and most absorbed by leaves
- Translocation primarily in the xylem
- Thorough coverage of foliage important for postemergence applications
- Susceptibility to postemergence sprays greatest when high light intensity occurs after spraying

Resistance has evolved in more than 75 weed species
- Soil persistence varies from < 1 month to > 2 years
- Repeat soil applications has not resulted in increased rate of breakdown
- Low mammalian toxicity

Selectivity

- Placement in soil (depth protection)
- Directed sprays
- Differential uptake by roots and/or leaves
- Differential translocation – roots to foliage
- Differential metabolism – corn (atrazine), tomatoes (metribuzin), carrots (linuron)
- Differential age of crops and weeds, large seeds

Chemical Properties

- Selective and nonselective, preemergence and postemergence control of annual grasses and broadleaf weeds in cropland and noncropland areas
- Not volatile and do not photo-decompose
- Ionic – moderately adsorbed to soil
- Problems with ground water contamination
- Some are “Restricted Use Herbicides” – due to groundwater hazards
**Chemical Properties**

- Residual activity – 4–6 weeks
- Broken down primarily by acid hydrolysis and soil microbes
  - Carry-over can be a problem in high pH soils (>7.0)
- Readily translocated – most are shoot or root absorbed and moved upward
- Application method of some product/crop combinations are important
  - Metribuzin – PRE in soybeans, POST in wheat, POST in corn

**Triazines**

- Very important family – discovered in 1950’s
- Heavy usage in U.S.
  - Approximately 30% of the corn herbicides labeled today contain atrazine.
  - 75% of herbicides applied to corn contain atrazine
    - Cheap
    - Effective

**Triazines are active in the chloroplasts**

**The chloroplasts contain the chlorophyll that captures light energy**

**Photosystem II Inhibitors**

Leaves develop chlorosis (yellowing) followed by necrosis (tissue death)

Chlorosis due to chlorophyll destruction (photooxidation)

Necrosis due to membrane disruption from lipid peroxidation
Photosynthesis overview

Light

\[ 6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \]

- overall this is a highly unfavorable reaction
- it must be carried out in many small steps

So – Where do Photosynthesis II Inhibiting Herbicides Act?
How Do Treated Plants Die?

1. What’s important about the ionic-nature and solubility of this family?
   a) Takes a rainfall to move them into rooting zone.
   b) Too much rain can cause them to leach to GW.

2. What’s important about the method of application, site of entry into the plant, translocation properties, with the MOA of this family?
   a) Must have sunlight to be active in the plant.

Specifics Concerning Triazines

- Non-selective
  - Used in cotton, celery, etc.

Small Changes in Chemical Structures Can Make Big Changes to Selectivity

Specific Triazine Herbicides

Atrazine / AAtrex

- Corn, sugarcane, grain sorghum (statewide with a 24c label)
- PPI, PRE, POST
- Rotational restrictions
- Restricted Use Herbicide
- Uses and rates restricted
- Wheat injury, high pH
- Many Premixes

Atrazine Carryover in High pH Soil
**Simazine (Princep)**

- Soil activity, POST activity minimal
- Corn, sugarcane, turf (some), nurseries, Xmas tree, fruits, nuts
- Ground H₂O

**Metribuzin (Sencor)**

- Crops
  - Bermudagrass turf, soybeans, potatoes, dormant alfalfa, tomatoes, sugarcane, wheat
- Short residual
- PRE and POST activity

**PS I Inhibitors**

- Formulated as dichloride or dibromide salts
- Soluble in water
- Strong cations
- Rapid absorption in plants
- Rapid plant kill with high light intensity

**Characteristics**

- Little or no translocation
- Strongly adsorbed by clay
- Mammalian toxicity high for paraquat, moderate for diquat
- Resistant weeds have evolved

**Characteristics**

- Land preparation & no-tillage
- Preemergent sprays
- Directed sprays
- Pasture renovation
- Aquatic weed control (diquat)
- Non-crop weed control
- Preharvest desiccation
- Selective weed control in peanuts

**Uses**
Selectivity

- Differential selectivity occurs – insufficient to allow application in most crops
- Examples of limited selectivity
  - Peanuts
  - Perennial ryegrass

Photosystem I Reaction Center

Response to Paraquat

Dinitroanilines – Seedling Root Inhibitors
- Remains one of the most important herbicide families we have today
- Many consider this herbicide family the “foundation” to an effect weed control program
- Very affordable!

Seedling Root Inhibitors

paraquat
Mode of Action
- Inhibits cell division
- Inhibits mitosis
- Location of activity in plant
  - Developing roots

Chemical Characteristics
- Most are volatile
- Most will photodecompose
- Minimal leaching
- Do not translocate in plants
- Are non-ionic with H₂O solubilities < 1 ppm
- Are adsorbed to soil

Characteristics
- Preemergence control of grasses and small-seeded broadleaves
  - Must be applied PRE
  - Will not control established weeds
  - Some rotational crop restrictions
  - Absorbed by roots

Examples
- Prowl – pendimethalin – soybean, peanut, corn, rice, cotton, etc.
- Pendulum – pendimethalin – turfgrass
- Treflan – trifluralin – soybean, cotton, alfalfa, etc.
- Balan – benefin – alfalfa, clover, lettuce
- Barricade – prodiamine – turfgrass

Selectivity by:
  Herbicide placement – do not contact crop roots

Other Characteristics
- All form yellow/orange suspensions
  They were actually first discovered and developed as dyes

- Varying rates of degradation
  Degradation due entirely to microorganisms

Injury Symptoms
Clubbed Roots

Swollen hypocotyls leading to Brittle Bean Syndrome in Soybean

Purple stem discoloration in corn and sorghum.

Specific Dintiroaniline Herbicides

**Trifluralin**

- Treflan**
  - also Trifluralin
  - also several formulations
    - TR10 - 10% granular
    - M.T.F. - multiple-temperature formulation
    - E.C.

**Trifluralin/Treflan**

- PPI (pre-plant Incorporated)
- 2X rate for johnsongrass
- labeled on over 50 crops
- TOXIC TO FISH
- Will NOT LEACH
- Must incorporate - due to photodegradation and volatility
**Pendimethalin**
-(Prowl and Pendulum)

- Very similar to Treflan
- Labeled on many crops, maybe near 50
- BASF has several “pre-packages” containing Prowl or Treflan
- Not as volatile as Treflan

**Prodiamine (Barricade)**
-Turf herbicide
- Must be incorporated—H₂O not tillage
- MUST be applied before weeds emerge
- Don’t use on turf with bare spots or on areas where complete weed control would leave bare spots
- Longest residual dinitroaniline available today

**Oryzalin (Surflan)**
- Does not require mechanical incorporation
- Used on turf and other specialty crops
- Uses on agronomic crops declining because of cost

**Bottom Line**
The Dinitroaniline herbicides are an old and still very important herbicide family.

**Example Quiz ?**
Which of the following herbicide groups is responsible for the symptomology in this image?

- *ALS Inhibitor*
- *ACCase Inhibitor*
- *Photosystem II Inhibitor*
- *Photosystem I Inhibitor*
- *Seedling Root Inhibitor*