TEXAS A&M AGRILIFE RESEARCH

Herbicide Persistence and The Utility of Bioassays

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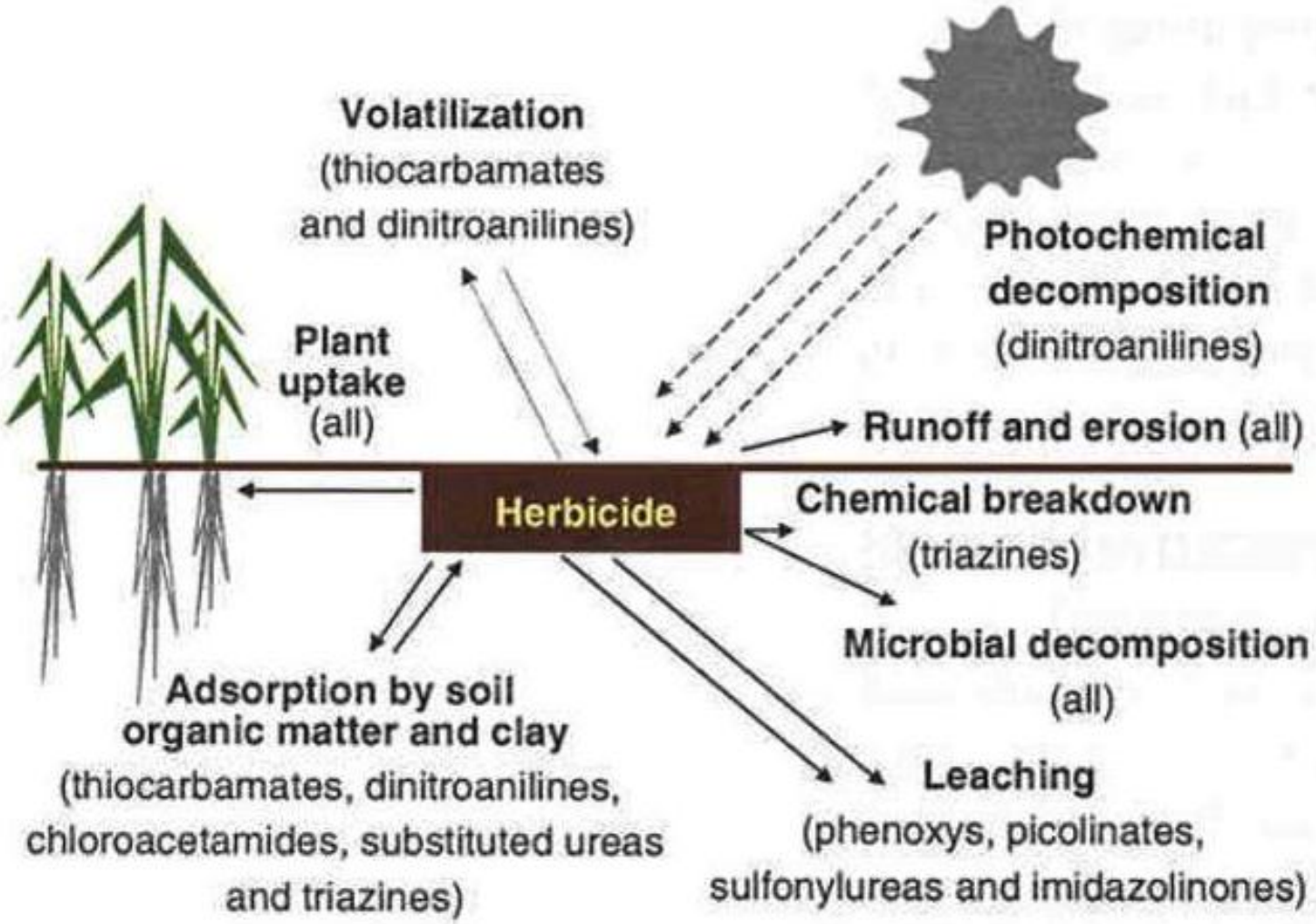
Improving Life through Science and Technology.

Potential Causes of Carryover

- Late applications
- Excessive rates
- Poor soil health
- Drought

Things that can happen to an herbicide



Degradation Mechanisms
Chemical degradation

- Oxidation
  - –Loss of electrons
  - –Conditions – well aerated
- Reduction
  - –Gain of electrons
  - –Conditions – Wet, flooded areas
- Hydrolysis
  - –Degradation from reaction with water
  - –Conditions – Available water

Degradation Mechanisms
Physical degradation

- Photolysis
  - –Degradation through interaction with light
  - –Direct photolysis – Light energy breaks bonds of organic molecule
  - –Indirect photolysis – Light energy creates superoxides, hydrogen peroxides, oxygen radicals that degrade compounds

Degradation Mechanisms
Physical degradation

- Thermal degradation
  - –Degradation associated with heat
  - –Interactively works with other degradation mechanisms
  - –Higher temperatures = Faster degradation

Degradation Mechanisms
Biological degradation

- Most dominant mechanism
- Involves microbes possessing enzymes that catalyze chemical reactions

Degradation Mechanisms
Biological degradation

- Microorganisms
  - –Bacteria
    - Most numerous – ~10,000,000/g of soil (upper 2”)
  - –Actinomycetes
    - Really bacteria but separated due to numbers and importance
    - Responsible for soil smell after tillage – geosmin
    - Make up 5 to 20% of total bacteria

Degradation Mechanisms
Biological degradation

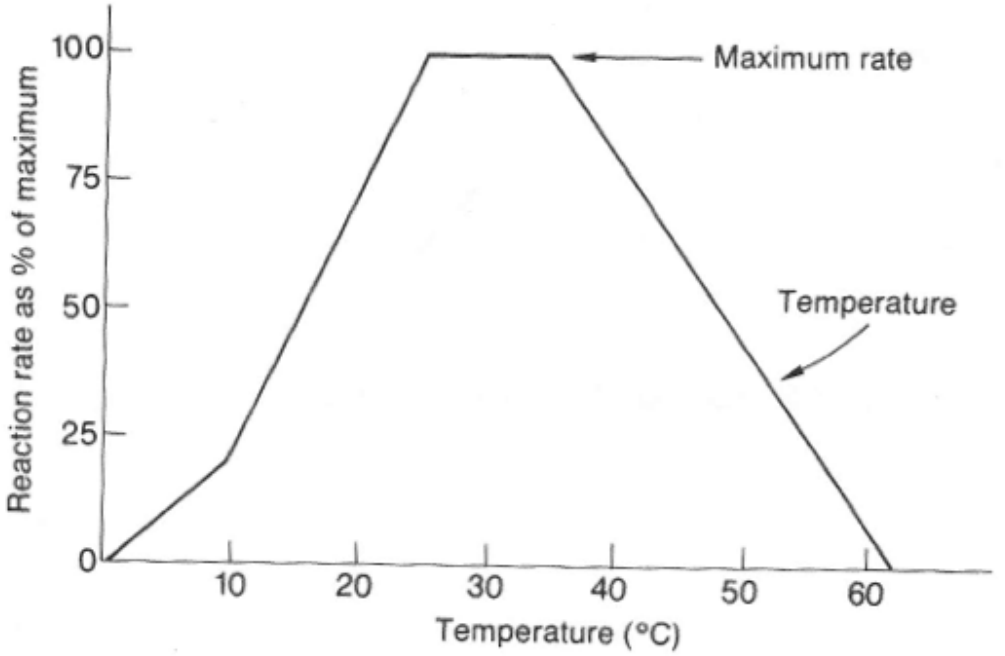
- Microorganisms
  - –Fungi
    - Less numerous than bacteria
  - –Plants

Factors Affecting Biological Degradation

Soil temperature – 77 to 95 F provides maximum microbial activity

(Paul and Clark, Soil Microbiology and Biochemistry, 1989)

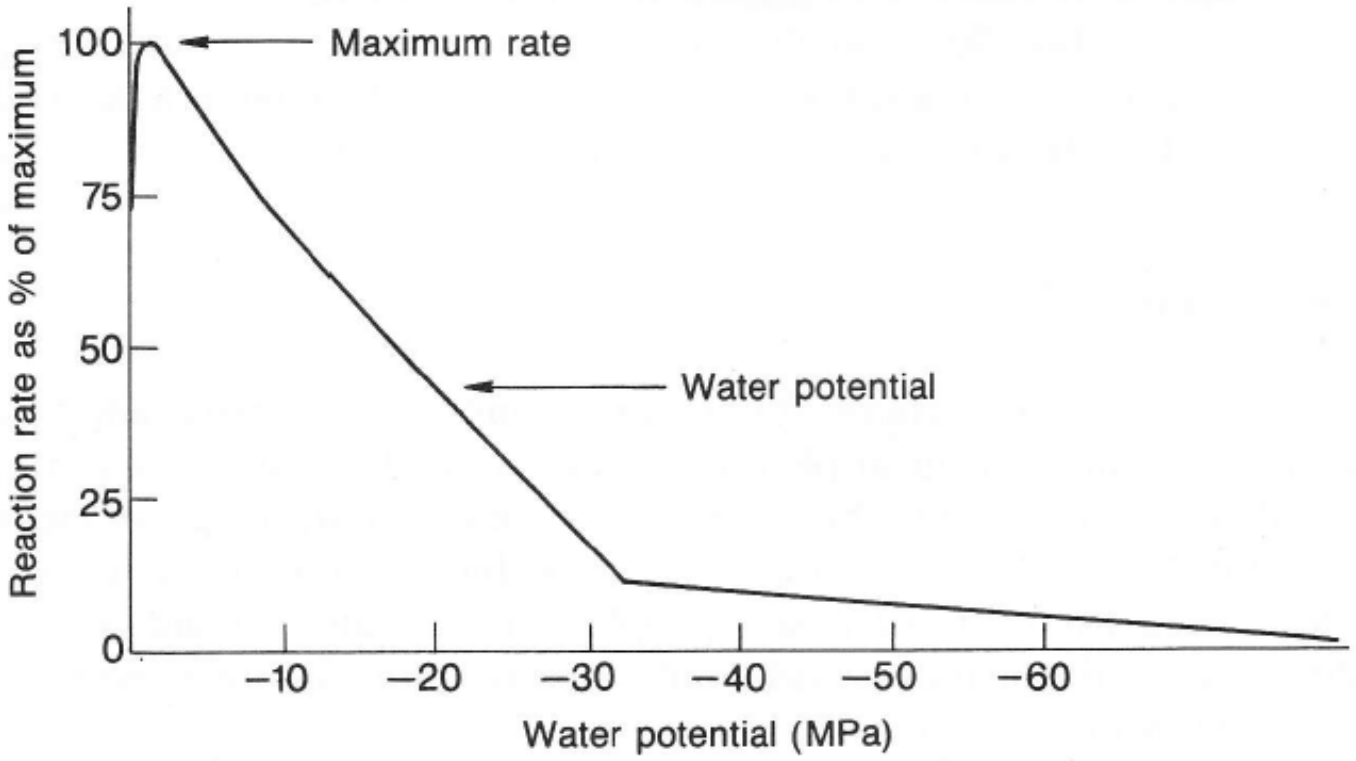
Figure 2.9. Relative microbial reaction rates at various temperatures.



Factors Affecting Biological Degradation

Soil moisture

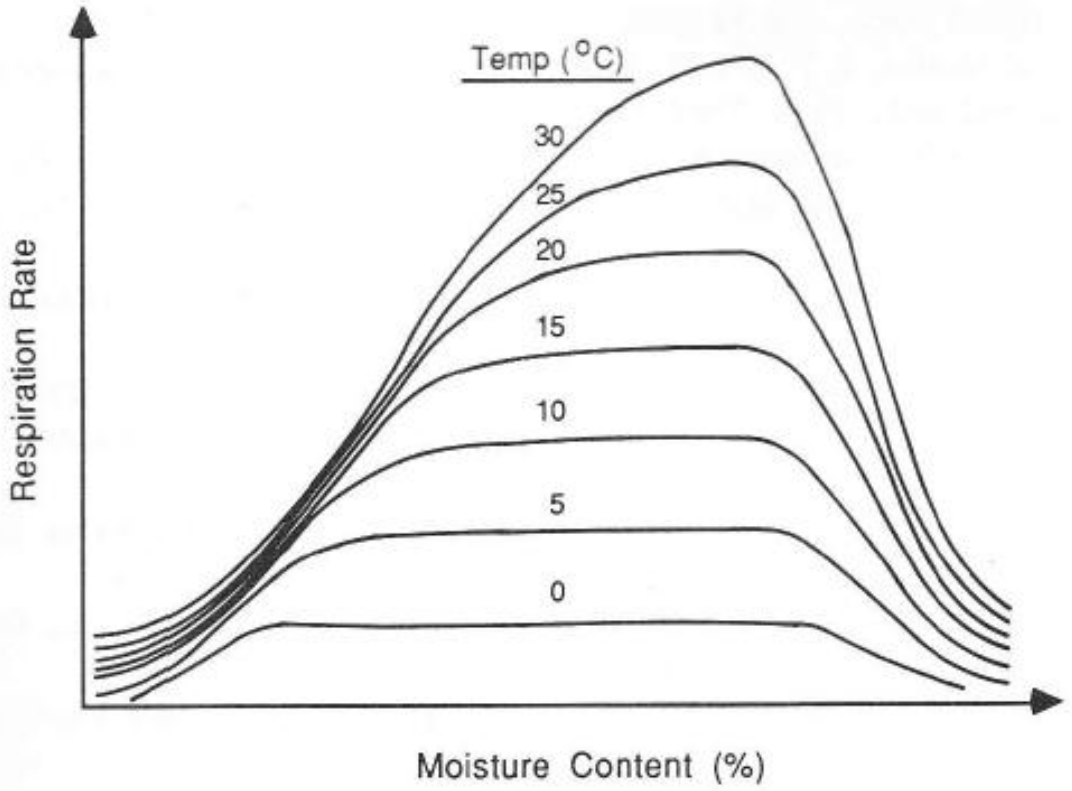
(Paul and Clark, 1989, Soil Microbiology and Biochemistry)



Factors Affecting Biological Degradation

Soil moisture and temperature interaction

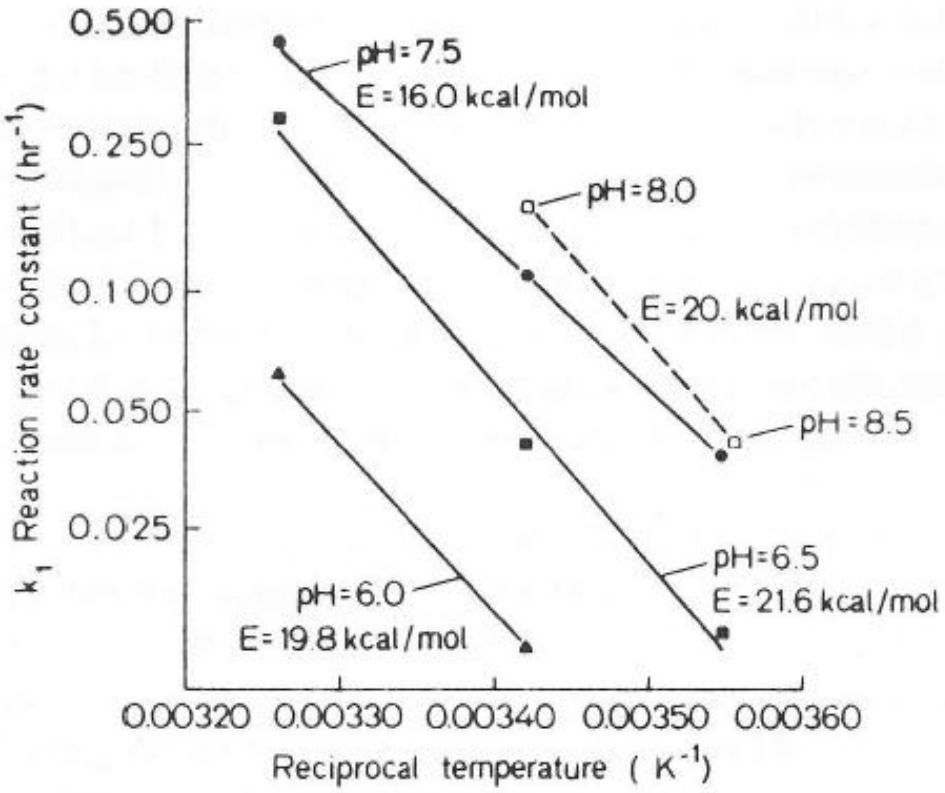
(Bunnell and Tait, 1974)



Factors Affecting Biological Degradation

Soil pH

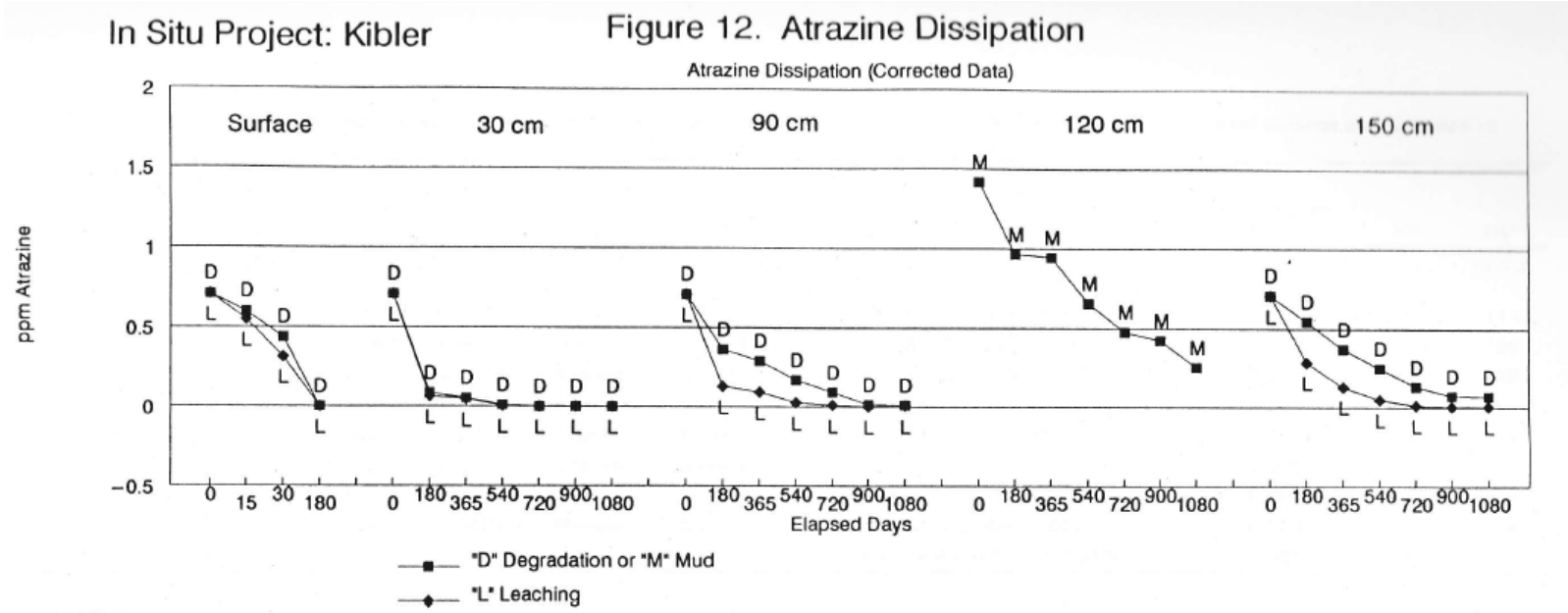
Figure 2.8. Combined effect of pH and temperature on reaction rate constants (hr^{-1}): ammonia oxidation (k_1) by *Nitrosomonas* (top graph); nitrite oxidation (k_2) by *Nitrobacter* (bottom graph). (From Wong-Chong and Loehr, 1978.)



Factors Affecting Biological Degradation

Soil depth

(Lavy et al., 1996)



Factors Affecting Biological Degradation

Soil classification

- Clays
  - –Hold moisture
  - –Typically have greater organic matter
  - –Therefore, greater microbial activity
- Sands
  - –Higher oxygen, more oxidation
  - –Better drainage
  - –Typically less organic matter
  - –Therefore, lower microbial activity

Factors Affecting Biological Degradation

Previous applications

(Krutz et al., 2009)

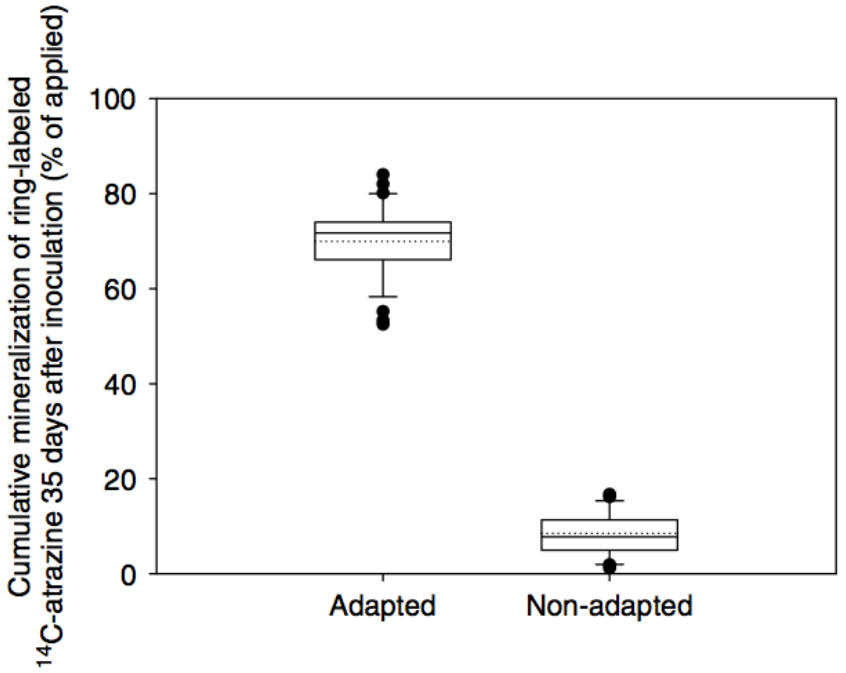
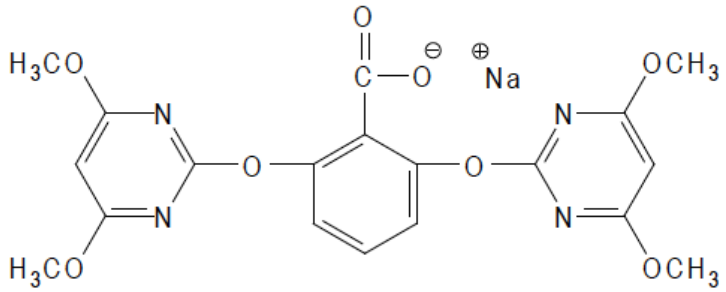


Figure 2. Box plot comparisons of published data for cumulative $^{14}CO_2$ evolution of ^{14}C-ring-labeled atrazine 35 days after inoculation in *s*-triazine-adapted and non-adapted soil. Aadapted from Krutz *et al.*[12] Boundary of box closest to zero indicates the 25th percentile, a solid line within the box marks the median, a dashed line within the box delineates the mean and the boundary of the box furthest from zero indicates the 75th percentile. Error bars above and below the box indicate the 90th and 10th percentile, and solid dots indicate outliers. The number of independent observations is 22 for non-adapted soils and 54 for *s*-triazine-adapted soils.[75,85,107–110,121,122,125,154–157]

Potential issues

- Sulfonylureas and related chemistry
  - –Persistent and more available in higher soil pH values
  - –Bispyribac-sodium DT_{50} in water
    - pH 4 = 448 h
    - pH 7 or 9 > 1 year

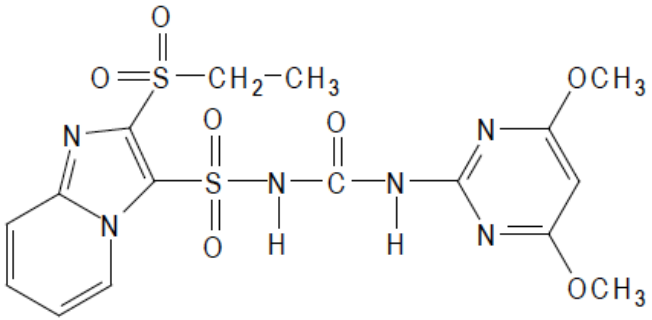
bispyribac



Potential issues

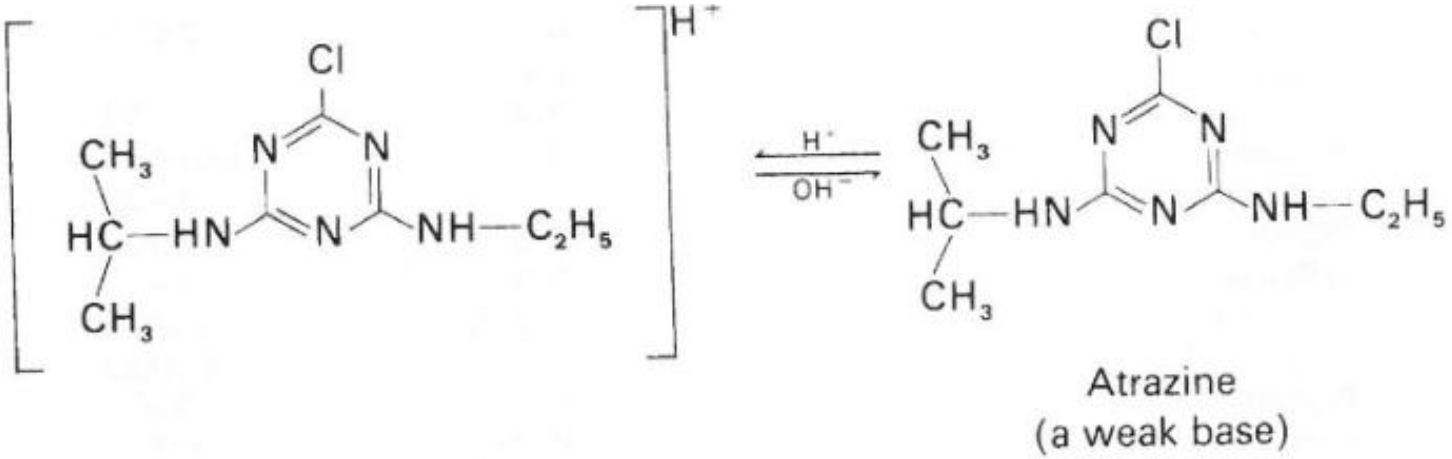
- Sulfonylureas and related chemistry
  - –pH and availability
    - Sulfosulfuron solubility
      - –18 mg/L (pH 5)
      - –1627 mg/L (pH 7)

sulfosulfuron



Potential issues

- Triazines
  - Higher pH values allow for more availability



Atrazine
(a weak base)

Potential sensitive areas

- Low adsorptivity, high availability
- Low soil health
  - Low organic matter
  - Low fertility
  - Low microbial activity
- Low moisture for extended period
- Higher pH soils – flumioxazin exception

Bioassays

- Biological assays vs. chemical assays
  – What's the difference?
- Coffee example
- Chemical assays
  - Extraction and quantification accuracy but not necessarily helpful in determining biological response
  - Biological sensor not as accurate for quantification
  - Plant roots extract differently than chemicals

Bioassays – Research Methods in Weed Science – 1986)

- Collect surface soil from several areas
- Approximately 1 gallon
- Mix thoroughly
- Collect similar soil from untreated areas
- Using available containers (500-mL to 1-L), plant sensitive species, i.e., seeds of next crop

Bioassays - Continue

- Replicate 3 times in both treated and untreated soils
- Water but do not saturate. Keep moist (not wet) for 3 weeks
- Observe symptoms – High concentrations will affect the plant early and potentially cause death

Possible symptoms

- Atrazine
  - Burnt cotyledons
  - Interveinal chlorosis

Photo from Purdue Extension

Possible symptoms

- Chloroacetamides
  - –Acetochlor, alachlor, dimethenamid, metolachlor
  - –Soybean - Heart-shaped leaves
  - –Corn – Buggy-whipping

Photos from Purdue Extension

Possible symptoms

- ALS-inhibitors
  - –Imidazolinones
  - –Sulfonylureas and related chemistry
  - –Red veins
  - –Chlorosis
  - –Stunting

Issues with Bioassays

- Could be highly variable due to:
  - Field variations
  - Soil texture variations
  - Sampling of soil
  - Depth of sampling variations

Issues with Bioassays

- Could be highly variable due to:
  - Variety of plants might be more tolerant than other varieties available
  - Low rates of chemistry being used which enhance variability and symptoms
  - Subtle symptomology