Herbicide Mode of Action

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Chemical - Herbicides

- over 150 active ingredients registered
- over 4000 trade names
- herbicides account for 55% of pesticide use
Herbicides

• Herbicide is a chemical compound, generally organic, that is used to control plants.

• Chemistry of the herbicide dictates -
  – how it works in the plant
  – how it behaves in the environment
How herbicides work

- Controlled/selective plant poisoning
  - applied to soil (root uptake) and/or leaves
  - contact or systemic
  - selective vs. non-selective
Herbicide Selectivity

- placement - keep it away from desirable plant
- uptake - apply so it doesn’t get in and move
- metabolism - some plants breakdown herbicides but..... ....
- target site is different
Mechanisms of Tolerance

Herbicide X

X does not bind to enzyme Y

X metabolized to Z

Sequestered in vacuole

X not absorbed
Formulations

• water soluble, oil soluble, salts, esters
• clay suspension, pellets, granules, wettable powders, emusifiable concentrates
• the goal of the formulation is to: store, mix/spray in water, get it in the plant, and minimize off-target damage
Plant Processes

1. photosynthesis
2. amino acids and proteins
3. fatty acid synthesis
4. growth inhibition (not covered here)*
5. cell membranes
6. pigment synthesis
7. growth regulation
Mode vs. Mechanism

- **mode-of-action** -- symptoms that occur after herbicide application leading to plant death
- **mechanism-of-action** -- actual biochemical site of herbicide activity
  - generally enzyme or co-factor
  - in some cases actual ‘site’ is unknown
Photosynthesis

- process where the plant uses light energy to convert \( \text{CO}_2 \) and \( \text{H}_2\text{O} \) to sugars, release \( \text{O}_2 \)

- Light reactions
  - chlorophyll absorbs light
  - passes energy down a biochemical chain
  - form intermediates to drive sugar formation
Herbicides - Photosynthesis

• block the flow of energy from chlorophyll to the intermediates
  – plant cannot make sugars - starves
  – chlorophyll continues to absorb light and this ‘excess’ energy forms toxic intermediates

• generally soil active, root uptake and movement through water stream to leaves
Diuron, Spike, Pramitol, Bromacil, Velpar

- used in a variety of cropping systems for broadleaf and some grass control
- mostly soil applied, but some foliar activity
- root uptake, translocation via water stream, little movement from foliar applications
- potent inhibitors of photosynthesis
Photosynthesis – Symptoms
Amino acids and Proteins

- essential building blocks for plant growth and function
- unlike animals, plants make their own
- amino acids are the primary components of proteins and nucleic acids
- proteins are generally storage proteins or enzymes
Herbicides - Amino Acids

• generally target a specific enzyme
  – blocks a vital step in the formation of amino acids-- proteins, enzymes…
  – aromatic amino acids
  – branched chain amino acids

• dependent on plant growth for activity
  – better growth - better control, slow death

• systemic herbicides, some have soil activity
Arsenal/Habitat, Plateau, Clearcast, Oust, Escort

- crops & vegetation management
- foliar & soil activity, used PPI, PRE or POST (soil activity can cause persistence)
- grasses, BL’s and good nutsedge activity
- accumulates in meristematic regions
- inhibit the synthesis of the amino acids valine, leucine, and isoleucine
Soil Activity!!
Glyphosate - *Roundup*...etc.

- broadspectrum postemergence weed control
- glyphosate labeled in multitude of areas
- extensively translocated throughout the plant, extremely stable in plant
- blocks synthesis of aromatic amino acids
glyphosate

Entireleaf morningglory
Glyphosate injury on pecans
Fatty Acid Synthesis

- Fatty acids are the primary building components of cell membranes and many intercellular membranes.
- Inhibition of fatty acids results in stunted growth and eventually death due to lack of membranes for cellular integrity.
Fusilade, Select

- registered in several crops, noncropland
- grass activity only, postemergence
- translocated to growing portions
- inhibits fatty acid synthesis, slow death
Cell Membranes

- maintain cell integrity
  - keep things in & out
- generate electrochemical gradients
  - allows for energy production
- maintain cell structure
  - turgor pressure maintains plant structure and helps the plant grow
Herbicides - Cell Membranes

- divert normal energy flow to form toxic intermediates
  - interact w/ membrane and cause disruption
- cause the membrane to become “leaky”
  - gradients cannot be formed, no energy for cellular functions - endothall
- generally contact, little movement in plant
Gramoxone and Reward

- non-selective postemergence activity
- little translocation, contact
- diverts normal electron flow, causes formation of radical oxygen and cell membrane disruption
- no soil activity
Z-scheme

Photosystem II

Photosystem I

Redox chain

Chl

DQ

DQH₂

O₂⁻

H₂O

O₂

H⁺ H⁺
Gramoxone
Valor, Stingray

- applied POST for BL weed control
- contact, no translocation in foliar treatments
- xylem movement from soil activity
- increase of light absorbing intermediates
- formation of highly toxic free radicals
Pigment Synthesis

- absorb light energy for photosynthesis
- also protect plant from excess light
- types of pigments
  - chlorophyll
  - carotenoids
  - flavanoids
  - anthocyanins
Sonar, Solicam

- block the formation of chlorophyll
- block the formation of carotenoids
  - carotenoids accept excess energy
  - when absent, chlorophyll dissinigrates
- generally slow death, plant starves
- soil active, movement through water stream
Pigment Injury Symptoms
Growth Regulation

- Hormones control plant growth and developmental changes, always present.
- Auxin mimics - cause uncontrolled growth
  - Auxin transport inhibitors
  - Prevent the normal distribution of auxin
- Soil and foliar applied, systemic throughout
Phenoxy Herbicides

- **2,4-D, 2,4-DB, 2,4-DP, MCPA**
  - BL weed control for a variety of crops (corn, pastures, legumes) and noncropland
  - salt, ester and oil formulations
  - foliar & root uptake - extensive translocation
  - cells undergo rapid uncontrolled division and elongation
Triclopyr/Garlon, Transline, Milestone

- used POST for BL weed control, brush & woody
- similar to phenoxys, primarily foliar applied but Milestone has soil activity
- foliar & root uptake - extensive translocation
- cells undergo rapid uncontrolled division and elongation
Triclopyr

Cucumber

Redroot pigweed