Herbicide Properties and Selection

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Agenda

- How herbicides work
- How herbicides move in plants
- Selectivity
- Differences between foliar and soil active products
- Factors affecting herbicide performance
- How to select the proper product(s)

The most expensive pesticide application is the one that does not work!

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Mode of Action vs Site of Action

- *Mode of action (HOW) -* name for the process the herbicide uses to control the weed
  - Manner in which herbicides affects plants at the tissue or molecular level
  - Description of the herbicidal activity on a specific physiological process in plants (e.g. imazapyr is an amino acid synthesis inhibitor)
- *Site of action (WHERE) -* the location within the plant where the herbicide impacts the development process
  - Typically the target is an enzyme used in carrying out a process like amino acid production or photosynthesis
  - Referred to by the protein function they inhibit, such as acetolactate synthase (ALS Inhibitor) or p-hydroxyphenylpyruvate dioxygenase (HPPD Inhibitor)

Herbicide Classification

University of Wisconsin Extension

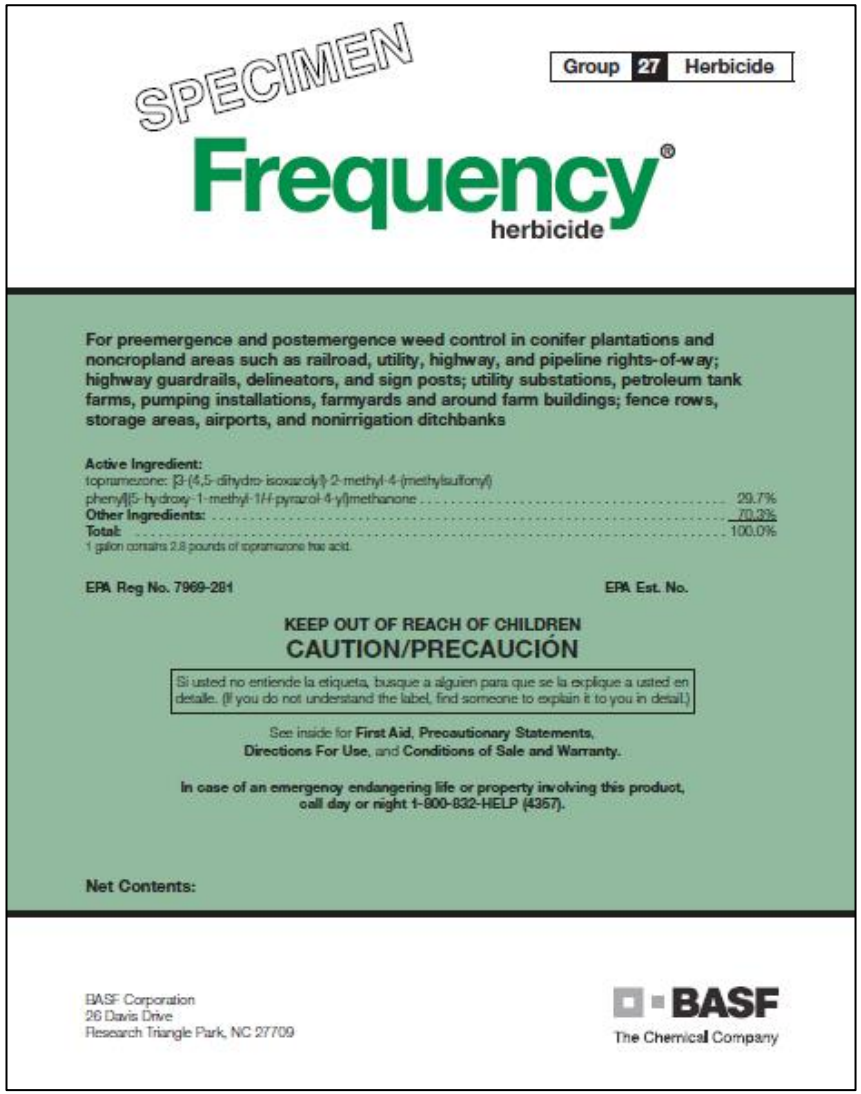
Mode of Action	Site of Action	Group	Example
Lipid Synthesis Inhibitors	ACCase Inhibitors	1	Sethoxydim
Amino Acid Synthesis Inhibitors	ALS Inhibitors	2	Imazapyr
	EPSP Synthase Inhibitor	9	Glyphosate
Growth Regulators	Unknown	4	Dicamba, 2,4-D, Aminopyralid
	Auxin Transport	19	Diflufenzopyr
Photosynthesis Inhibitors	Photosystem II Inhibitors	5	Atrazine
	Photosystem II Inhibitors	6	Bentazon
	Photosystem II Inhibitors	7	Linuron
Nitrogen Metabolism	Glutamine Synthesis Inhibitor	10	Glufosinate
Pigment Inhibitors	Diterpene Synthesis Inhibitor	13	Clomazone
	HPPD Inhibitors	27	Topramezone

Herbicide Classification

University of Wisconsin Extension

Mode of Action	Site of Action	Group	Example
Cell Membrane Disrupters	PPO Inhibitors	14	Saflufenacil
	Photosystem 1 Electron Diverter	22	Paraquat
Seedling Root Growth Inhibitors	Microtubule	3	Dinitroaniline
Seedling Shoot Growth Inhibitors	Lipid Synthesis Inhibitors	8	Butylate
	Long-chain Fatty Acid Inhibitor	15	Dimethenamid

Chemical Group Number



Frequency is a great substitute for Esplanade as part of your resistance management program!

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ALS inhibitors- General Symptoms

Giant hogweed- Arsenal®

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Auxin Herbicides – General Symtoms

Dicamba - Leaves curl down

2,4-D - Leaves curl up

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Auxin Herbicides - General Symptoms

Japanese knotweed - Vista® (fluroxypyr)

Giant hogweed – Milestone® (aminopyralid)

Mile-a-minute - Garlon® (triclopyr)

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Frequency® Herbicide

HPPD Inhibitor

Sensitive weeds turn white (“bleach”) due to loss of pigmentation

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Detail® Herbicide

PPO Inhibitor

Disrupting leaf cell membrane results in rapid burndown

Detail works post-emergent on Kochia, Russian thistle, pigweeds and marestail with short-term residual and is an alternative for glyphosate resistant broadleaf weeds as part of resistance management!

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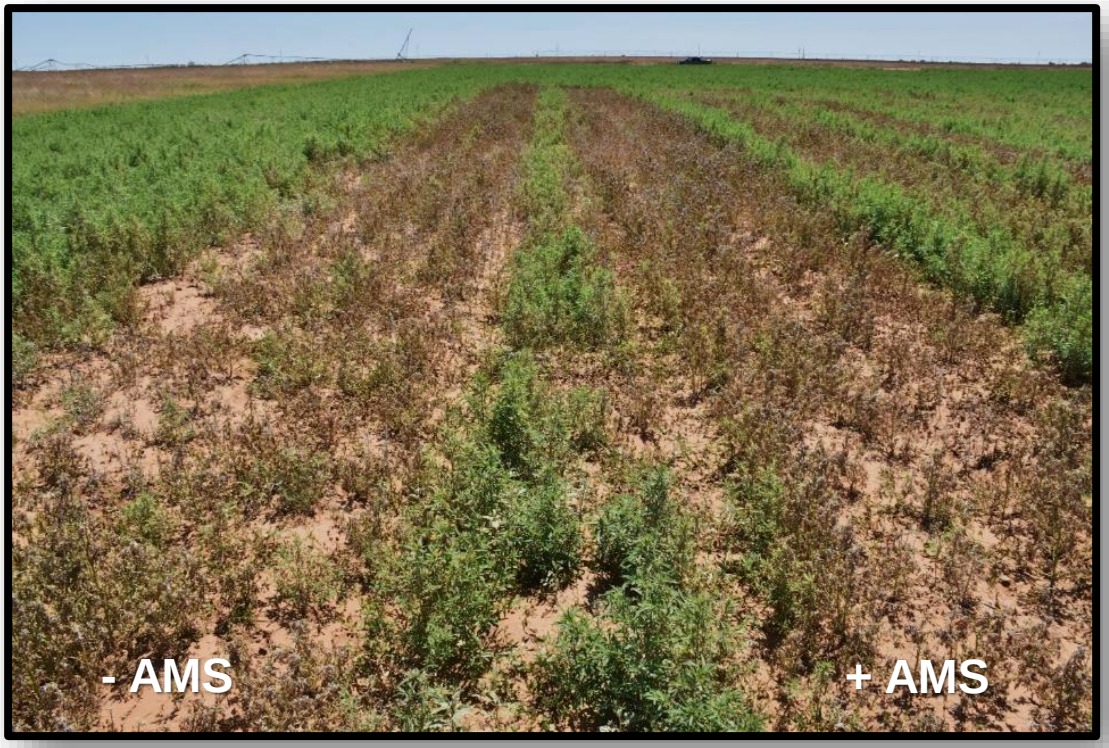
Finale VU® Herbicide

Glutamine Synthesis Inhibitor

Kochia Control on May 30, 2019 (8 DAT)



Disrupting photosynthesis results in rapid burndown

Finale VU works post-emergent on Kochia, Russian thistle, pigweeds, marestail and some grasses as an alternate to glyphosate for resistance management!

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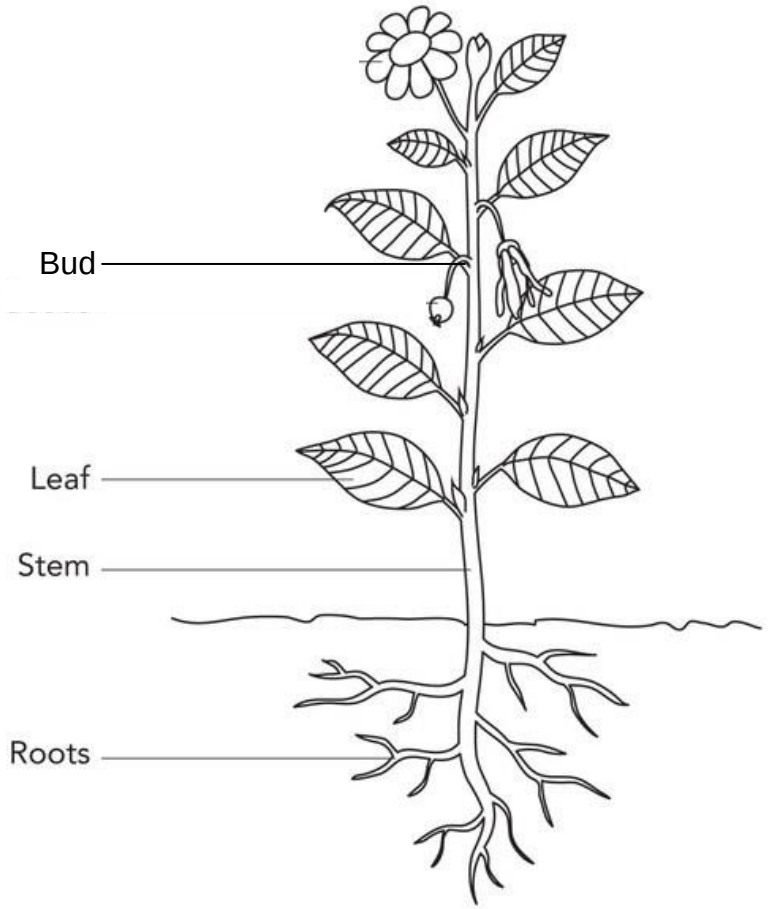
Where Do Herbicides Enter Plants

- Roots
- Stems / Shoots
- Leaves
- Buds



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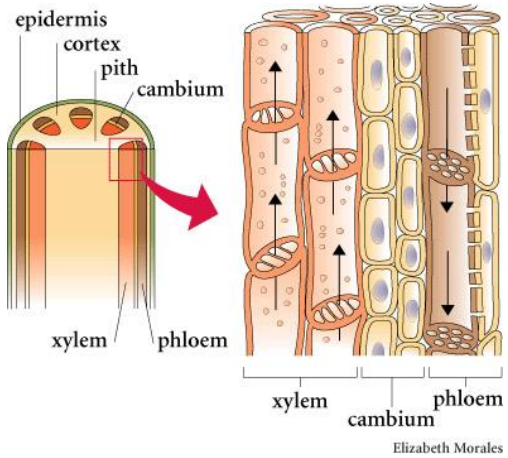
Translocation – Movement within Plants

- Xylem
  - Nonliving hollow tubes that move water, nutrients from roots to above ground plant parts
  - Primary means of moving herbicides UP from roots to shoots, stems and leaves
- Phloem
  - Living cells that carry organic nutrients (primarily sugar) to all parts of the plant
  - Primary means of moving herbicides DOWN from leaves to roots and shoots

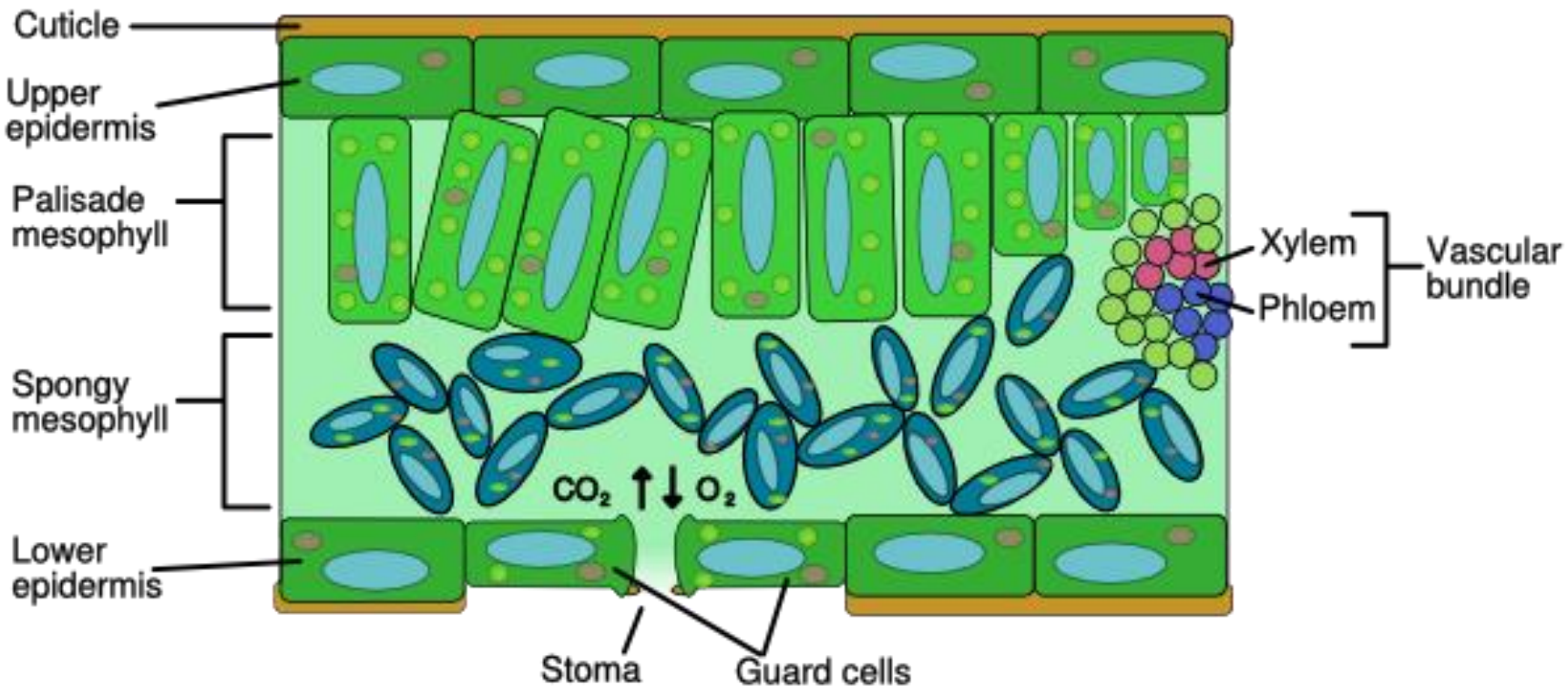


Herbicide Movement - Translocation

Movement of herbicide from the site of uptake to the site of action, where it kills the plant

- Systemic (mobile) products
  - Move through xylem and phloem
- Contact (immobile) products
  - Kill at point of uptake (leaves)

Where Do Herbicides Enter Leaves



The main barrier is the cuticle!!! Adjuvants are critical….

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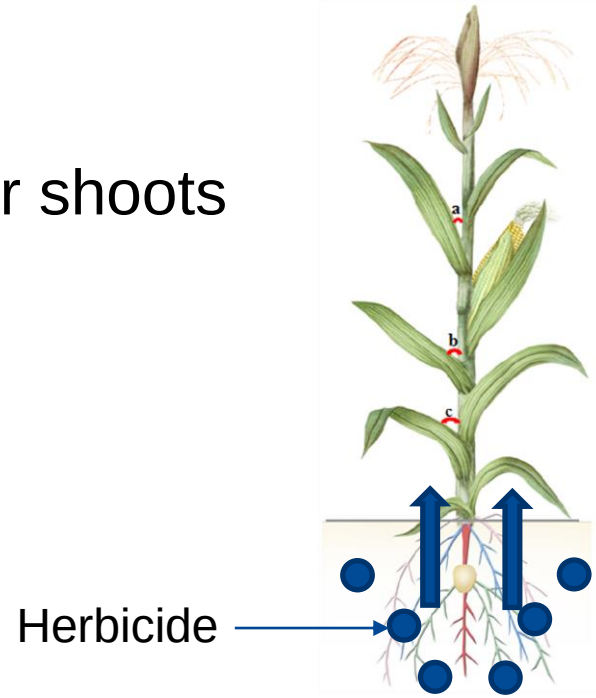
Where Do Herbicides Enter Plants

Soil Applied Herbicides

- Absorbed by seeds, roots or shoots
- Move through the xylem



Herbicides on Plant Foliage

- Volatilize off the leaf surface
- Photodegrade
- Crystallize or change in viscosity
- Trapped as a liquid on the cuticle
- Penetrates the cuticle and moves to the inner leaf
- Moves from inner leaf to xylem and phloem

Reasons For Herbicide Selectivity

- Plant rapidly breaks down or inactivates the active ingredient
- Failure of the herbicide to enter or move in the plant
- Application method – no contact

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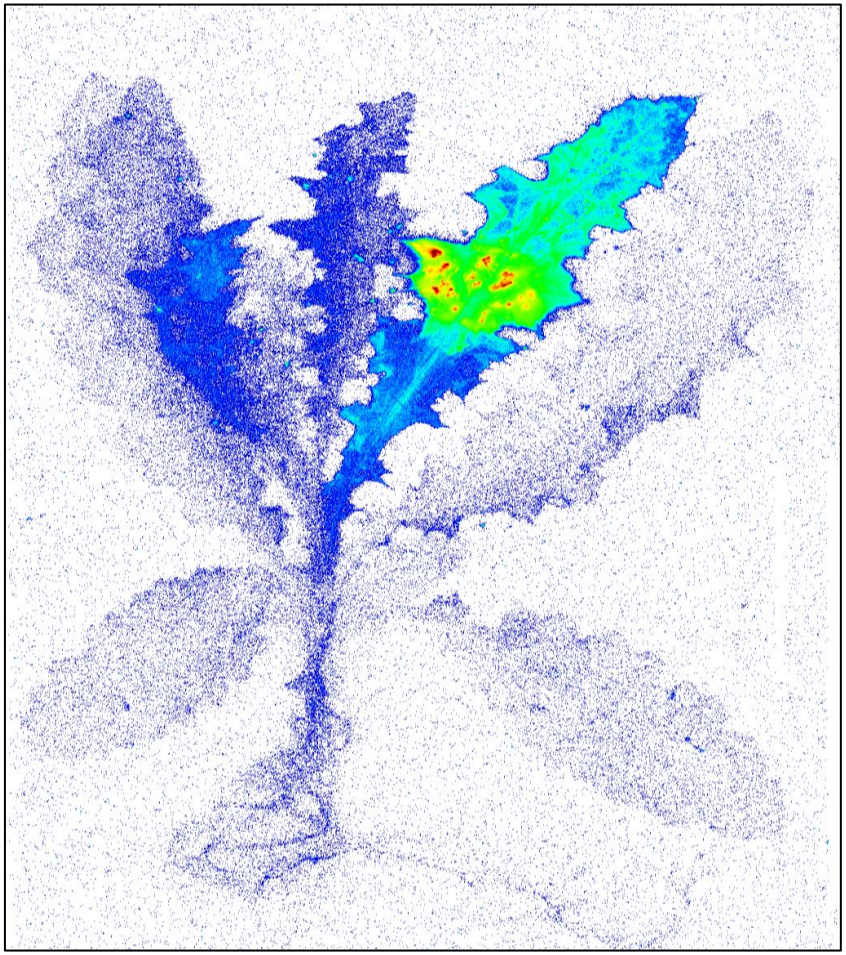
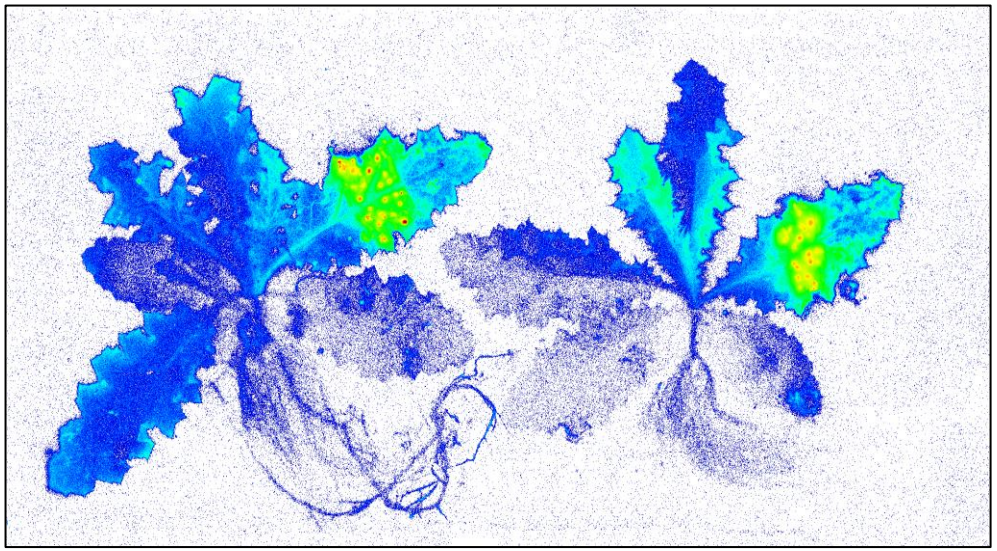
Stage of Growth Impacts Movement of Herbicides in Plants



Bolting



Rosette

Movement is better in the rosette stage

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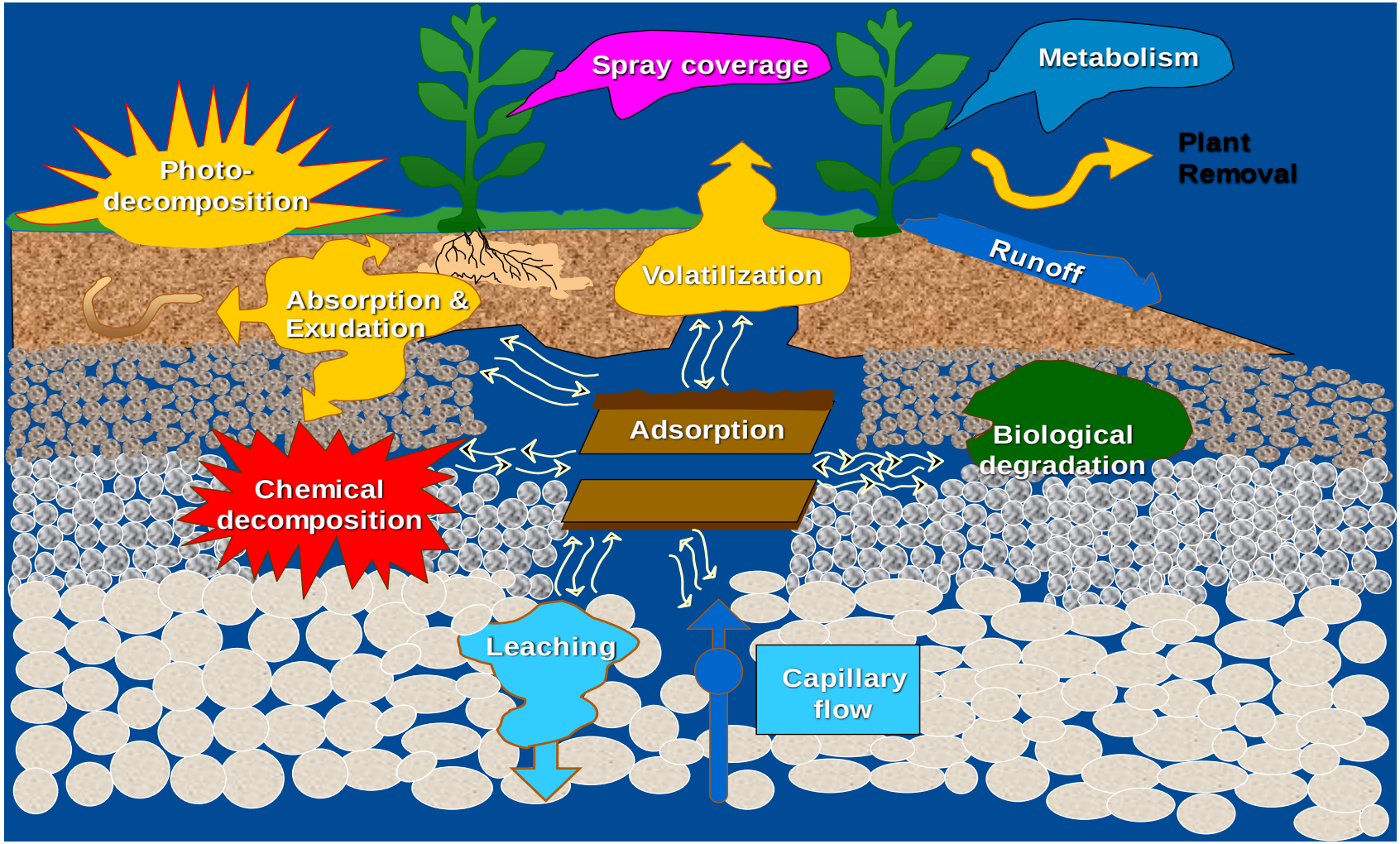
Environmental Fate of Herbicides



Courtesy of Mark Thompson, DuPont Crop Protection

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Factors Effecting Herbicide Performance

- Adequate contact with the plant - coverage
- Absorption by the plant
- Movement to the site of action - translocation
- Reach toxic levels at the site of action

Application Timing

- Plants must be actively growing at the time of foliar application for the herbicide to upset or stop the target plant process
  - Foliar applications typically occur in the spring and summer
  - Fall foliar applications on perennial weeds will work as uptake is mainly by the roots which are still actively producing root buds for the next season
- Soil active products require rainfall for soil incorporation and activation

Factors for Breakdown of Herbicides

- Moisture
- Temperature
- Humidity
- Sunlight
- Chemical and microbial breakdown
  - Increase in warm, moist conditions
  - Slow in cool, dry conditions
    - Greater possibility of carry-over following drought
    - If winter and spring conditions are wet and mild following a previously dry summer, herbicide carryover is likely

Temperature, Moisture, Humidity

- Low moisture, low humidity and high temperatures increases cuticle thickness and closes stomata, thereby reducing uptake and control
- High temperatures, low humidity and wind can dry spray droplets before the herbicide is absorbed. Product may vaporize or crystallize and be easily removed by wind or rain or degraded by sunlight
- Leaf cuticles are thicker and more resistant to penetration when leaves are mature late in the season
  - Adjuvants are critical!
- Best foliar uptake when temperatures are between 65 and 85 degrees

Sunlight

- Plant response to foliar applications is more rapid on sunny days since light enhances photosynthesis
- When photosynthesis is reduced other metabolic pathways slow or stop, reducing translocation and action of the herbicide
- Some herbicides will photodegrade if left on the leaf surface for extended periods

Herbicide Properties

- Sunlight
  - Many herbicides breakdown in sunlight (photolysis)
    - Liquid solution
    - On leaf surface
  - Typically less of an issue with persistent, soil applied products
    - Exceptions are Trifluralin and Pendimethalin
    - Incorporation will minimize breakdown by sunlight

Rain

- Rain following foliar application can reduce control
- Some herbicides can be rainfast in as little as 15 minutes
- Some products require up to 8 hours without rain for best performance
- Formulation can impact rainfastness
- Adjuvants can make a big difference

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Soil Factors Affecting Herbicide Performance

- Composition – Soil texture
  - Amount of sand, silt, clay and organic matter
  - pH
  - Types and abundance of soil microbes
- Soil half-life or soil persistence is the amount of time the product remains active in the soil

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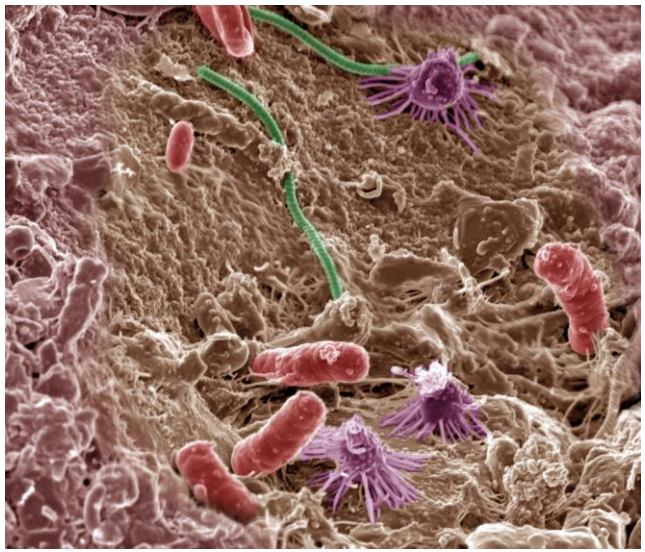
Soil Texture

- General Rule
  - Medium to fine textured soils **(Clay)** with 3%+ organic matter have the greatest potential to bind or hold the herbicide
    - Less susceptible to leaching
    - More of a factor in sensitive rotational crop injury
  - Coarse to medium textured soils with <3% organic matter **(Sand)** are less likely to retain herbicide
    - More susceptible to leaching
    - Less of a factor in sensitive rotational crop injury

Breakdown of Herbicides in Soil

- Microbial
  - The most important breakdown mechanism
  - Activity is greatest in warm, wet conditions
    - Fungi
    - Bacteria
    - Protozoans
    - Environmental factors
- Chemical
  - Photolysis - light
  - Hydrolysis - water



Breakdown of Herbicides in Soil

- Chemical and microbial breakdown are slower in high pH
  - Triazines and sulfonylureas
    - Breakdown slows and persistence greatly increases in high pH 7+
    - More herbicide is readily available to the plant
  - Imidazolinones
    - Breakdown slows and persistence increases in low pH <6
    - Greater soil absorption but can still be available a few months later (carry-over)

Herbicide Properties

- Water solubility
  - Leaching – movement of herbicide, dissolved in water, down into soil profile
  - High water solubility increases leaching potential
  - Other factors: Soil binding, physical characteristics, rainfall frequency and intensity, herbicide concentration and time of application

Herbicide Soil Movement

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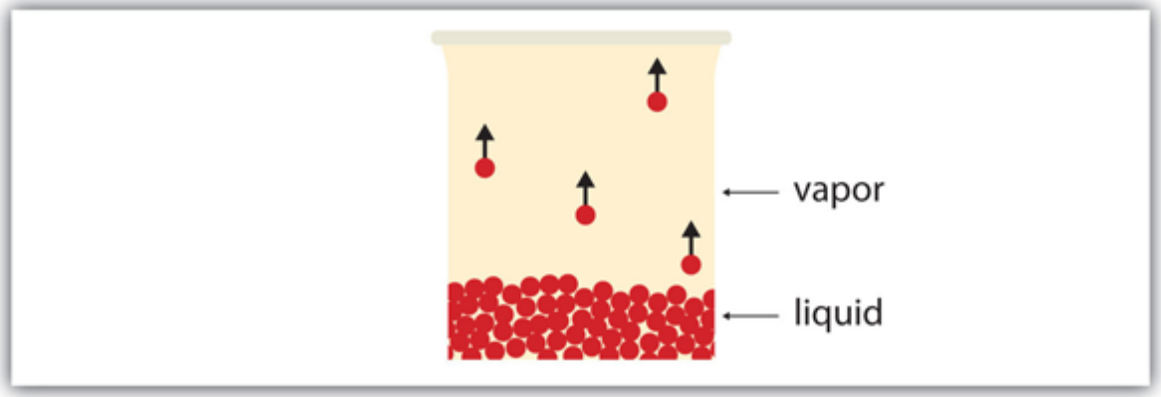
Herbicide Properties

- Vapor pressure of the product
  - Determines potential for volatility
  - Products with high vapor pressure have more potential for volatility
  - Volatilization potential increases with high temperature and low humidity
  - Soil incorporation decreases potential volatility
  - Most herbicides are relatively non-volatile under normal field conditions



Canopy Factors

- Foliage area determines the amount of herbicide intercepted
- Young weeds / trees with small leaves may not intercept a lethal dose
- Plants with hairy leaves (mullein) do not absorb herbicide easily as the hairs hold spray droplets away from the leaf surface
- Excessive old leaf growth from the previous season may also intercept herbicide preventing contact with new growth

Herbicide Selection Questions?

- Undesirable species to control
- Desirable species to save / release / plant
- Location
- Timing of application – pre or post
- Soils
- Weather conditions
- Type of application

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Impact on Herbicide Performance

- Herbicide(s) used
- Application method
- Application timing
- Environmental conditions
- Adjuvants and water quality
- Stage of plant growth
- Vegetation density/coverage

Conclusions

- Understand herbicide mode and site of action
- Know the target weeds and desirable weeds
- Use several different modes of action - Tankmixes
- Understand the soil and environmental conditions
- Use quality adjuvants
- Herbicide + mechanical/cultural techniques may be required
- Return to treated sites to reassess control strategies.
- Rotate your chemistry frequently

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Questions

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