Herbicide Symptoms and Mode-of-Action

2016 Roadside Vegetation Management Conference
State College, PA

Classifying Herbicides

- Many terms that we use to categorize herbicides describe

How They are Used

-instead of-

How They Work

Examples

- Preemergence vs Postemergence
- Soil Applied vs Plant Applied
- Many herbicides are used both ways

Examples

Product	Pre	Post
GlyPro	No	Yes
Oust XP	Yes	Yes
Karmex DF	Yes	Yes
Arsenal	Yes	Yes

Classifying by Activity

- Soil Activity
- Contact vs Systemic
- Selective vs Non-selective
- Mode of Action

Herbicide Soil Activity

- Very few herbicides have NO soil activity

  Roundup (*glyphosate*)

- Some herbicides have almost no soil activity

  Krenite S (*fosamine*)

- Some herbicides are highly rate dependent

  Arsenal (*imazapyr*)

- Many herbicides are used primarily for their soil activity

  Oust (*sulfometuron*)

Contact vs Systemic

- As commonly used, the term *Contact Herbicide* refers to limited movement within the plant and fast activity

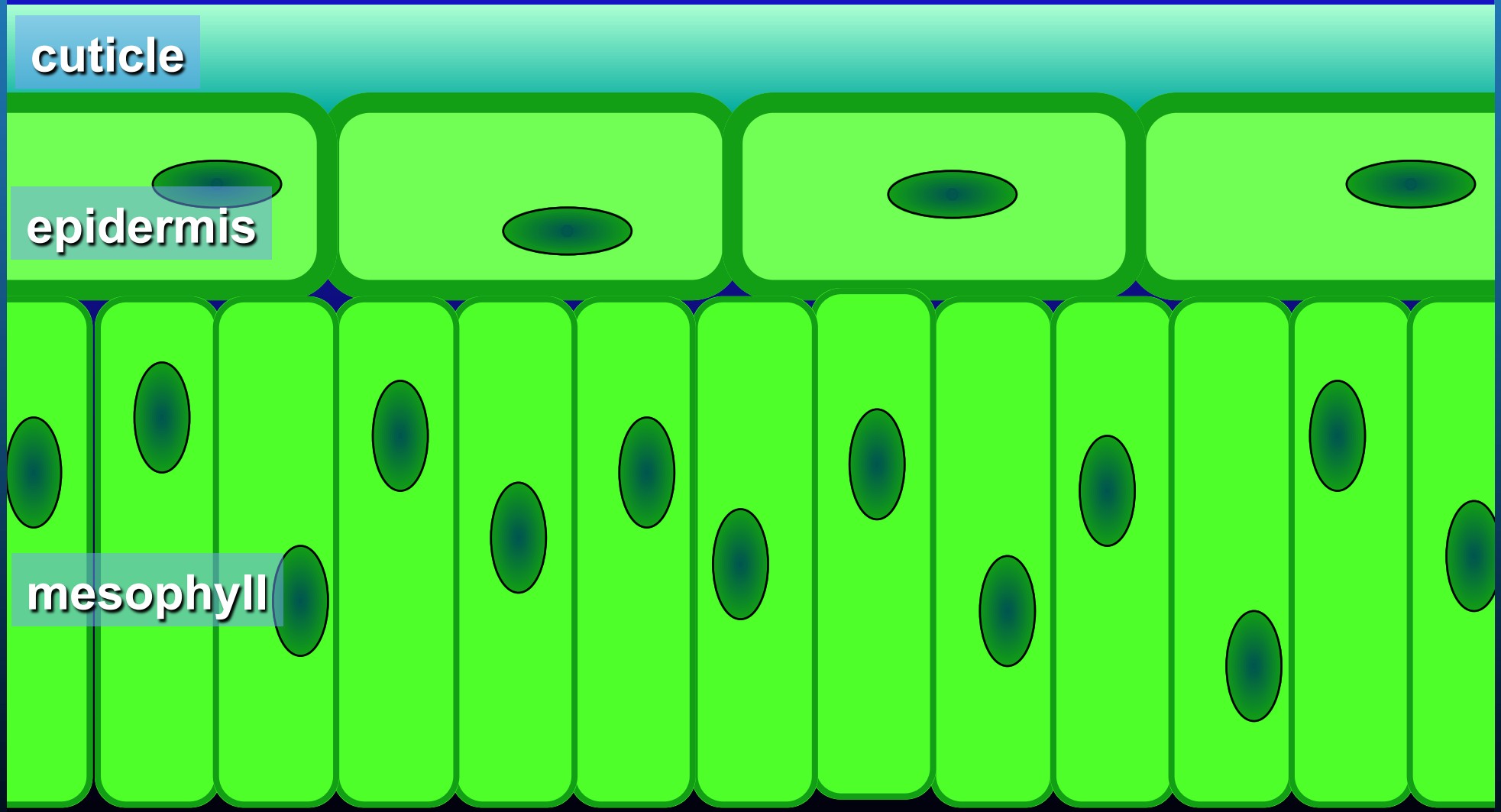
Contact vs Systemic

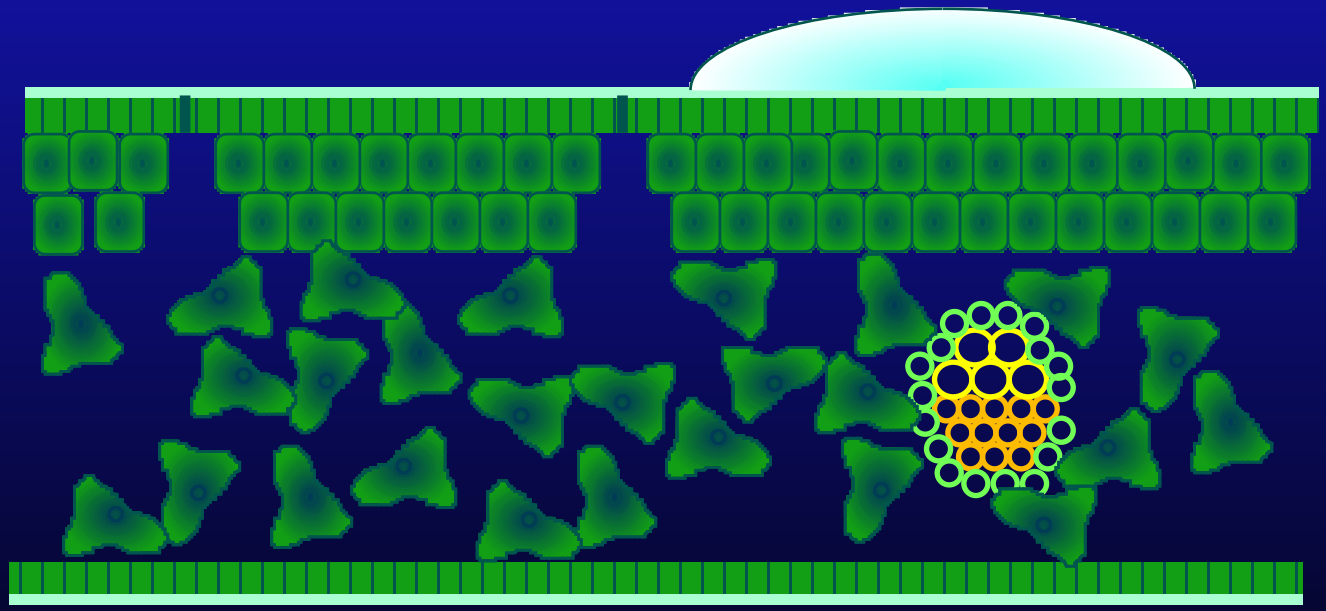
- Systemic herbicides will move out of the treated part of the plant
- Some move with the water stream - upwards in plant
- Some move with sugars - move to 'growing points'

Herbicide Movement in Plants

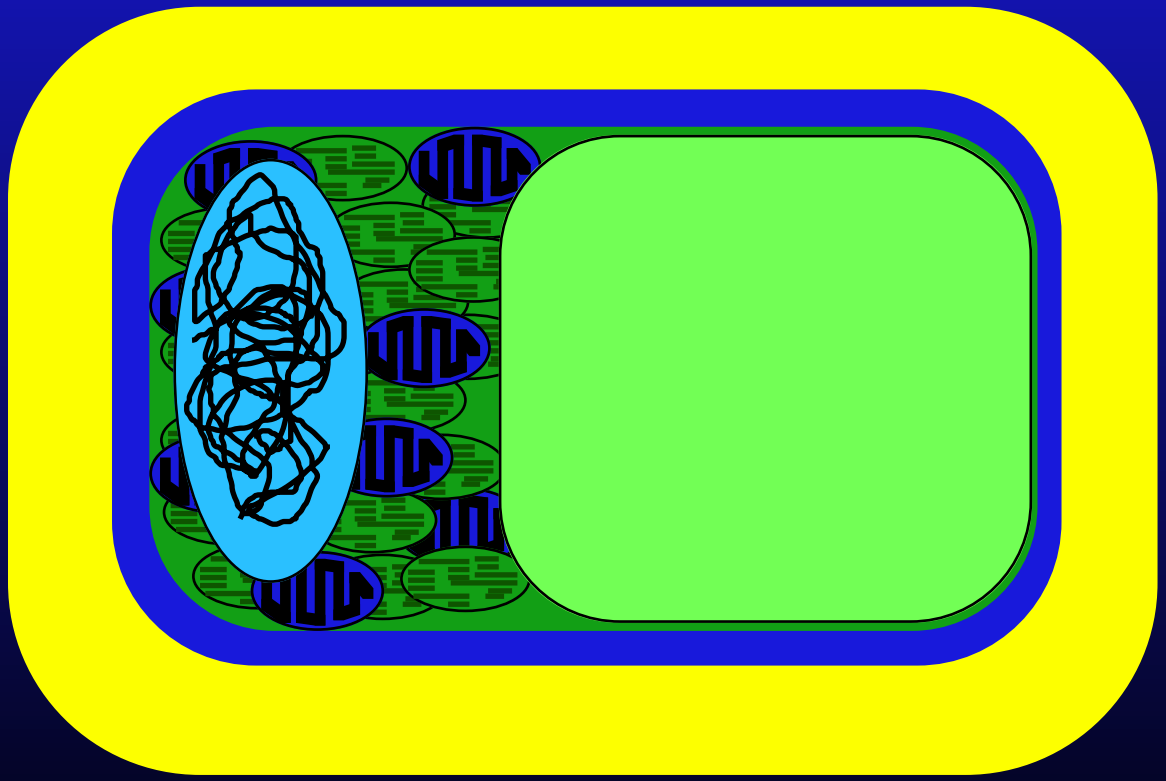
- Complex
- Even the fastest-acting contact herbicide has to move to specific locations within plant cells to act

Magnified Cross Section of Leaf Surface





The Plant Cell



- Cell Wall
- Cell Membrane
- Nucleus
- Organelles:
  - chloroplast
  - mitochondria
  - endoplasmic reticulum
- Vacuole

Contact Herbicides

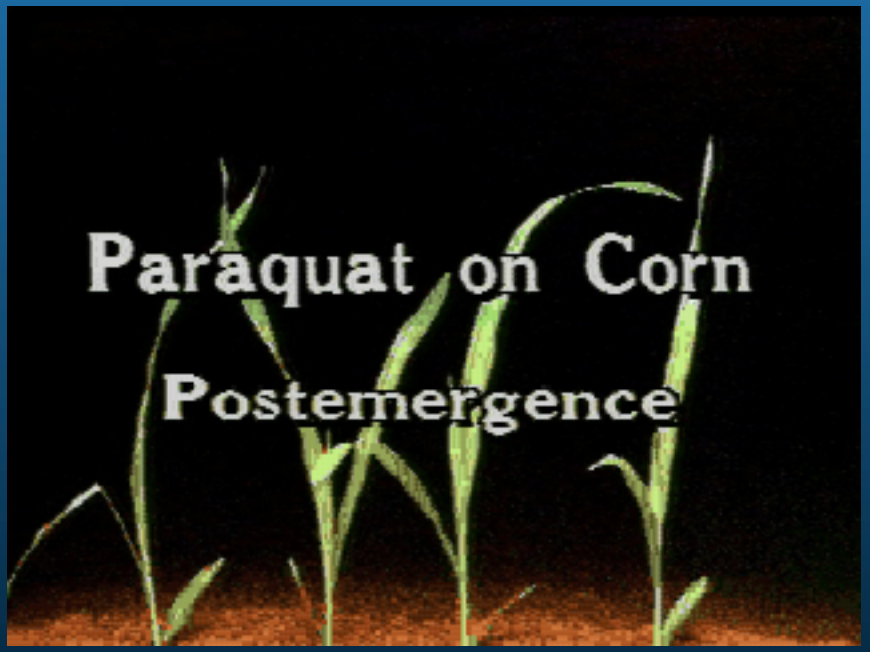
- Contact herbicides tend to only affect the portions of the plant they contact
- Common Examples:

  Paraquat - 'Gramoxone'

  Diquat - 'Reward'

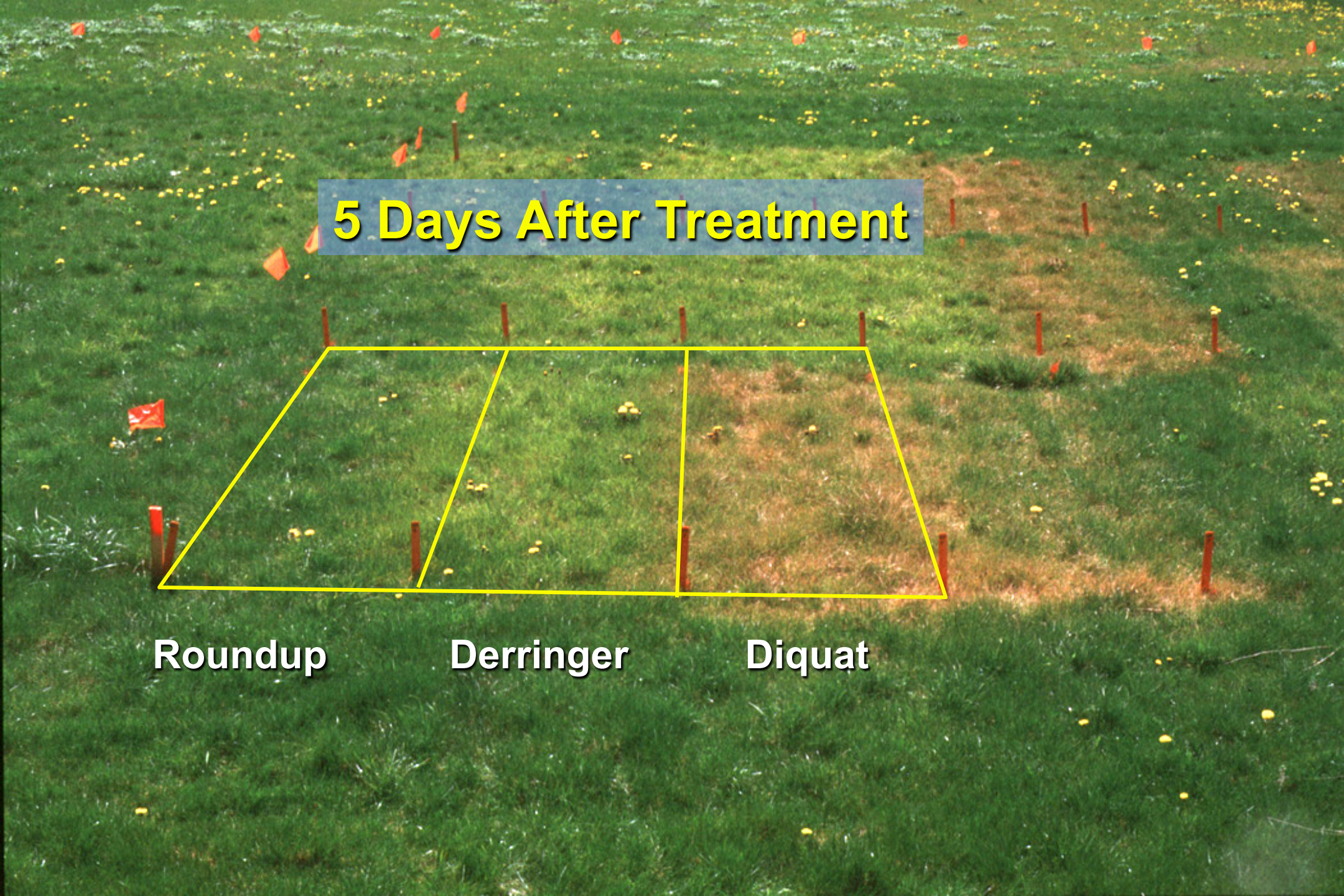
  Glufosinate - 'Derringer'

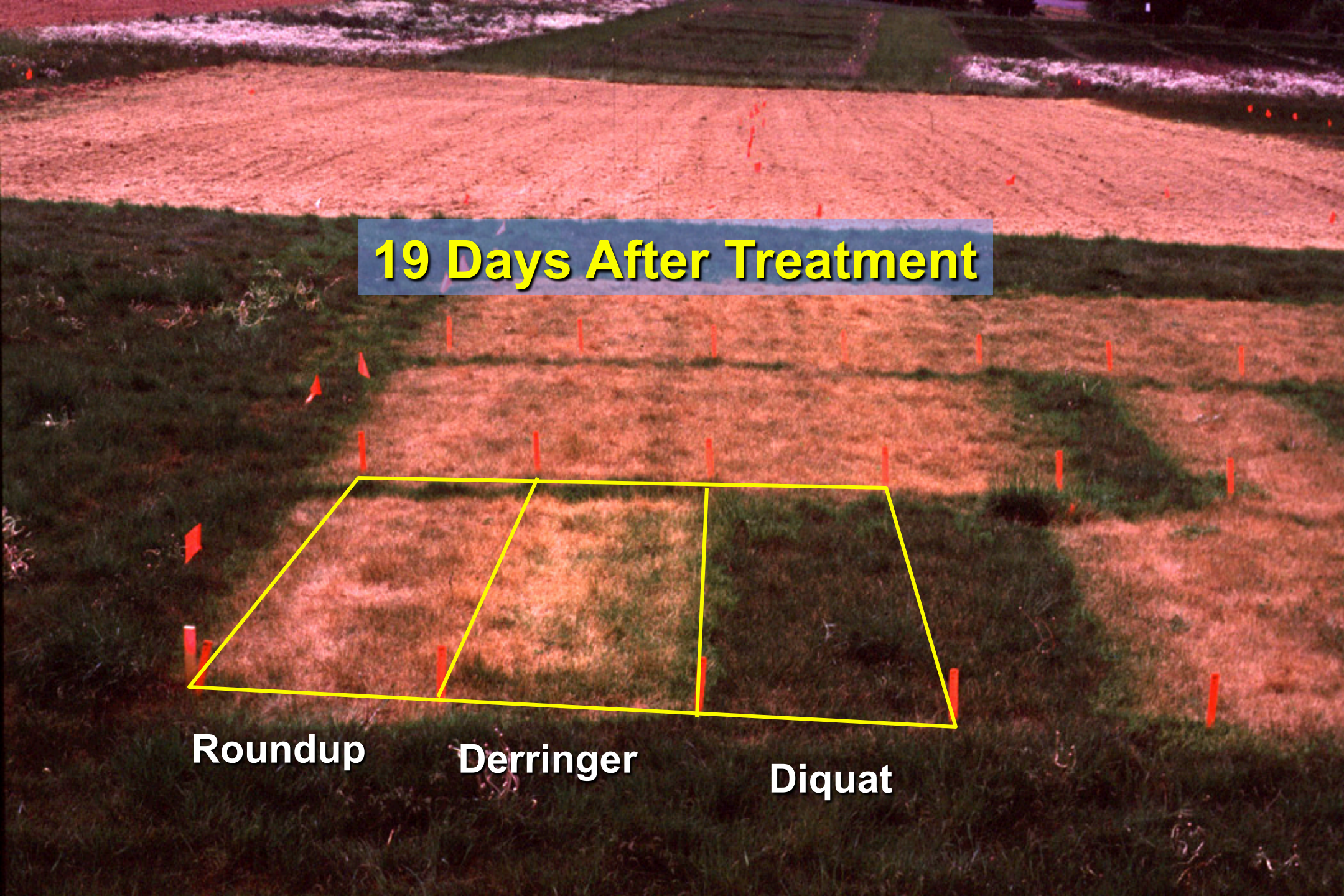
Contact Herbicide Symptoms

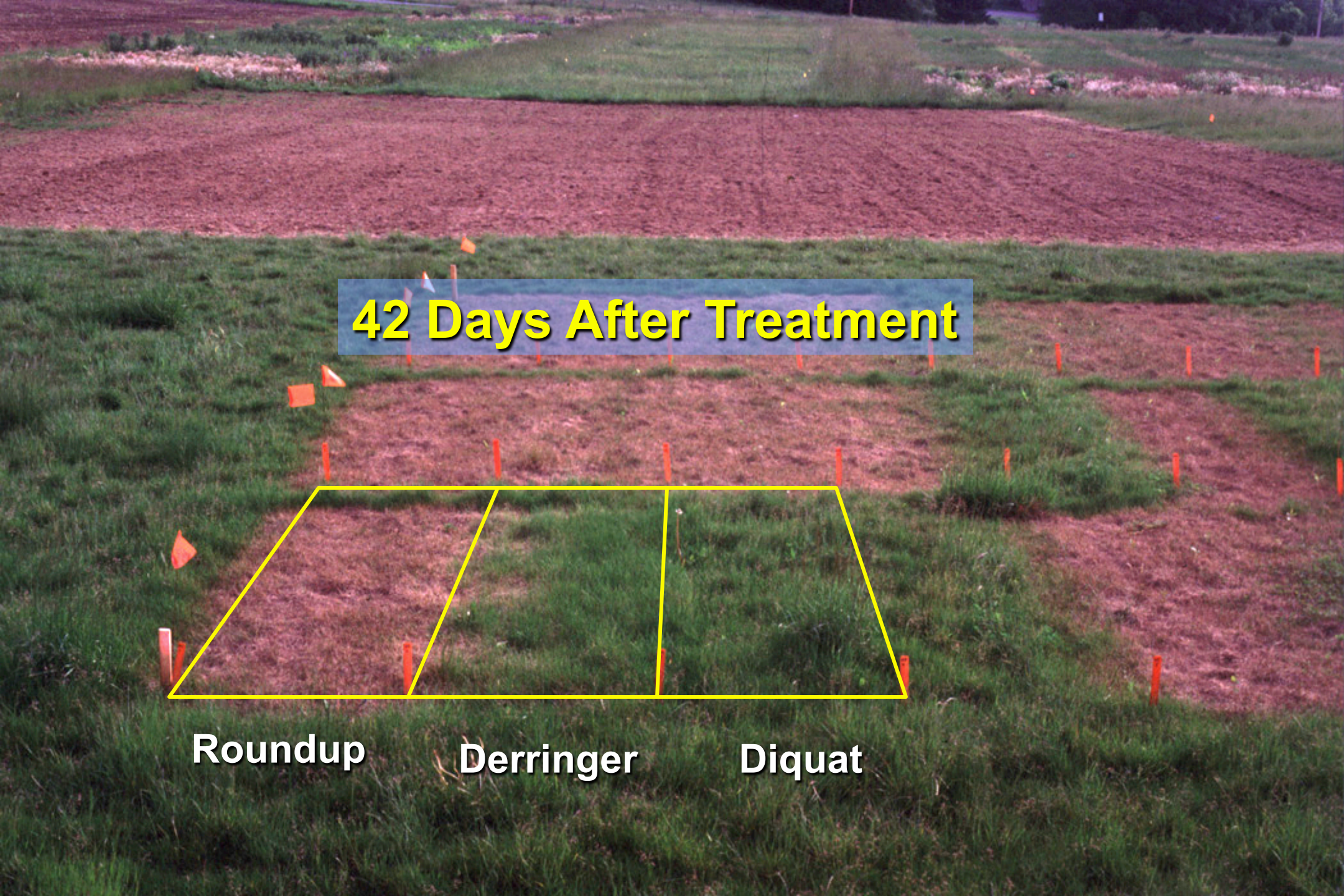


Limited Effect of Contacts

- Burn of treated foliage
- Do not effect untreated buds and roots
- Perennials grow back
- Must be used with other herbicides to be truly effective on roadsides


5 Days After Treatment
Roundup
Derringer
Diquat


19 Days After Treatment
Roundup
Derringer
Diquat


42 Days After Treatment
Roundup
Derringer
Diquat

Contact Herbicides

- Can interfere with the activity of systemic herbicides (antagonism)
  - Damage plant tissue before systemic herbicides can move through it

Herbicide Selectivity

- Deposition/Absorption
- Translocation
- Metabolism/Degradation
- Presence of Target Site

Herbicide Mode of Action (MOA)

- Describes the events that occur at the molecular level within the specific structures within plant cells
- Herbicides are described by MOA and chemical family.
- Several families may have the same MOA

MOA Examples

- Amino acid synthesis inhibitor
- Growth Regulator
- Photosynthetic inhibitor
- Root inhibitor (cell division inhibitor)

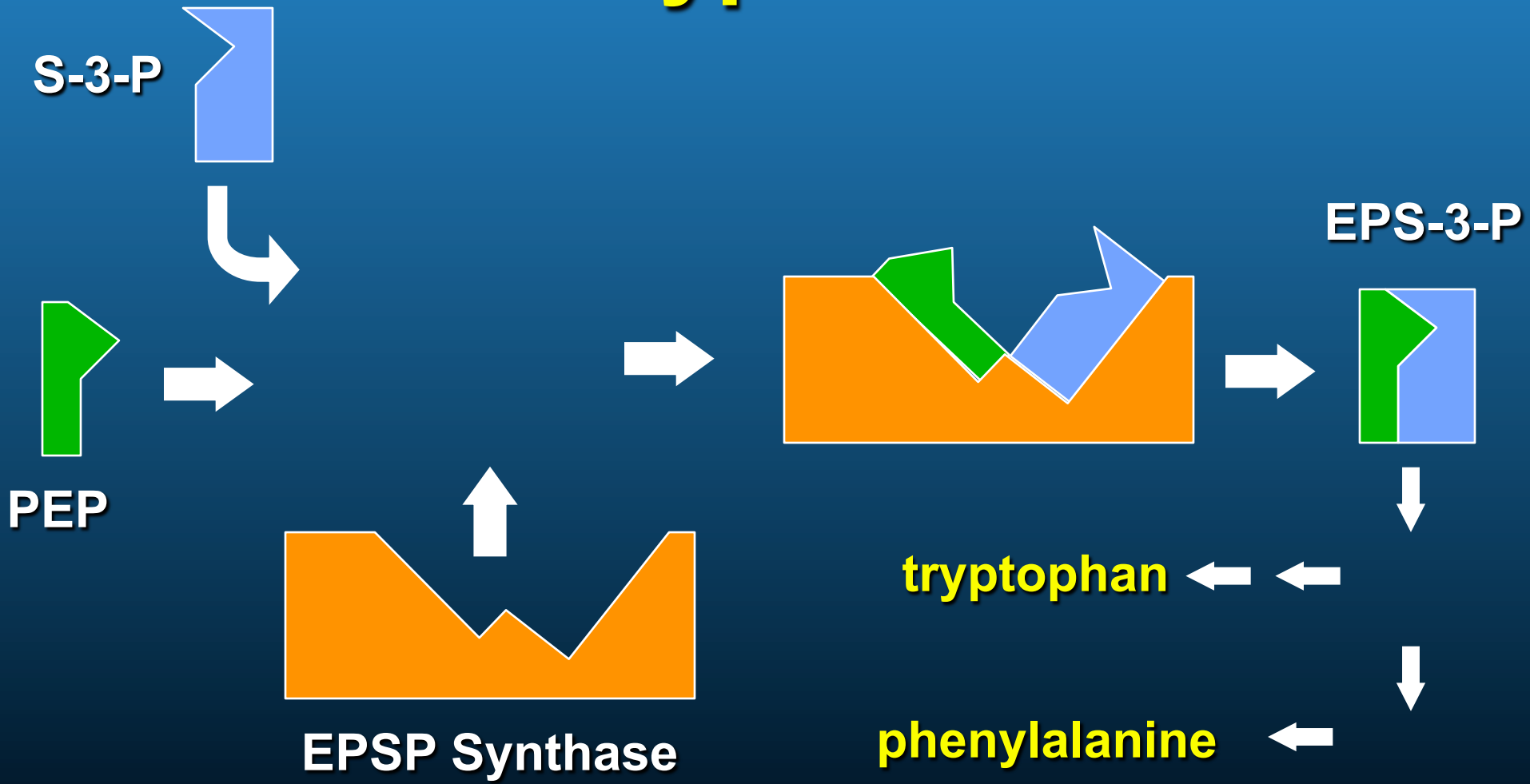
Amino Acid Synthesis Inhibitors

- Examples -
  - Glyphosate (Accord XRTII, Glyphomate 41)
  - Escort XP
  - Oust XP, Oust Extra
  - Arsenal
- Prevent plant from creating certain amino acids

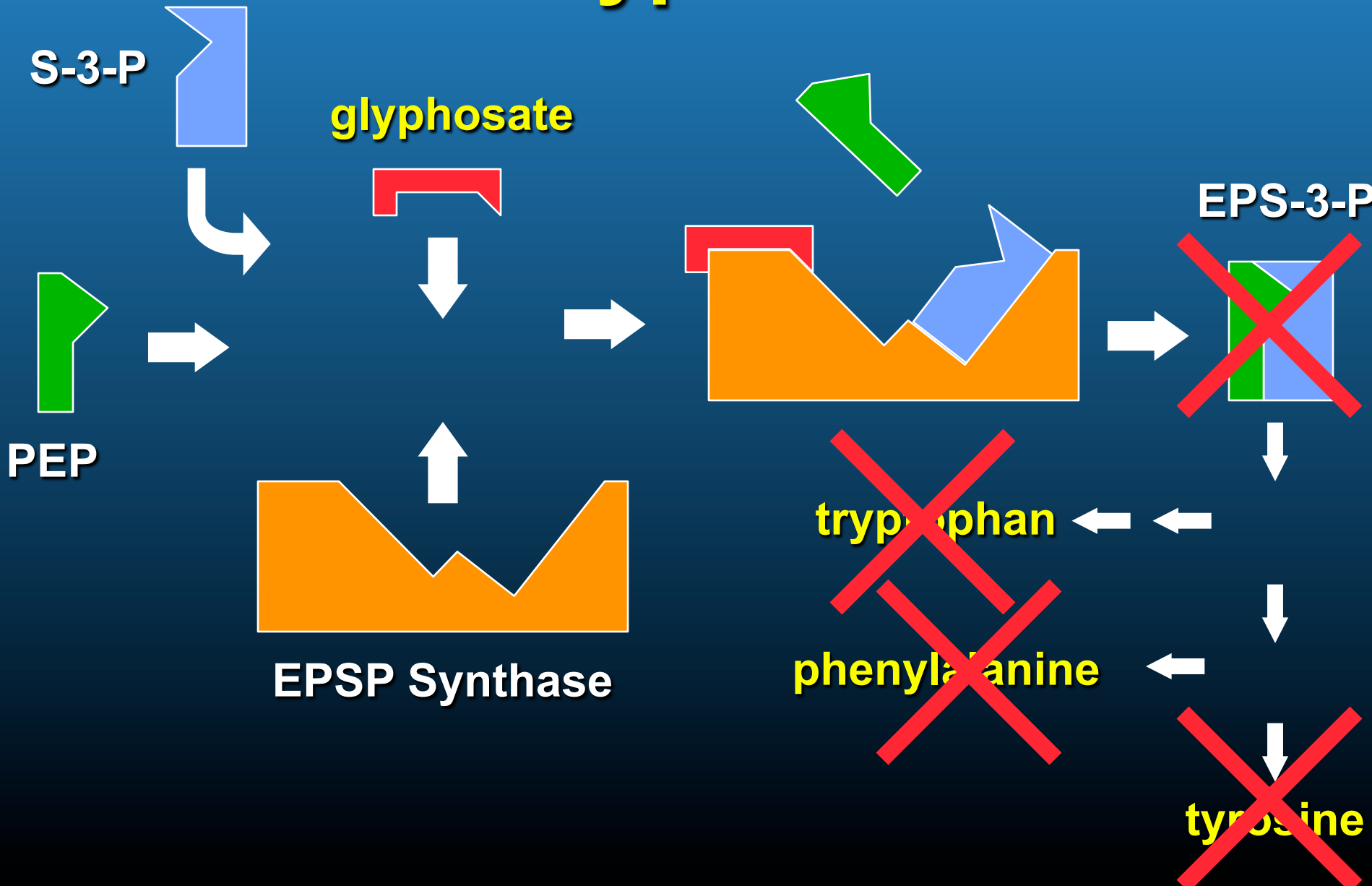
Amino Acid Synthesis Inhibitors

- The 20 amino acids are necessary for creating proteins-'protein alphabet'
- Proteins (500 to many thousand AA) are vital for all plant physiological functions
- Stop *ANY* amino acids > stop protein synthesis > stop growth

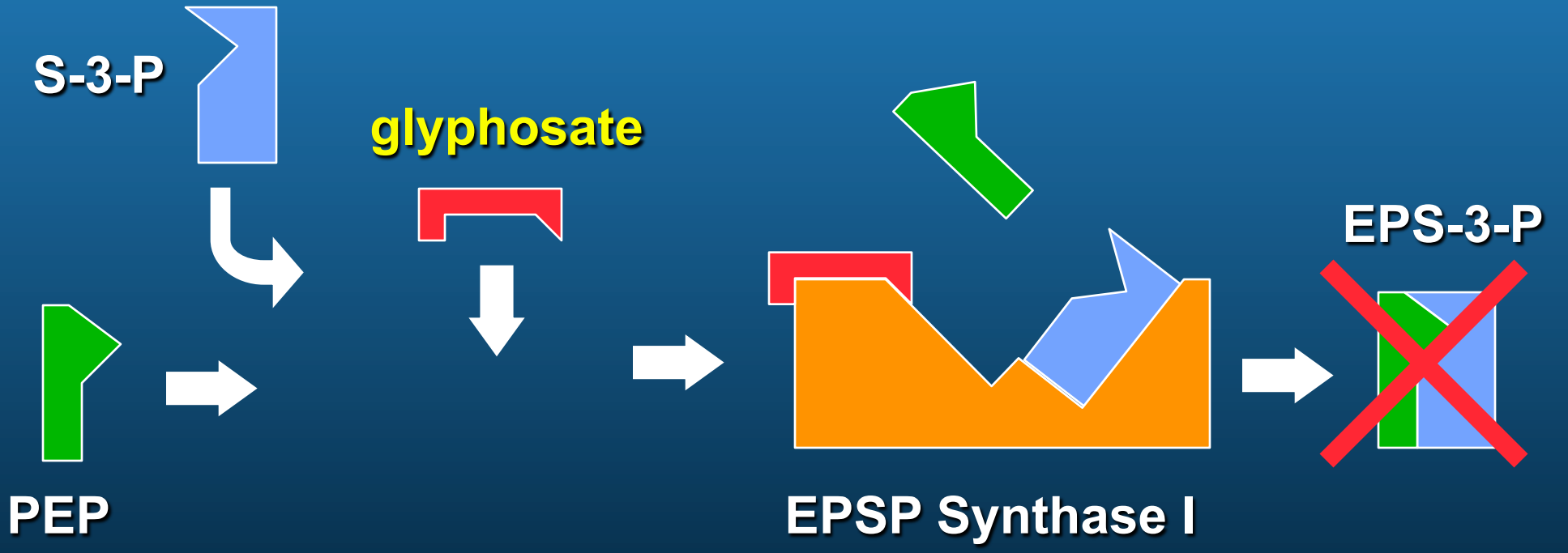
Glyphosate

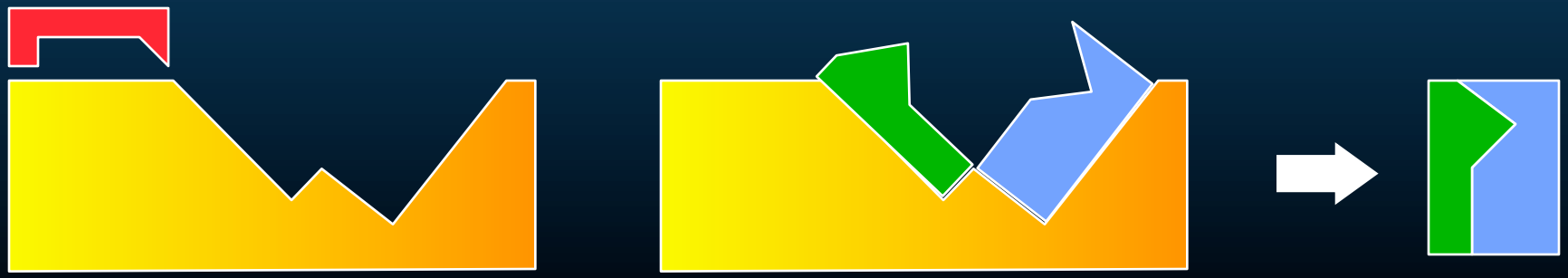

S-3-P
PEP
EPSP Synthase
EPS-3-P
tryptophan
phenylalanine
tyrosine

Glyphosate


S-3-P
glyphosate
PEP
EPS-3-P
EPSP Synthase
tryp phan
phenyla anine
tyr ine

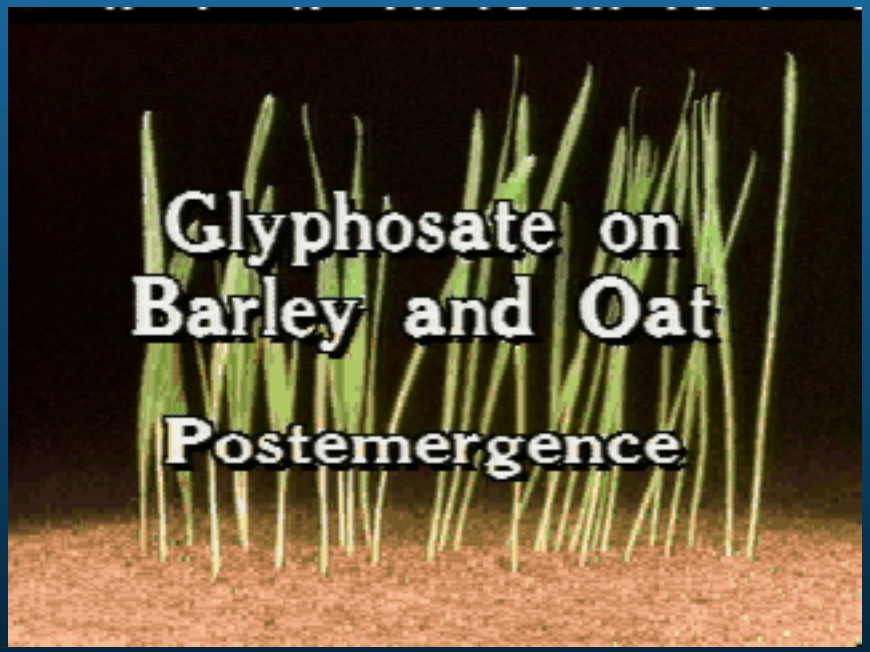
Glyphosate Resistance (RoundUp Ready®)





EPSP Synthase II (from bacteria - genetically inserted)

Glyphosate Symptoms



Escort, Oust, Arsenal

- Similar mechanism to glyphosate
  - Different enzyme - ALS
  - Prevents synthesis of amino acids valine, leucine, isoleucine
- Like glyphosate, slow acting

Escort, Oust, Arsenal

- Unlike ESPS Synthase, the ALS enzyme takes on different forms in different plant species, and even *within a plant species*
- Some forms of the ALS enzyme are not inhibited by these herbicides
- Herbicide resistance

Growth Regulator Herbicides

- 2,4-D
- Garlon
- Vanquish
- Method
- Milestone

Growth Regulator Herbicides

- Control broadleaf weeds, brush
- Do not injure grass
- Major component of PENNDOT 7713 program

Growth Regulator Herbicides

- Act like plant hormone *auxin*
- Plants are very sensitive to auxin in very small concentrations
- Herbicides (synthetic auxins) destroy the plants ability to regulate its growth

Growth Regulator Symptoms

- Stem curling and twisting
- Leaf cupping
- Tumor-like growths

Growth Regulator Symptoms

Growth Regulator Herbicides

- Are applied to foliage, but have varying degrees of soil activity
- Significant - picloram (Tordon), Vanquish, Method

Photosynthetic Inhibitors

- Older chemistry - 1950's, 1960's
- Absorbed by
  shoots
  roots after soil application
- Move with water stream - UPWARDS
- Karmex, Krovar I, Spike, Velpar DF

Photosynthetic Inhibitors

- Other examples - atrazine, simazine, Pramitol

Photsynthetic Inhibitors

- Bind to a receptor protein that receives high energy electrons from chlorophyll
- Prevents the transfer of electrons through the photosynthetic 'chain'

Photosynthetic Inhibitors

- Plant can no longer convert sunlight into chemical energy
- High energy electrons are still being captured by chlorophyll, and cause formation of free radicals, which result in destruction of cell membranes and cell death

Photosynthetic Inhibitors

Product	Soil Applied	Foliar Applied
Karmex DF	YES	YES
Krovar I	YES	YES
Spike	YES	YES
Velpar DF	YES	YES

Photosynthetic Inhibitors

Root Inhibitors

- Preemergence only
- Have to be in soil before seed germination
- Pendulum, Endurance, Preen, Treflan, Prowl, Pre-M
- Best effect is on grasses

Root Inhibitors

- Absorbed by root, prevent cell division
- Little to no movement within root
- Unable to form roots, seedlings usually die before they emerge

Root Inhibitor Symptoms

Summary

- Most applications are mixtures with different MOA
- Different routes of entry and sites of activity in the plant
- Mixtures increase activity on specific species
- Mixtures increase number of species controlled
- Using, and changing mixtures *prevents* selecting resistant species