An Introduction to Herbicides

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Spray Smart

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Outline

- Herbicide definition
- Herbicide advantages and disadvantages
- Herbicide classification
- Herbicide modes of action

What is a herbicide?

- A chemical substance or cultured organism used to kill or suppress the growth of plants – WSSA

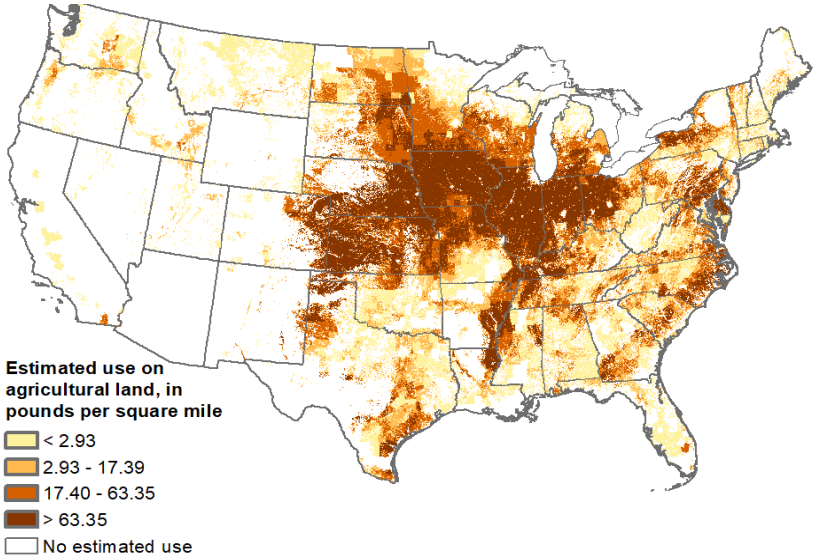
No herbicide use

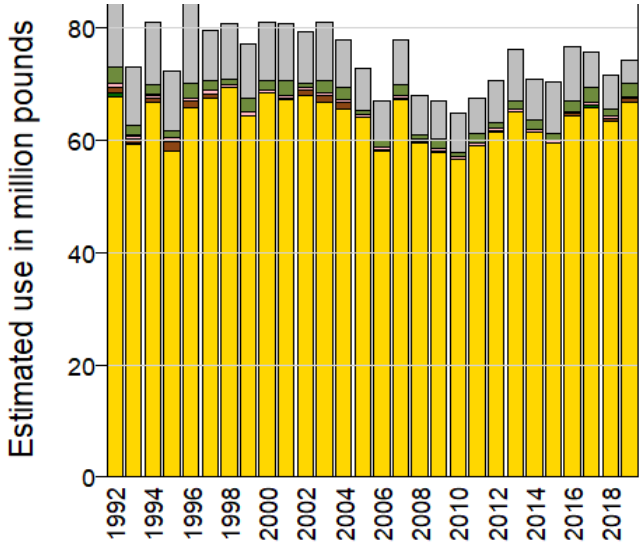
Herbicide use

Herbicide use

- Worldwide sales >$33 billion in 2020
- Applied to >85% of US crop acres

Estimated atrazine use in 2019





Source: USGS Pesticide National Synthesis Project

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Herbicides: advantages

- Reduces cost and drudgery of weed control compared to hand weed control
- Better efficacy compared to mechanical weed control – can have residual effect
- Can allow for reduction in tillage and help in soil and water conservation
- Can be less stressful to the crop
- Can reduce fertilizer and irrigation requirements
  - Reduce weed competition for nutrients, light & water

Herbicides: disadvantages

- Non-target plant toxicity or damage
  - Example: 2,4-D drift may harm neighboring vegetables
- Environmental persistence
  - Varies by herbicide
  - Residual effect/carryover can limit choice of next crop
- May cause environmental pollution
  - Example: atrazine & metribuzin → ground water contamination
- Encourage monoculture production
  - Herbicide resistant crops → herbicide resistant weeds

Herbicide classification

- Crop of use
- Observed effect
- Site of uptake
- Contact or systemic
- Selectivity
- Time of application
- Chemical structure
- **Mode of action**

Herbicide classification

- Crop of use
  - Very important to know the crop a herbicide can be appropriately used
    - Never a complete classification

  - Example: sugarcane herbicides are from different chemical families and modes of action

Herbicide classification

- Observed effect
  - Description of effects on the plants
  - Very important to know; however, different chemical families can cause similar outward effects
  - Effects can also look similar to diseases, nutrient deficiency, environmental factors etc

Freeze damage in sugarcane

Paraquat damage in sugarcane

Herbicide classification

- Site of uptake
  - Foliar vs. soil applied herbicides
    - Postemergence vs preemergence herbicides
  - Good information but does not necessarily relate to any other classification

POST (weed)

POST (crop)

Herbicide classification

- Contact herbicides
  - Only kills the part of the plant that they contact
  - Do not move into or affect any other part of the plant - no translocation throughout the plant
  - Good coverage is essential

Diquat injury on sugarcane

Herbicide classification

- Systemic herbicides
  - Will move throughout the plant once taken by leaves, stems, or roots
  - Good coverage still desirable, but not as critical
  - Contact of a single leaf can cause death of entire plant

Glyphosate injury on sugarcane

Herbicide classification

- Selectivity
  - Herbicide kills certain plants but leave others unharmed
    - Non-selective vs. selective
      - Glyphosate (Roundup) vs. topramezone (Armezon)
    - Grass vs. broadleaf
      - *S*-metolachlor (Dual II Magnum) vs. atrazine
      - Sethoxydim (Poast) vs. imazethapyr (Pursuit)
    - Emerging vs. established
      - Pendimethalin (Prowl H_20) vs. asulam (Asulox)

Herbicide classification

- Selectivity

PRE *S*-metolachlor (Dual II Magnum)
Target: grass weeds

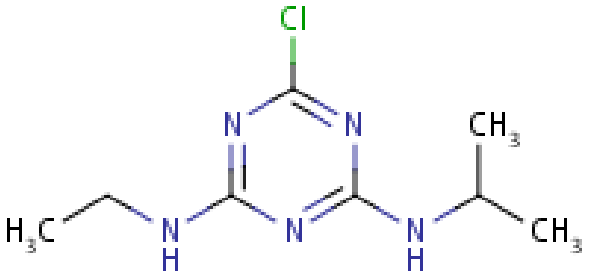
PRE atrazine
Target: broadleaf weeds

Herbicide classification

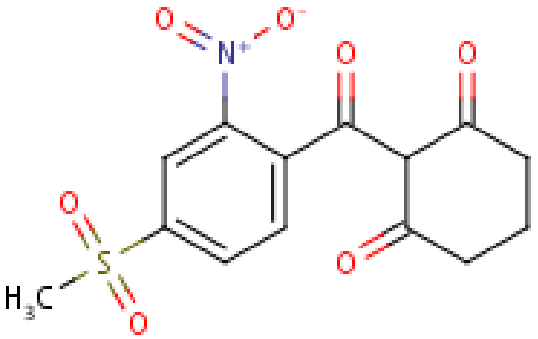
- Time of application
  - Preplant – prior to crop planting
    - Paraquat (Gramoxone)
  - Preemergence – after crop planting, but prior to crop/weed emergence
    - Atrazine, mesotrione (Callisto)
  - Postemergence – after weed/crop emergence
    - Atrazine, mesotrione (Callisto)

Herbicide classification

- Chemical structure
  - Not a simple relationship between a chemical's structure and its biochemical behavior



Atrazine



Mesotrione

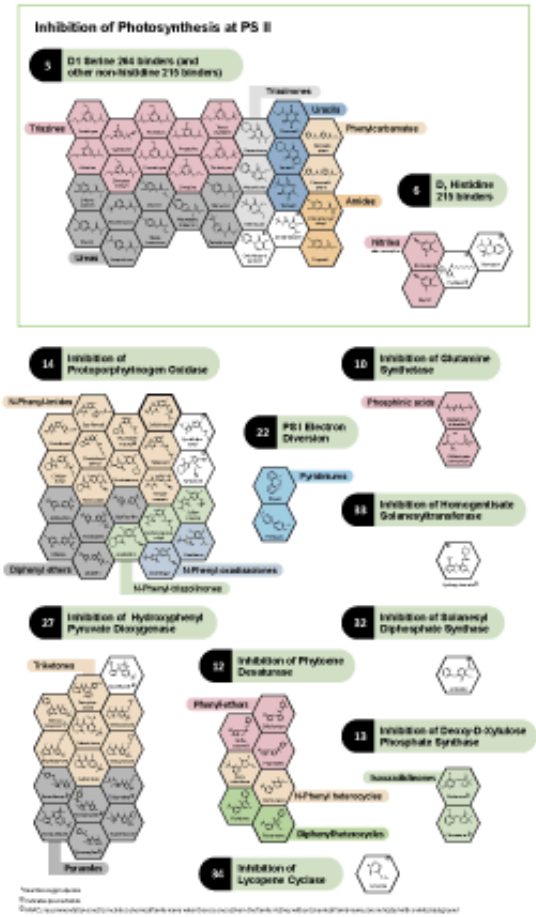
Herbicide classification

- **Mode of action**
  - Biological process or enzyme in the plant the herbicide interrupts → affect normal plant growth and development
    - How the herbicide kills the plant
  - General description of injury symptoms on susceptible plants
    - Most informative for diagnosis of injury

HRAC Mode of Action Classification 2022

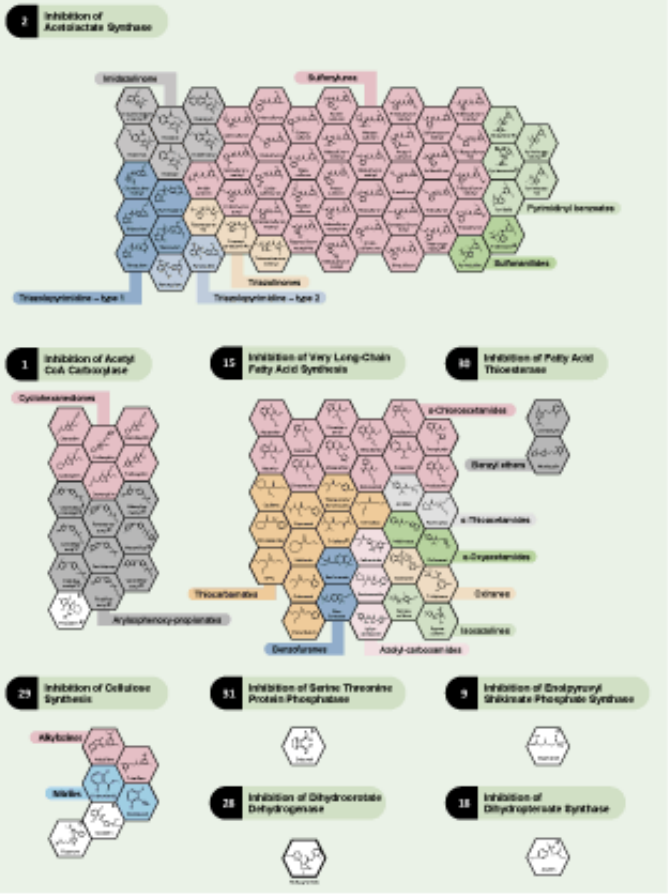
HERBICIDE RESISTANCE ACTION COMMITTEE

Light Activation of ROS[a]



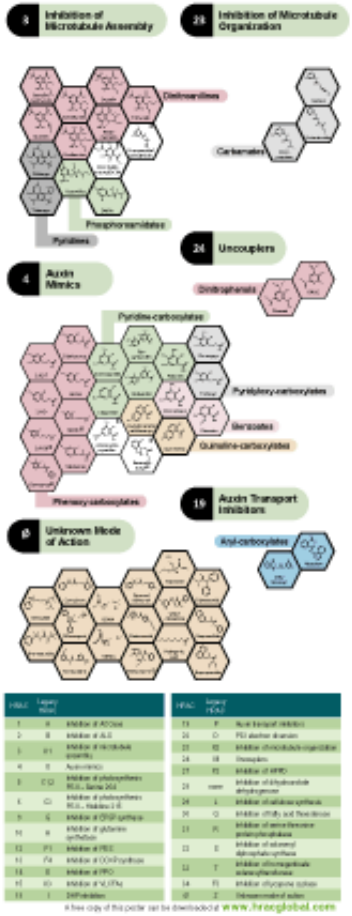
11 modes of action
87 active ingredients

Cellular Metabolism



9 modes of action
120 active ingredients

Cell Division and Growth



6 modes of action
57 active ingredients

26 modes of action
264 active ingredients

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Herbicide modes of action

- Photosynthesis inhibitors (at photosystem II)
- Pigment inhibitors
- Cell membrane disruptors
- Lipid synthesis inhibitors
- Seedling growth inhibitors
- Growth regulator herbicides
- Amino acid synthesis inhibitors
- Microtubule (DHP) inhibitor

Photosynthesis inhibitors

- Inhibit photosynthesis at photosystem II
- Plants left in the light will die faster
- Injury symptoms
  - Develop over several days
  - Start with the oldest leaves, progresses to new leaves
  - Yellowing between leaf veins or along margins, necrosis
  - Yellowing or bronzing of leaves which turn brown (nonmobile herbicides – bentazon)

Atrazine, Metribuzin, Evik, Basagran


Atrazine injury in lettuce


Atrazine injury in green bean


Evik injury in sweet corn


Basagran injury in green bean

Photosynthesis inhibitors

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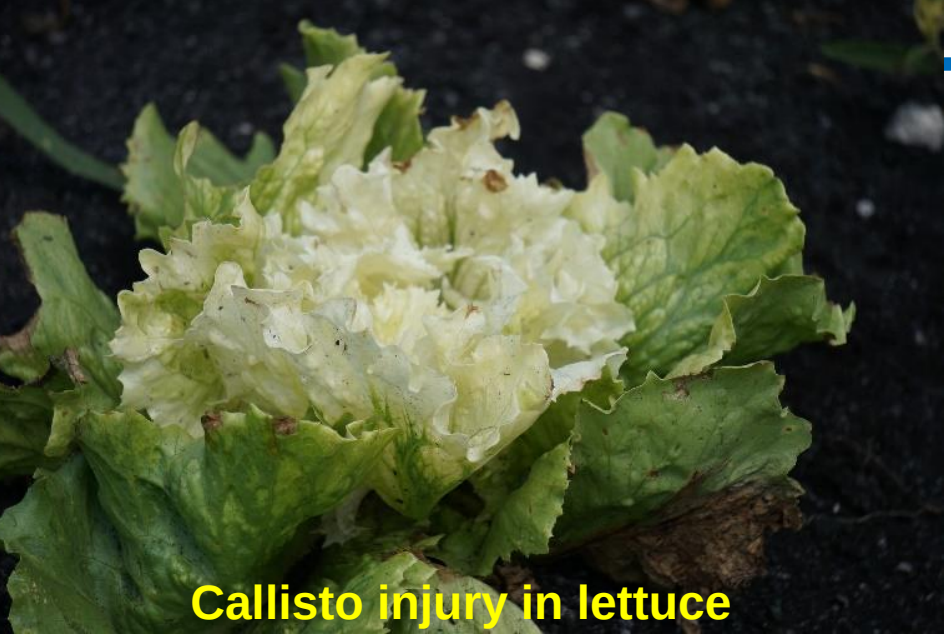
Pigment inhibitors

- Prevents formation of photosynthetic pigments by inhibiting formation of carotenoids (protects chlorophyll) or plastid isoprenoids
- Injury symptoms
  - Whitened foliage (or translucent), sometimes with a pink or purple tinge
  - New growth bleached a few days after exposure, death occurs after 1 to several weeks
  - Plants often recover from light bleaching

Callisto, Armezon, Laudis, Command


Callisto injury in lettuce


Armezon injury in green bean


Command injury in sweet corn


Armezon injury in sugarcane

Pigment inhibitors

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Cell membrane disruptors

- Rapid cell membrane disruption
- Activated by exposure to sunlight
- High light intensity → increased injury
  - Injury symptoms can occur <1 to 2 hours with death in 1 to 3 days
- Injury symptoms
  - Water-soaked or dark green spots within a few hours, followed by browning and necrotic spots
  - Reddish-colored spotting and speckling of foliage may occur

Gramoxone, Tribune, Reflex, Aim


Tribune injury in sweet corn


Aim injury in sugarcane


Gramoxone injury in sugarcane


Reflex injury in sweet corn

Cell membrane disruptors

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Lipid synthesis inhibitors

- Inhibit formation of fatty acids essential for production of plant lipids - critical for integrity of cell membranes and new plant growth
- Grass control, little to no effect on broadleaves
- Injury symptoms
  - Discoloration (or yellowing) and disintegration of meristematic tissue (growing point) followed by death of new leaf tissue
  - Base of leaves become brown, mushy, and rotten in appearance
  - Newest leaf tissue usually pull easily from the whorl exposing decaying tissue

Poast, Select, Clincher, Fusalide


Poast injury in sugarcane


Poast injury in sugarcane


Clincher injury in sugarcane


Fusalide injury in sugarcane

Lipid synthesis inhibitors

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Seedling growth inhibitors

- Root inhibitors (dinitroanilines)
  - Inhibit root development by disrupting cell division in the meristems located at the root tip
  - Yellow in color
- Injury symptoms
  - Deformed shoots - short and swollen
  - Stem below cotyledon in broadleaf plants is swollen and cracked
  - Stunting, crinkled leaves
  - Tips of lateral or secondary roots become short and stubby, pruned

Prowl H_2O

Seedling growth inhibitor

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Seedling growth inhibitors

- Shoot inhibitors (chloroacetamides)
  - Inhibit VLCFA that are important constituents of the plasma membrane → loss of cell integrity and eventually plant death
  - Affect susceptible plants before they emerge, do not inhibit seed germination or control emerged plants
- Injury symptoms
  - Stunted plants which fail to emerge
  - Grasses that emerge appear twisted and malformed and fail to unroll from the whorl, giving the plant a “buggy-whip” appearance
  - Broadleaves may have crinkled leaves and shortened midveins producing a “drawstring” effect on the leaf tip

Dual II Magnum

Seedling growth inhibitor

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Growth regulator herbicides

- Abnormal cell division and cell proliferation that disrupts transportation of water, nutrients, and carbohydrates
- Injury symptoms
  - Epinastic bending and twisting of stems and petioles
  - Stem swelling (particularly at nodes)
  - Leaf malformations (cupping, curling, crinkling, parallel venation, leaf strapping)
  - Stunted root growth

2,4-D, Banvel

Growth regulators

Amino acid inhibitors

- Inhibit an enzyme (ALS) involved in the synthesis of branch chain amino acids - essential building blocks of proteins required for plant growth
- Accumulate in areas of new growth where effects are first observed
- Injury symptoms
  - Stunting, interveinal chlorosis (yellowing), red or purple leaf venation, and necrosis (death) apparent 1 to 4 weeks
  - Improper leaf unfurling and translucent leaf tissue in grasses

Pursuit, Londax, Sandea, Envoke

Branch chain amino acid inhibitors

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Amino acid inhibitors

- Inhibits an enzyme (EPSP synthase) that leads to depletion of aromatic amino acids needed for protein synthesis
- Injury symptoms
  - Inhibition of new growth, followed by gradual yellowing of new tissue which progresses to older tissue
  - Slow symptom development
  - Turn yellow in 5 to 7 days, turn brown and die in 10 to 14 days

Roundup

Aromatic amino acid inhibitor

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Microtubule (DHP) inhibitor

- Inhibit cell division and meristematic growth by interfering with microtubule function (primarily helps to support and shape the cell)
- Injury symptoms
  - Chlorosis (yellowing) of young leaves and stunting followed by necrosis
  - Growing points are usually killed in 1 to 2 weeks while older mature leaves senescence much more slowly
  - Can take up to 4 weeks for death of the entire plant to occur

Asulox

DHP inhibitor

Remember for chemical weed control

- Do it right
  - Proper herbicide(s)
  - Proper herbicide rate(s)
  - Proper placement of material
  - Proper time of application
  - Proper manner of application
- READ THE HERBICIDE LABEL, IT'S THE LAW

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