

Herbicide Resistance: A Growing Issue for Hay Producers

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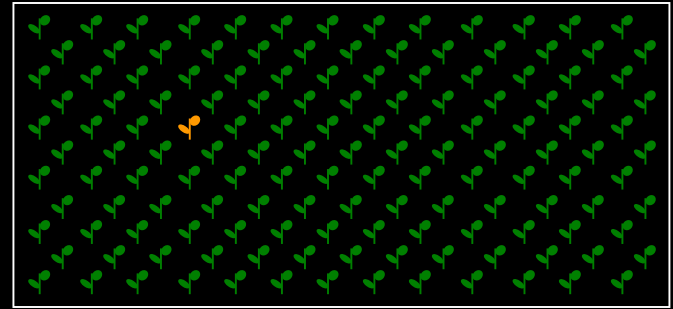
University of Georgia

Herbicide resistant weeds in Georgia hayfields

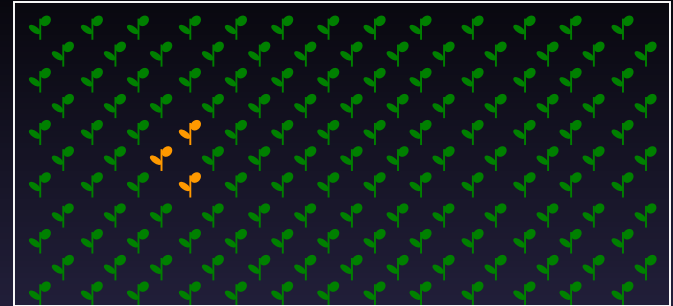
- **Reduced weed control efficacy**
- **Fields have reduced yield due to injury from alternative herbicides**
- **Drift of herbicide alternatives injuring neighbor crops**

Progression of Herbicide Resistance

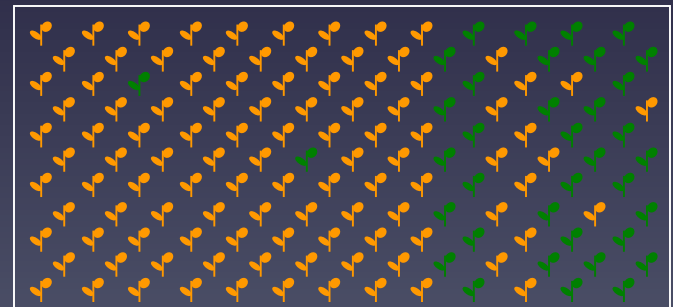
Year 1



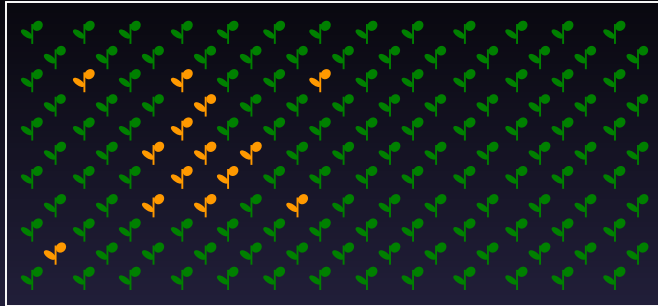
Year 2



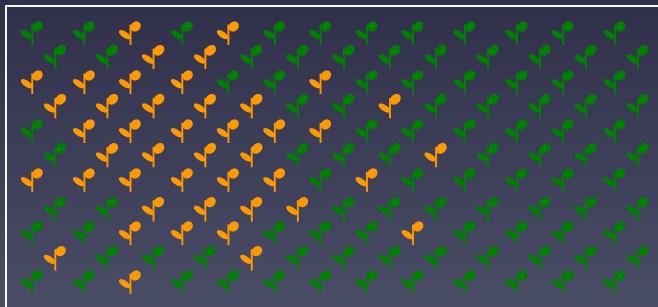
Year 5



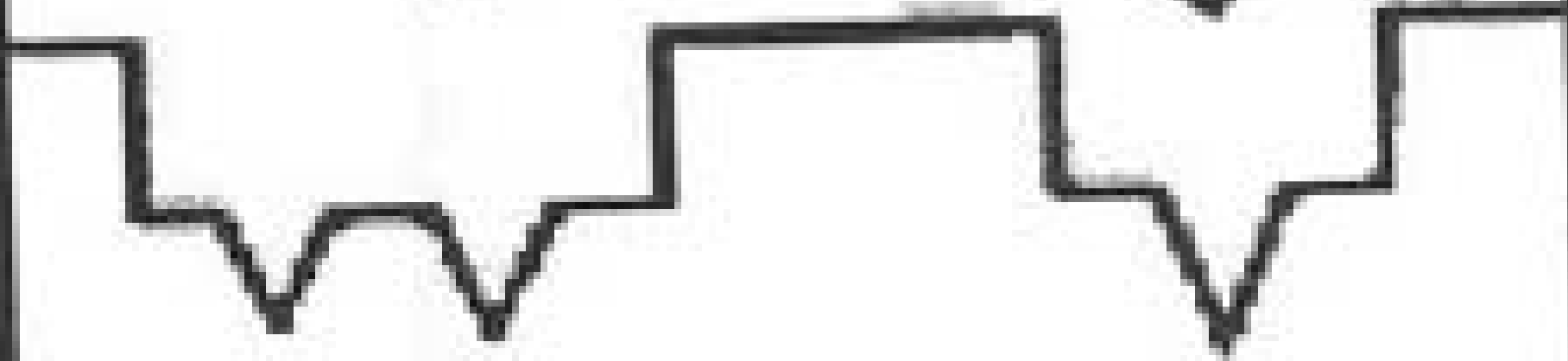
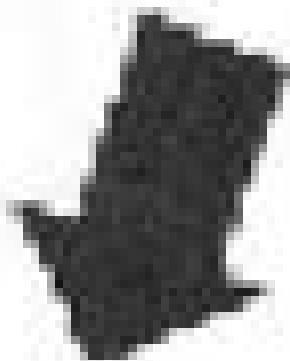
Year 3



Year 4

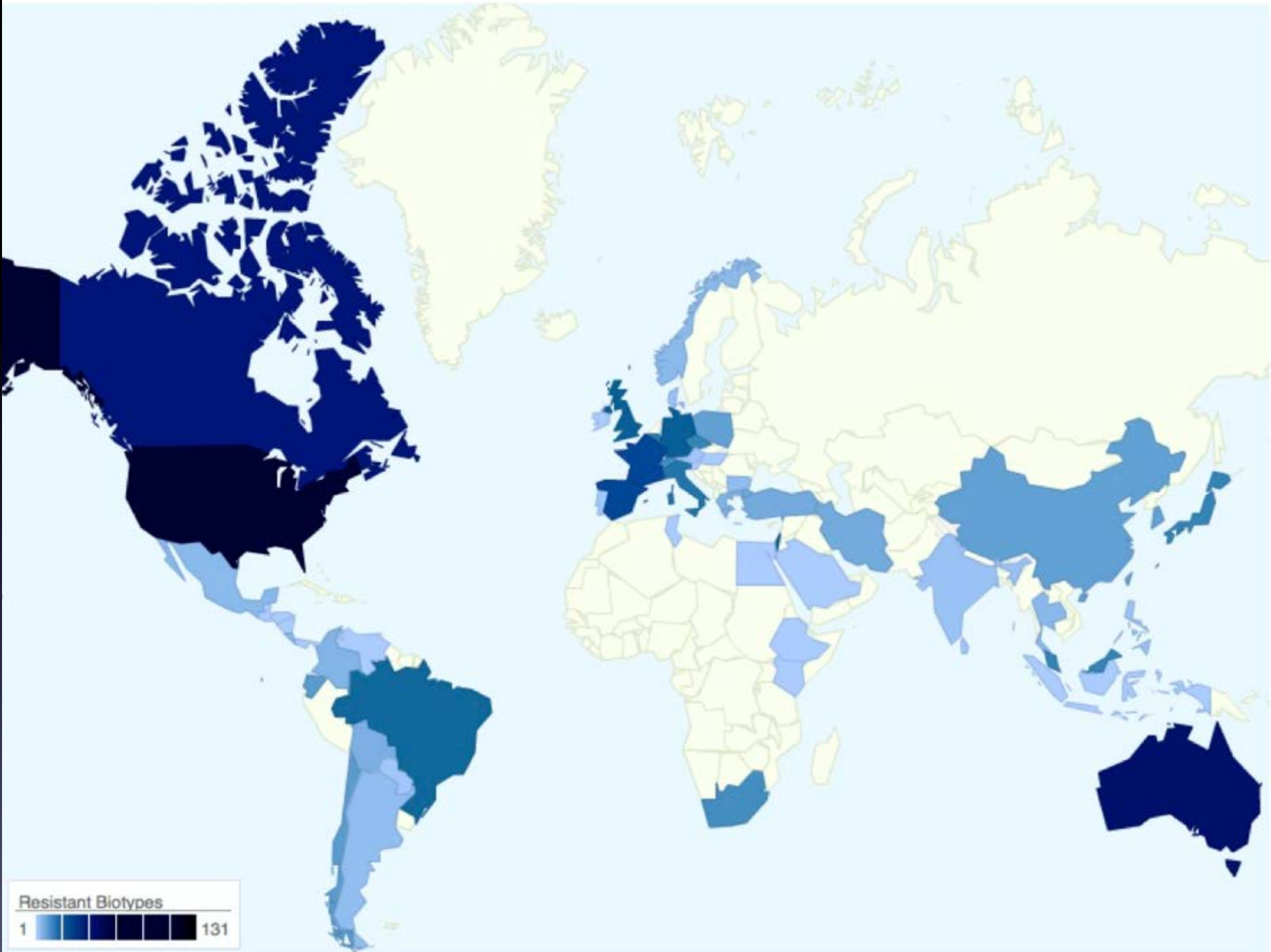


Herbicide

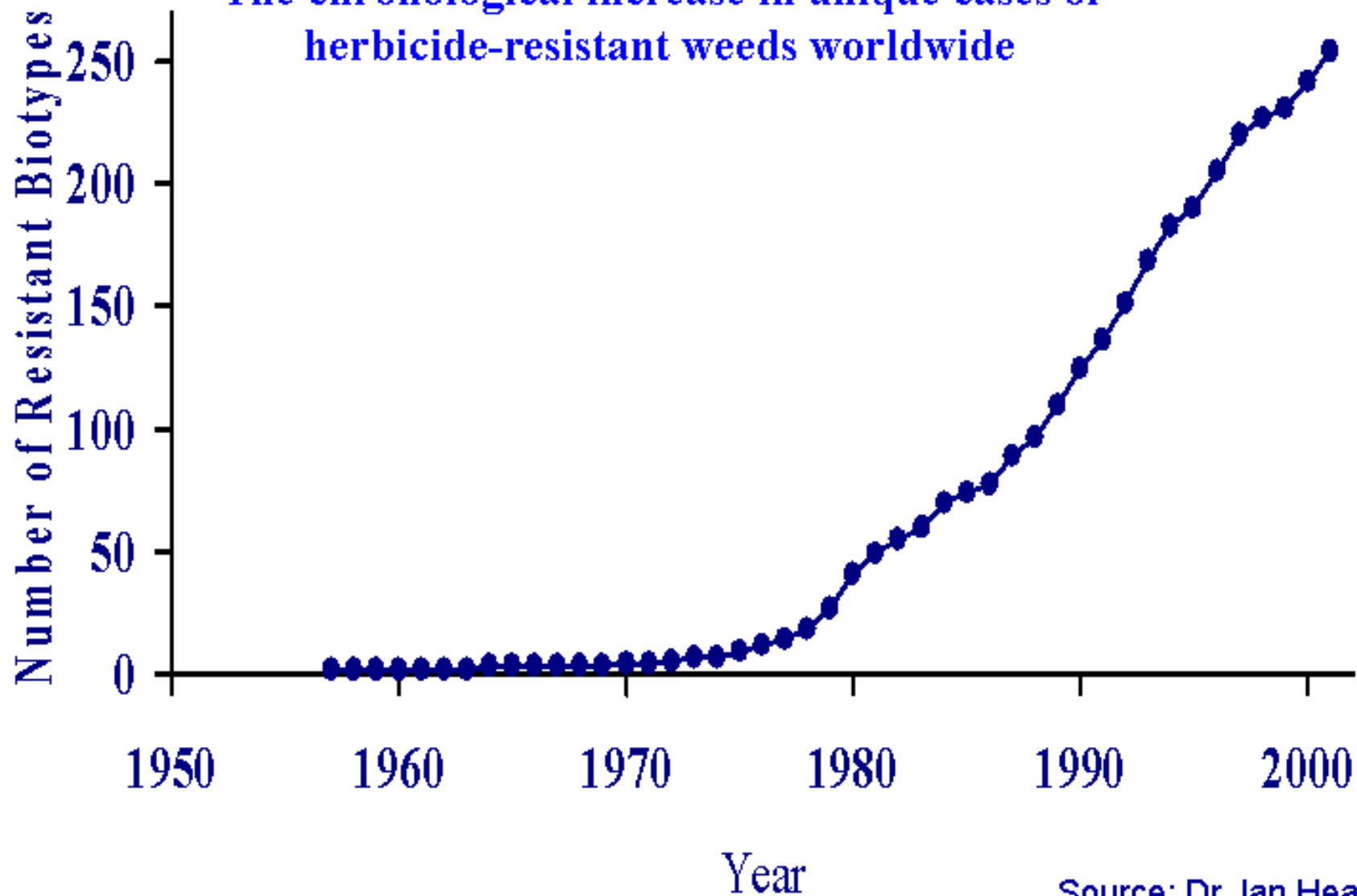


Why Are Plants Resistant to Herbicides?

- Altered site of action
- Overproduction of target site enzyme
- Enhanced metabolism
- Sequestration

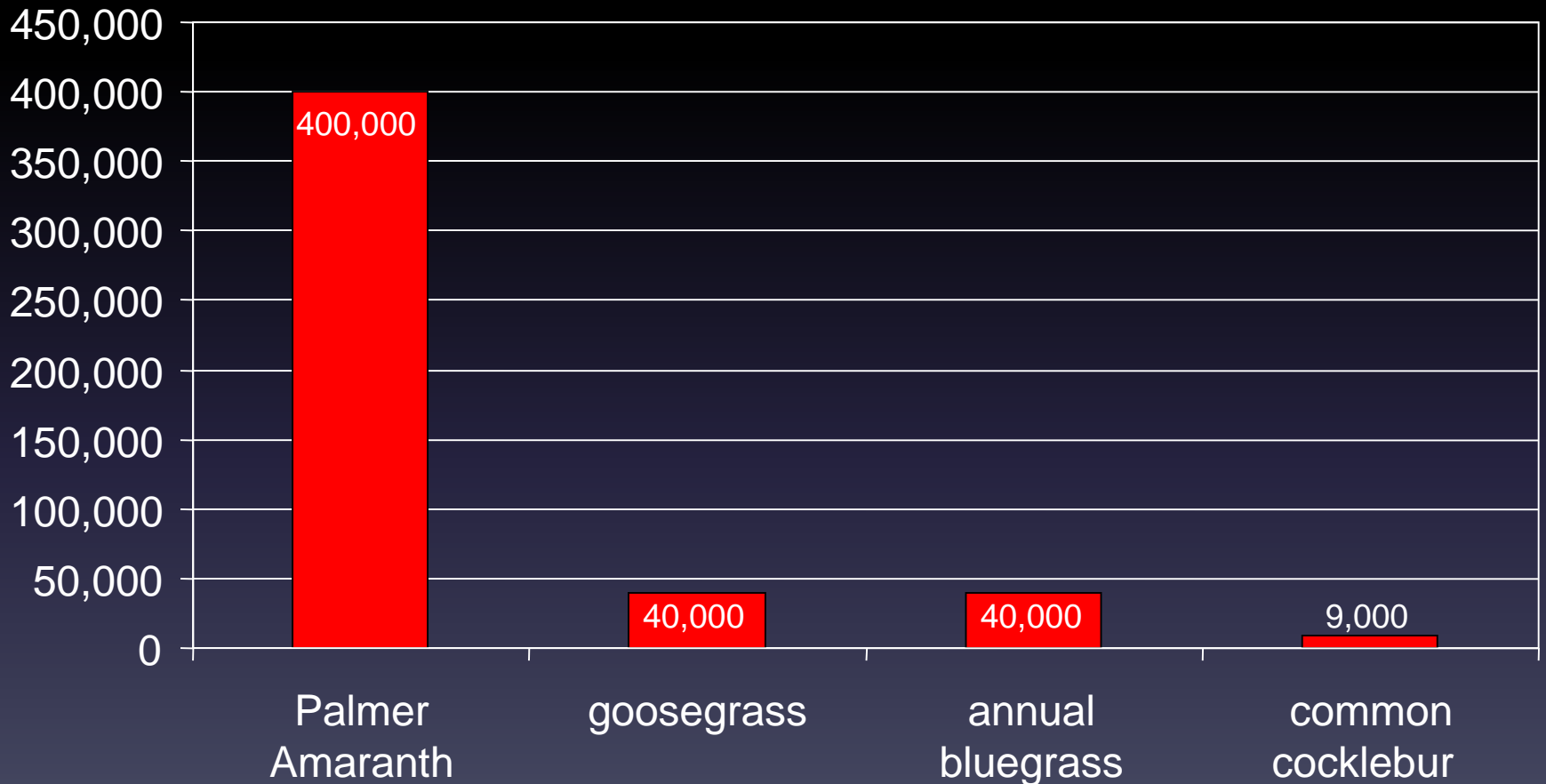


The chronological increase in unique cases of herbicide-resistant weeds worldwide



Source: Dr. Ian Heap
www.weedscience.com

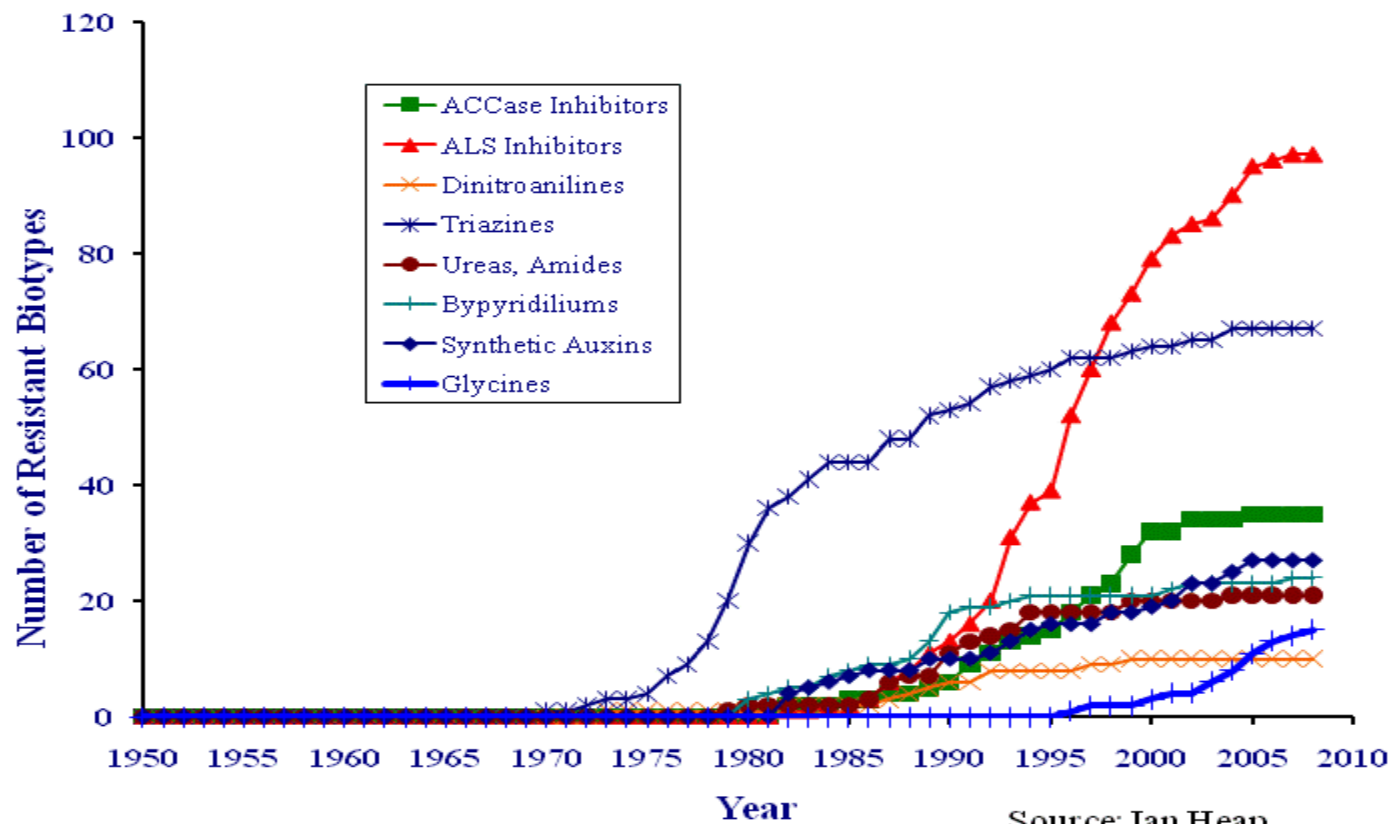
Average Number of Seed per Plant



peanut - 175; cotton - 250; corn - 800

Herbicide Resistant Weeds

By Mode of Action



Source: Ian Heap
<http://WeedScience.com>





Italian Ryegrass Control in Hayfields

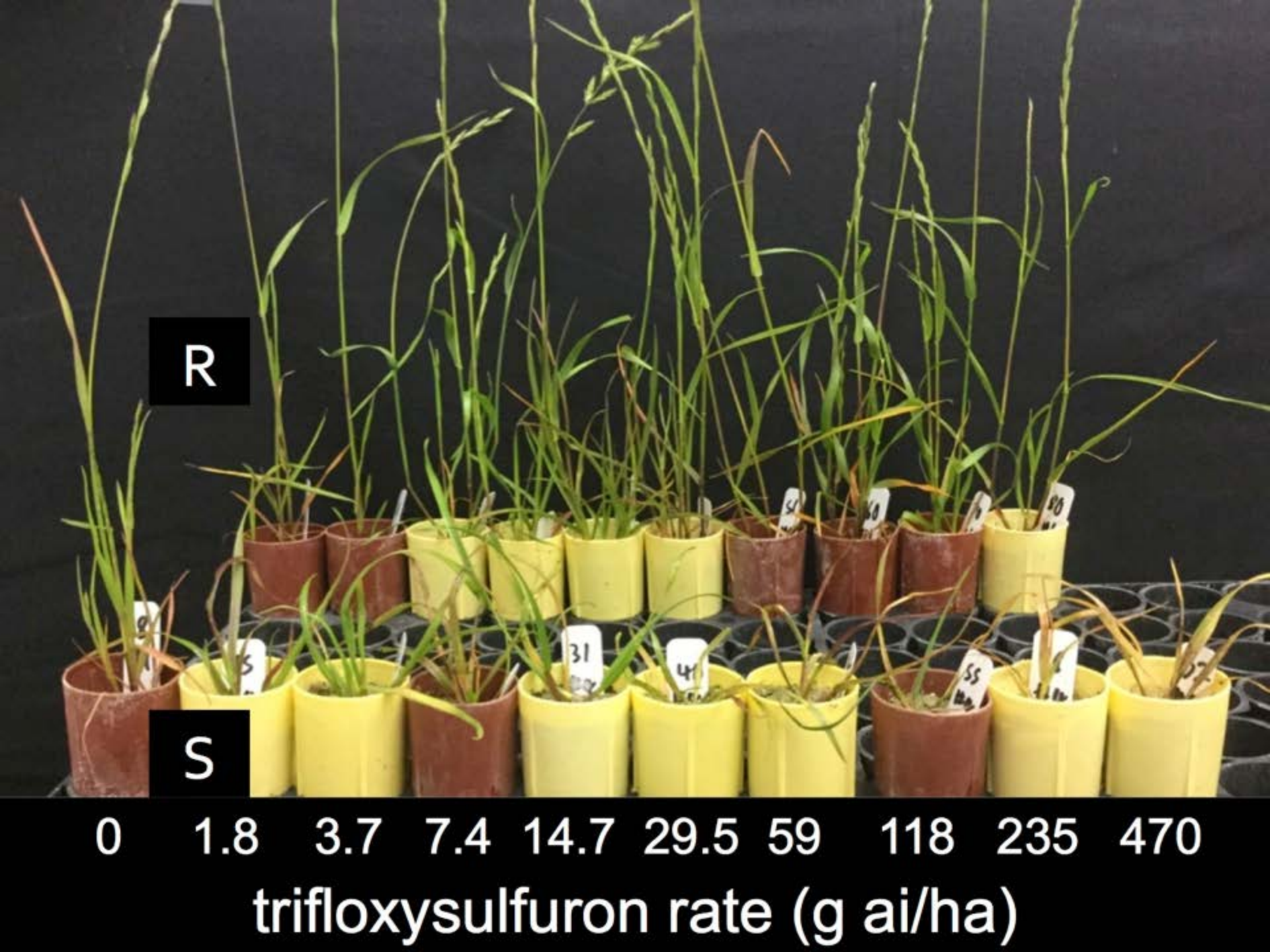
WSSA Group	Common Name	Trade Name
1	sethoxydim	Poast, others
2	metsulfuron	Cimarron
2	nicosulfuron + metsulfuron	Pastora
2	imazapic	Impose
9	glyphosate	various

R

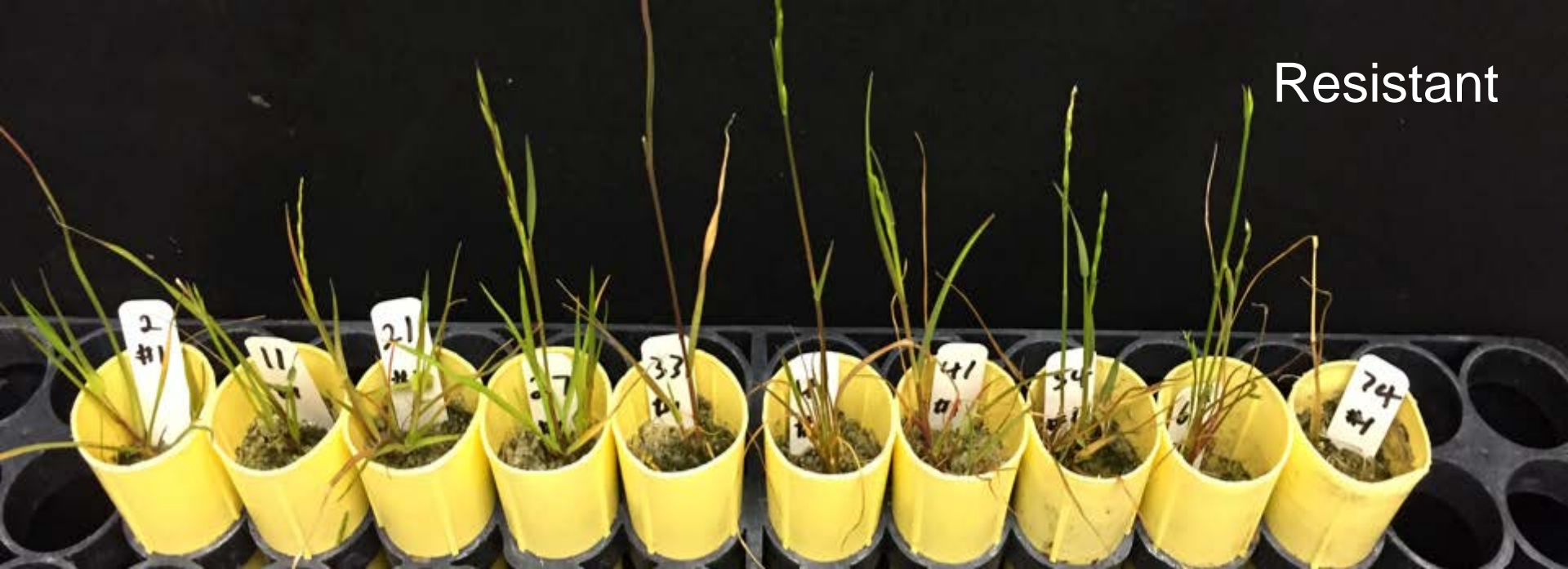
S

0 1.8 3.7 7.4 14.7 29.5 59 118 235 470

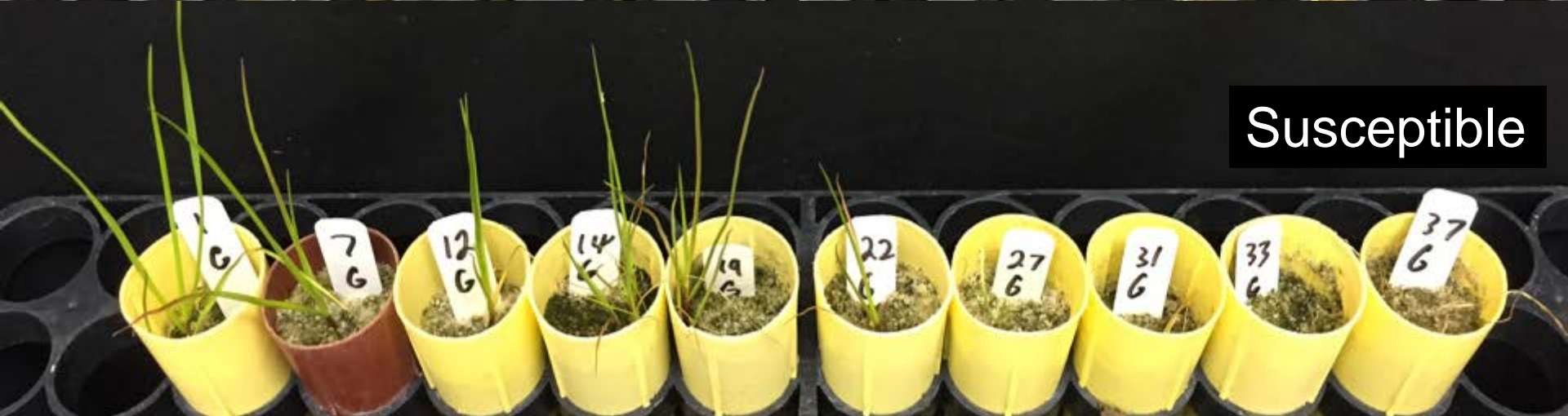
trifloxysulfuron rate (g ai/ha)



Resistant



Susceptible

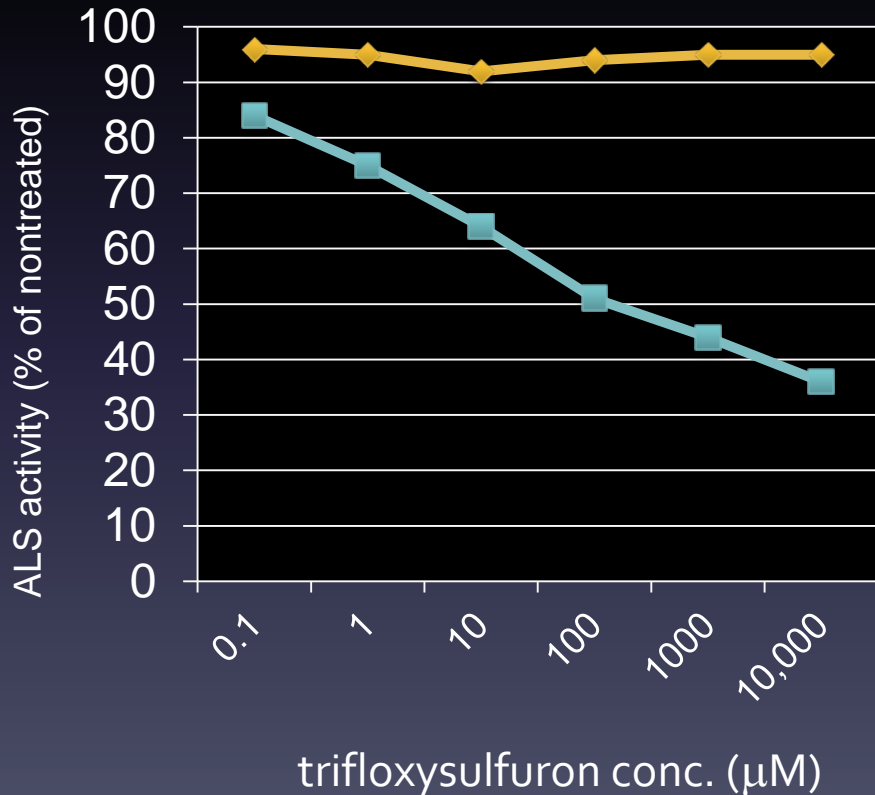


0 13 26 53 105 210 420 840 1680 3360
glyphosate (g ae ha⁻¹)

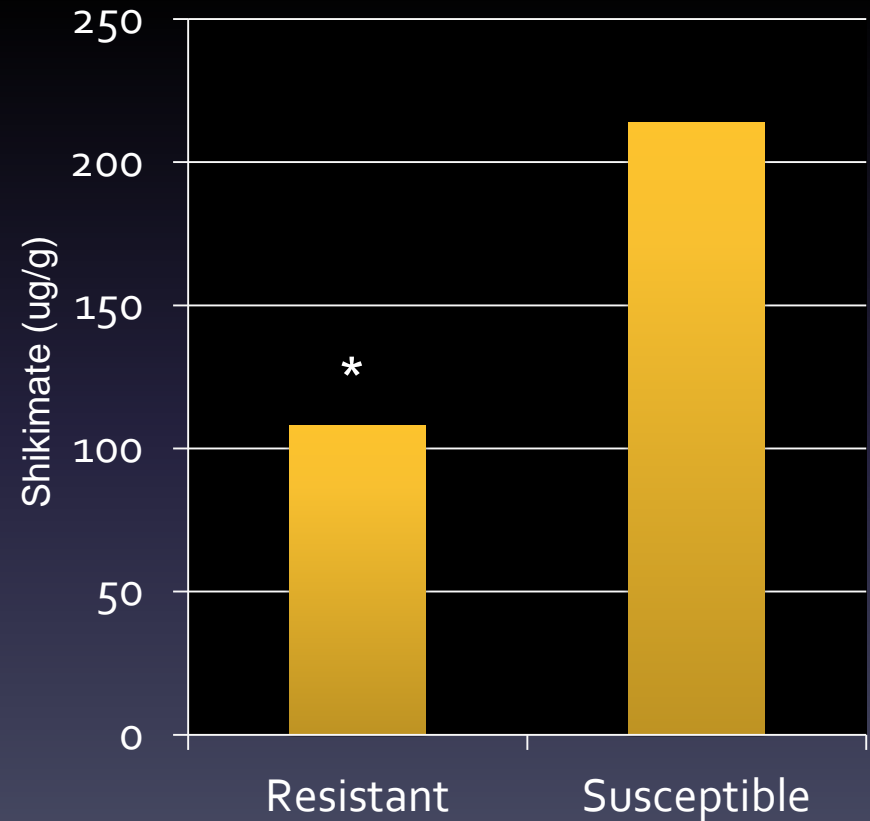
Basis for Ryegrass Resistance

ALS Inhibition

◆ Resistant ■ Susceptible



Shikimate assay (Glyphosate)



Ryegrass Resistance

- Resistant to:
 - Glyphosate, ALS inhibitors (Pastora, Impose)
- Mechanism
 - Target site susceptibility
- Alternatives
 - Sethoxydim
 - Prowl (PRE control)



Vaseygrass

Control in pastures:

Imazapic (Impose)

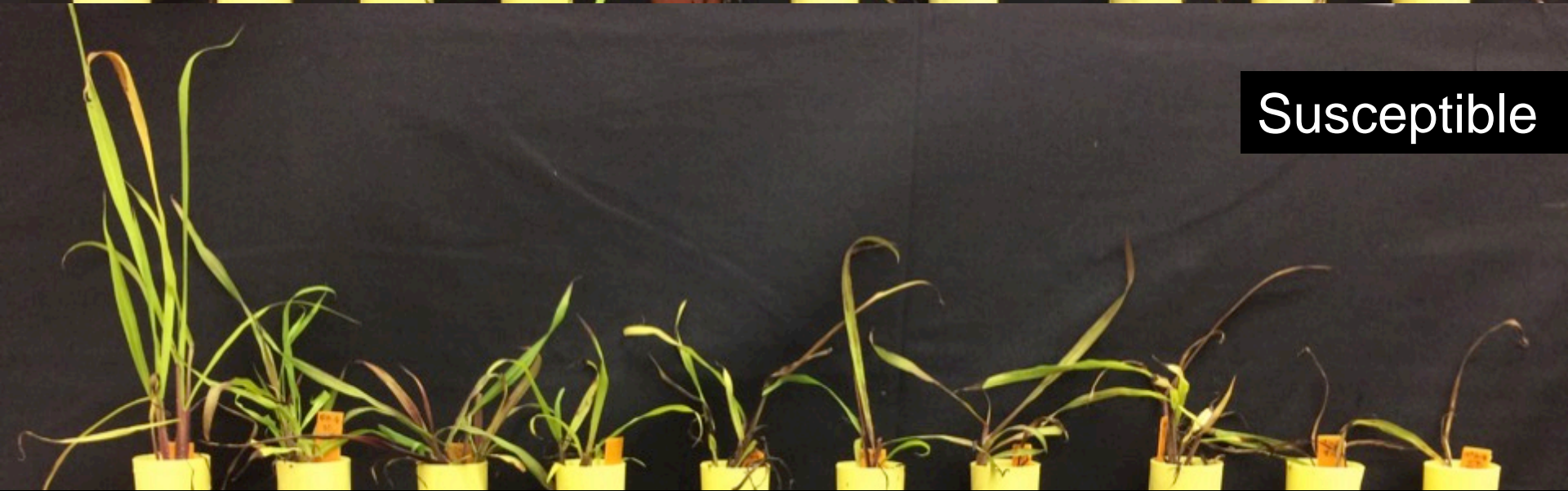
Pastora (nicosulfuron +
metsulfuron)

sethoxydim

Resistant



Susceptible



0 8.8 17.5 35 70 140 280 560 1120 2240
imazapic (g ae ha⁻¹)



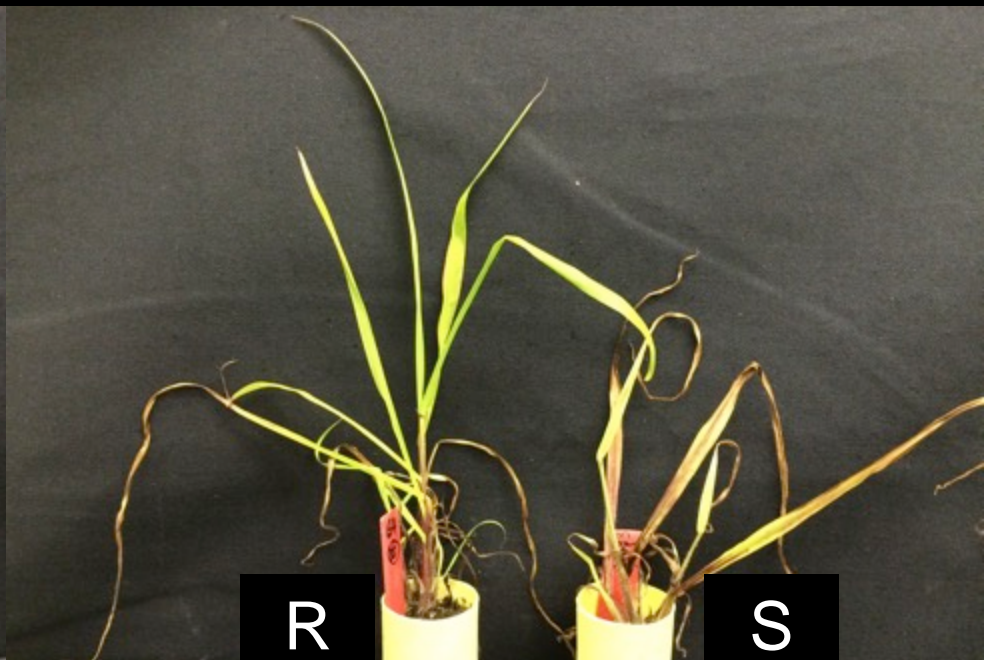
Nontreated



Impose (imazapic)



Oust (sulfometuron)



Accent (nicosulfuron)

Vaseygrass Control in Hayfields

WSSA Group	Common Name	Trade Name
1	sethoxydim	Poast, others
2	nicosulfuron + metsulfuron	Pastora
2	imazapic	Impose
9	glyphosate	various

ALS-Resistant Vaseygrass

- Resistance was greater than 80x of the susceptible biotype
- Target site inhibition
 - ALS enzyme activity was not inhibited
- Glyphosate or sethoxydim will control it





Cimarron at 0.25 oz/acre + NIS (1 WAT)



Resistant

Susceptible

Susceptible

4 WAT



Resistant



0 1.3 2.6 5.2 10.5 21 42 84 168 336

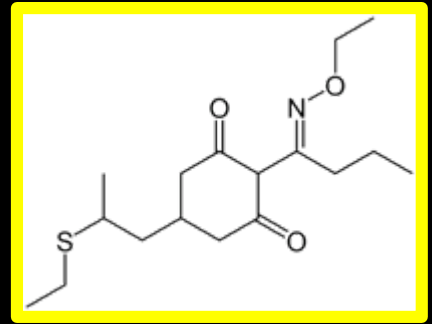
Metsulfuron-methyl Rate (g ai ha⁻¹)

Metsulfuron Resistant Spurge

- Gene mutation that confers resistance to all ALS inhibitors
- Alternatives to control
 - Dicamba, triclopyr, others

Sethoxydim Resistance in Crabgrass and Goosegrass

sethoxydim



- Characteristics
 - Trade names: Segment, Poast, others
 - Mechanism of action: ACCase inhibitor
- Postemergence control of grassy weeds
 - Crabgrass, goosegrass, crowfootgrass, bermudagrass, others
- Advantages for weed control in Georgia
 - Efficacy for selective weed control

Goosegrass (*Eleusine indica*)



Resistant



Susceptible



0 25 50 100 200 400 800 1600 3200 6400
diclofop-methyl (g ai ha⁻¹)

Resistant



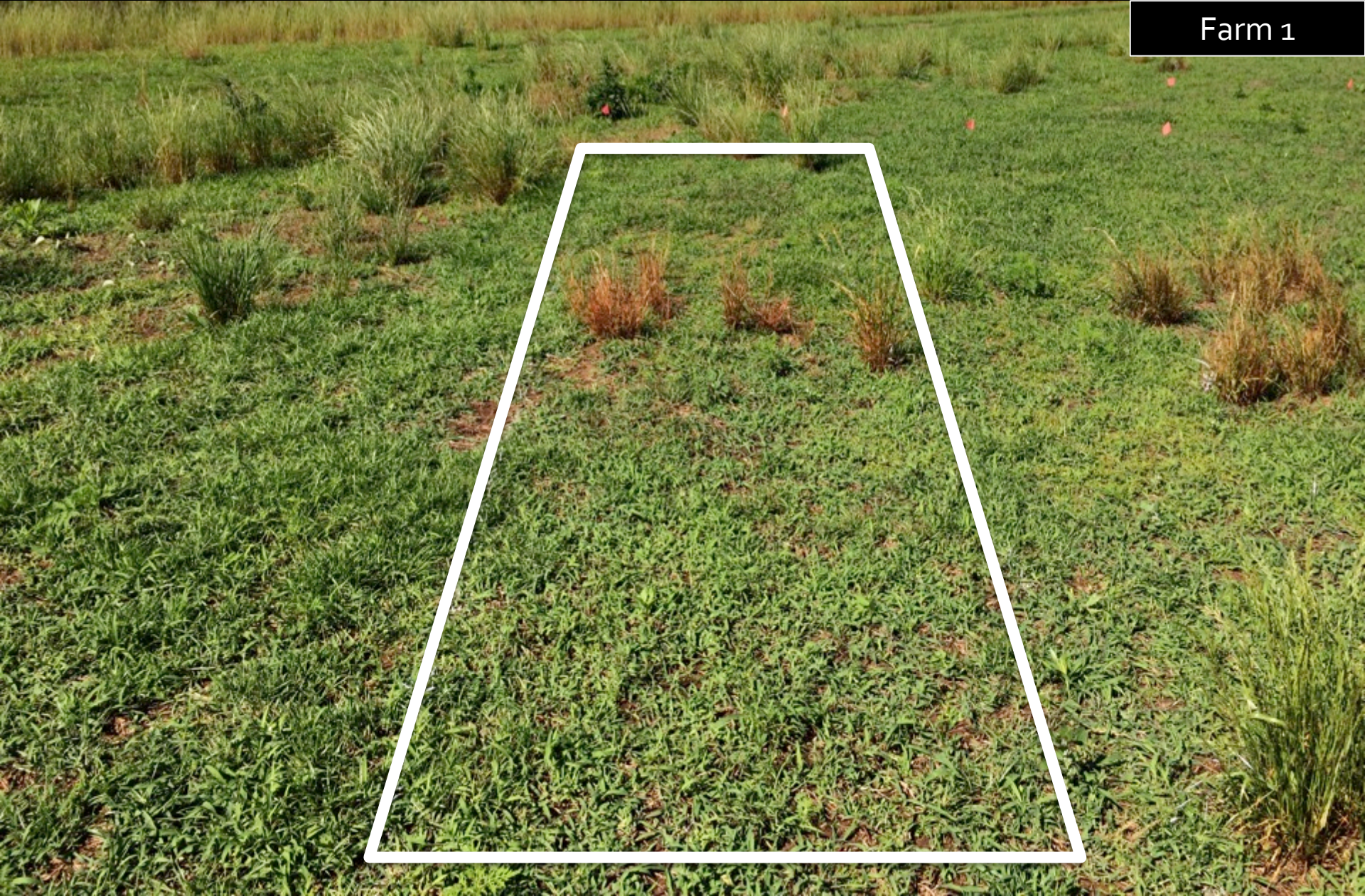
Susceptible



0 25 50 100 200 400 800 1600 3200 6400
sethoxydim (g ai ha⁻¹)

Segment 6.8 pt/acre (3x rate)

Farm 1



Segment 6.8 pt/acre (3x rate)

Farm 1





0 25 50 100 200 400 800 1600 3200 6400

Sethoxydim rate (g ai/ha)

Southern Crabgrass
R - Population 1



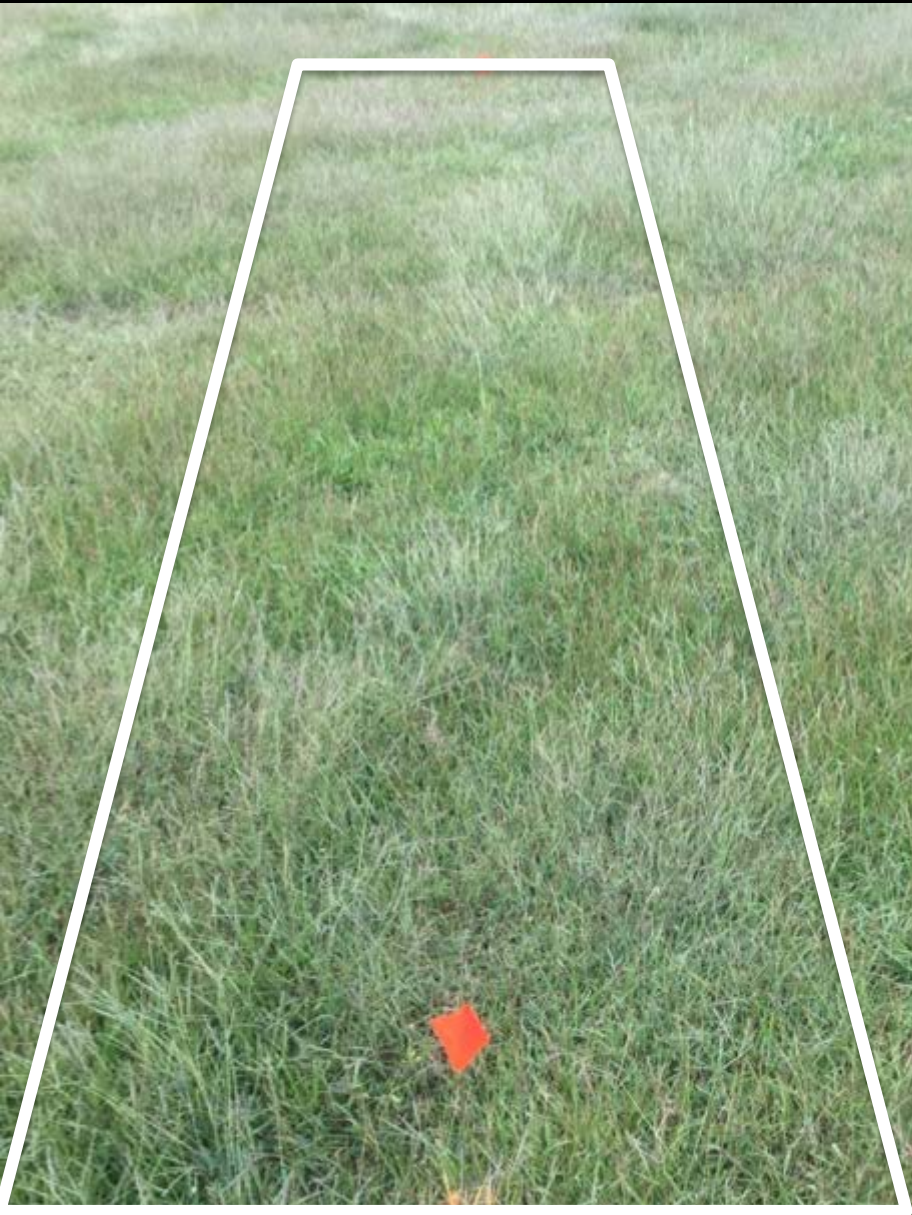
0 25 50 100 200 400 800 1600 3200 6400

Sethoxydim rate (g ai/ha)



Nontreated

Segment (sethoxydim) 2.3 pt/acre



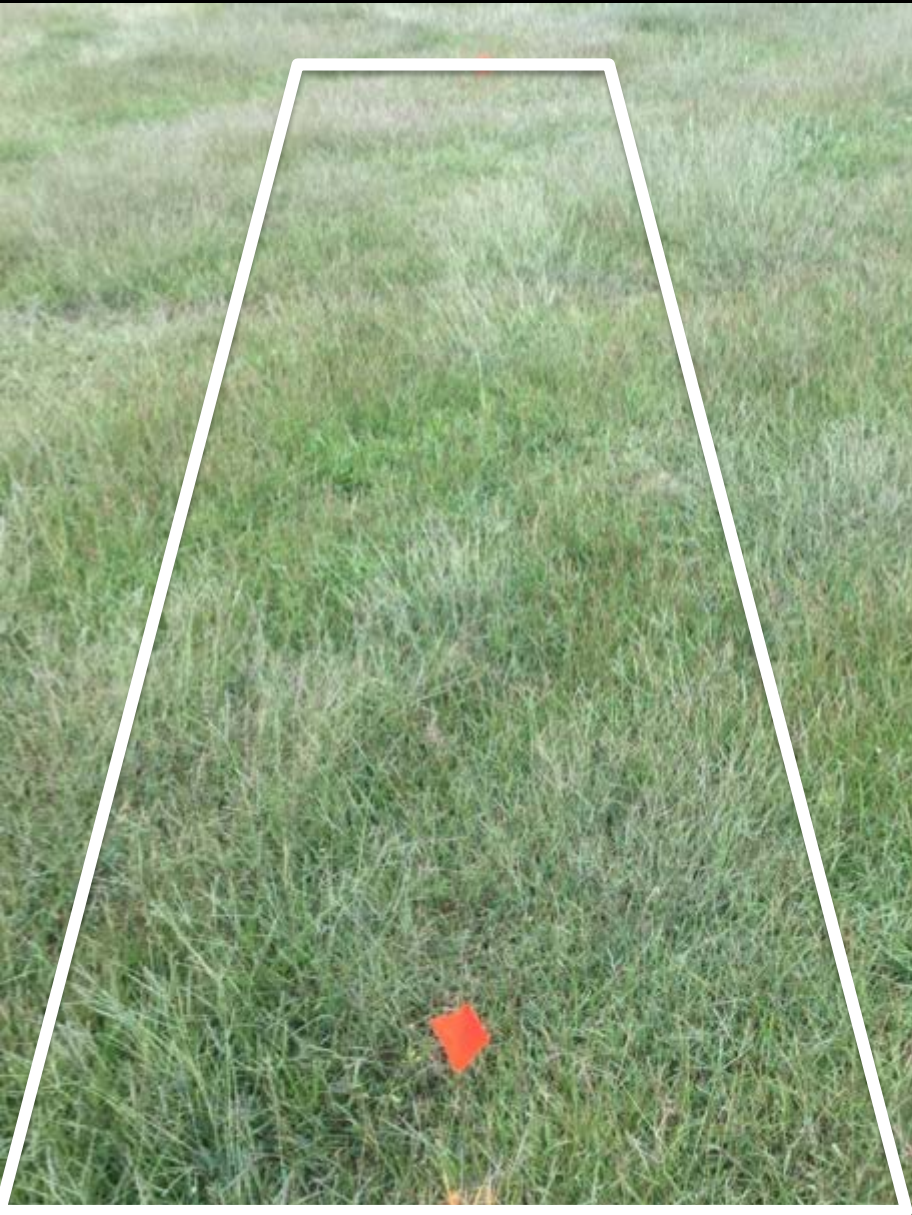
Nontreated

Segment (sethoxydim) 7 pt/acre



Nontreated

Envoy (clethodim) 32 oz/acre



Sethoxydim Resistant Goosegrass



Sethoxydim Resistant Goosegrass



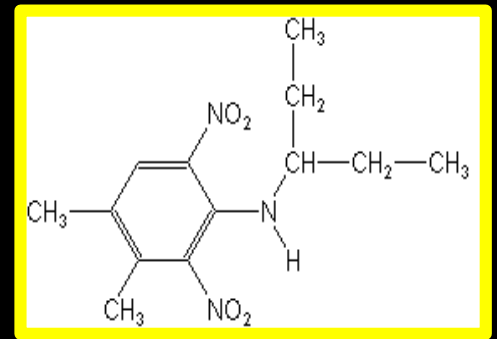
Sethoxydim Resistant Crabgrass



Crabgrass and Goosegrass Control in Hayfields

WSSA Group	Common Name	Trade Name
1	clethodim	Select
	sethoxydim	Poast, others
2	nicosulfuron + metsulfuron	Pastora
	imazapic	Impose
9	glyphosate	various

pendimethalin



- Trade Name: Prowl H₂O (3.8SL)
 - Family: Dinitroaniline
 - Mode of action: Mitosis inhibition
- Applications: 1.1 to 4.2 qt/acre
- Maximum Use: 4.2 qt/acre per year
- Use in perennial grass pastures



DNA Herbicide Injury



prodiamine (Barricade)

0

1 μM

100 μM





1 μ M
3 weeks after treatment

prodiamine (Barricade)

0

1 μM

100 μM

0

1 μM

100 μM



Goosegrass

Resistant

Susceptible

Resistant

Susceptible



Nontreated

Dithiopyr 1 μ M

Implications for Hayfields

- Bermudagrass, bahiagrass, and alfalfa
 - Prowl H₂O is the only PRE herbicide labeled
 - Exclusive use will lead to selection pressure for resistant biotypes
- Other pasture species
 - No PRE herbicides available

ALS-Resistant Sedge

- Populations identified in 2014
 - Sedges were not controlled after a Sedgehammer (halosulfuron) application
 - History of exclusive halosulfuron use for over 15 years
- Halosulfuron (Sedgehammer, Sandea, Proledge, others)
 - Widely used in turf and ornamentals for sedge control
 - Resistance had not been reported in turfgrass systems

Annual sedge
(*Cyperus compressus*)



8 WAT

R

S

0 4.4 8.8 17.5 35 70 140 280 560 1120

Halosulfuron-methyl Rate (g a.i./ha)

Photo: J. Yu, UGA



Gene Sequencing for the ALS Enzyme (McElroy, Auburn University)

Pro-197



Arabidopsis	CAAGTCCCTCGT CGTATGATTGGTACAGATGCGTTTCAAGAGACTCCGATTGTTGAGGTA
Translation ORF/CDS	Q V P R R M I G T D A F Q E T P I V E V
Susceptible	CAGGTCCCCCGT CGCATGATCGGGCACTGATGCCTTCCAAGAGACACCAATTGTTGAAGTG
Translation ORF/CDS	Q V P R R M I G T D A F Q E T P I V E V
Resistant	CAGGTCTCCCCG TGCGCATGATCGGGCACTGATGCCTTCCAAGAGACACCAATTGTTGAAGTG
Translation ORF/CDS	Q V S R R M I G T D A F Q E T P I V E V



Sedgehammer (halosulfuron) at 1.3 oz/acre



Sedgehammer (halosulfuron) at 1.3 oz/acre

ALS-Resistant Annual Sedge Control



Sedgehammer 1.3 oz/acre +NIS



Outrider 1.3 oz/acre + NIS

ALS-Resistant Annual Sedge Control



Dismiss 12 oz/acre + NIS

Basagran 2 pt/acre + NIS

Herbicides for Sedge Control in Hayfield

WSSA Group	Common Name	Trade Name
2	imazapic	Impose
	halosulfuron	Sandea
	sulfosulfuron	Outrider
9	glyphosate	various

2,4-D failures











2,4-D Resistance

- First case from turf confirmed in Indiana
 - Buckhorn plantain (Patton et al. 2017)
 - Cemetery treated with 2,4-D exclusively
- Suspect plantain resistance
 - Segregation in your population
 - Need higher 2,4-D rates to control
 - Rule out other causes of failure

Herbicide Resistance Should Only Be Suspected When

- The same herbicide or herbicides with the same mode of action have been used year after year.
- One weed normally controlled is not
- Healthy weeds are mixed with controlled weeds (same species)
- Patches of uncontrolled weeds are spreading.

Causes of herbicide failure are ruled out

Causes of Herbicide Failures

- weed size**
- moisture
- temperature
- humidity
- rate
- application method
- calibration
- others

All possible reasons for poor performance should be investigated before considering the possibility of resistance!!!

Herbicide Resistance

Managing Herbicide Resistance

- Rotate herbicides from year to year
- Rotate herbicides with different mode-of-action.

Questions