

Herbicide resistance, what are we doing and what can you do?

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What is resistance?

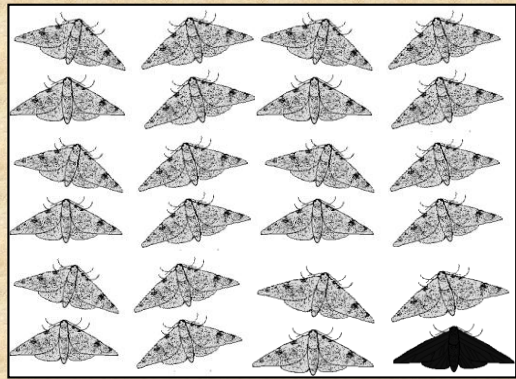
The naturally occurring inheritable ability of some weed biotypes within a given weed population to survive a herbicide treatment that would under normal use conditions effectively control that weed population.

Tolerance? Susceptibility?

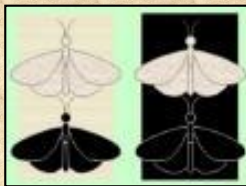
Selection pressure, Population dynamics/frequency



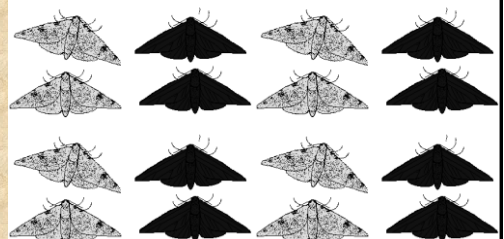
Biston betularius pepper moth



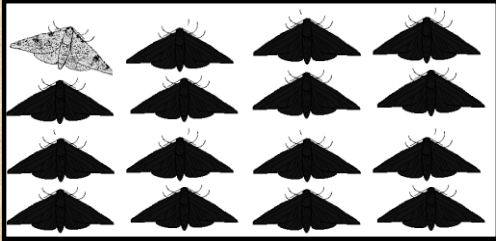
Industrial Revolution



Selection Pressure



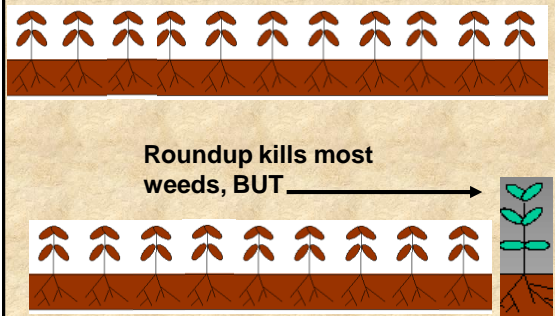
Change in moth color resulting from selection pressure



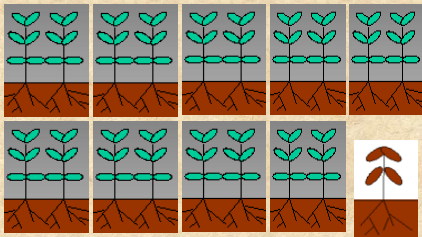
So what? Who cares about moths anyway?



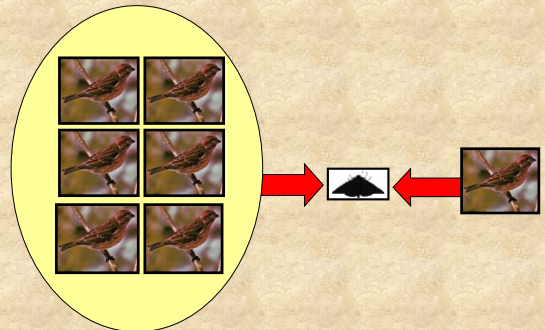
Selection pressure, Population dynamics/frequency



Resistance problem



Which would go faster?



Importance of Resistance

- Resistance to most all herbicide families has been documented.
- Preventing or extending the time for development is an important management decision.
- Resistance prevention may not be the most inexpensive option.
- Sustaining inexpensive chemistries as long as possible is important.

Resistance Mechanisms

- Uptake
- Translocation
- Metabolism
- Site-of-Action
- Increased production of target enzyme

Uptake

- How the herbicide enters a plant.
- Resistance
 - Leaf hairs
 - Prevent herbicide from contacting leaf surface.
 - Waxes
 - Prevent herbicides from penetrating leaf surface

Translocation

- How a herbicide moves within a plant.
 - Xylem (from roots to leaves) (water conduit)
 - Phloem (from leaves to roots) (photosynthate conduit)
- Resistance
 - Failure to contact adequately with herbicide.
 - Retention in translocation stream.

Metabolism

- How plants alter compounds within cells.
- Resistance
 - Chemical detoxification
 - Some biotypes within a species metabolize compounds more readily.
 - ACCase herbicides
 - Enhanced ability of resistant biotypes to detoxify herbicide

Site-of Action

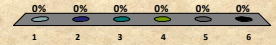
- Specifically where a herbicide binds and acts within a process.
- Resistance
 - Triazine herbicides
 - Alteration of binding site within the chloroplast
 - ALS herbicides
 - Altered from of enzyme that no longer binds with herbicide

Target Enzyme Production

- Specific enzymatic process
- Resistance
 - Glycine herbicides
 - Increased enzyme production overcomes herbicide effects

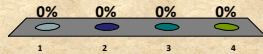
How many herbicide resistant biotypes are there world wide?

1. 50
2. 100
3. 200
4. 250
5. 350
6. 370



How many resistant biotypes are in the US?

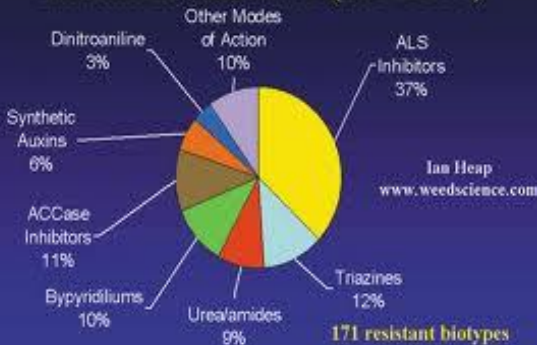
1. 25
2. >25
3. >50
4. >100



History of Herbicide Resistance

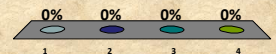
- To date 370 resistant biotypes (200 species) (115 dicots and 85 monocots).
- 139 of these are in the US.
- Resistance results from the selection with in a population that has a naturally occurring tolerance.
- Resistance to glyphosate, triazine and ALS inhibiting herbicide families is a wide spread problem in Colorado Agriculture.

Herbicide-Resistant Weeds (1984 to 1999)

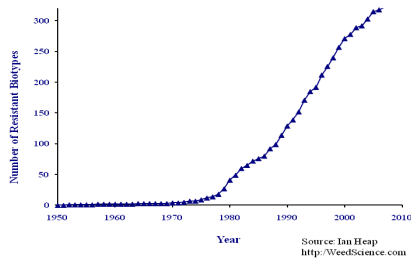


Approximately what year was resistance first confirmed?

1. 1960
2. 1975
3. 1980
4. 1998



Occurrence of Resistance



Types of Resistance

- Cross resistance
 - A particular weed is not controlled by different herbicides with similar modes of action.
 - Kochia resistance to sulfonylurea and imidazolinone herbicides (ALS inhibiting).
- Multiple resistance
 - A particular weed is not controlled by different herbicides with completely different modes of action.
 - Kochia resistance to triazine and ALS inhibiting herbicides.

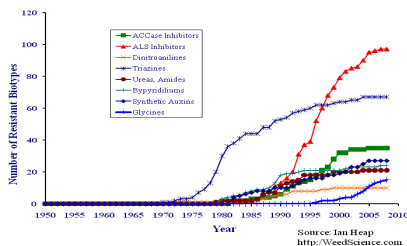
Most Important Herbicide-Resistant Species

- | | |
|-------------------------|-------------------------------|
| 1. Rigid Ryegrass | <i>Lolium rigidum</i> |
| 2. Wild Oat | <i>Avena fatua</i> |
| 3. Redroot Pigweed | <i>Amaranthus retroflexus</i> |
| 4. Common Lambsquarters | <i>Chenopodium album</i> |
| 5. Green Foxtail | <i>Setaria viridis</i> |
| 6. Barnyardgrass | <i>Echinochloa crus-galli</i> |
| 7. Goosegrass | <i>Eleusine indica</i> |
| 8. Kochia | <i>Kochia scoparia</i> |
| 9. Horseweed | <i>Conyza canadensis</i> |
| 10. Smooth Pigweed | <i>Amaranthus hybridus</i> |

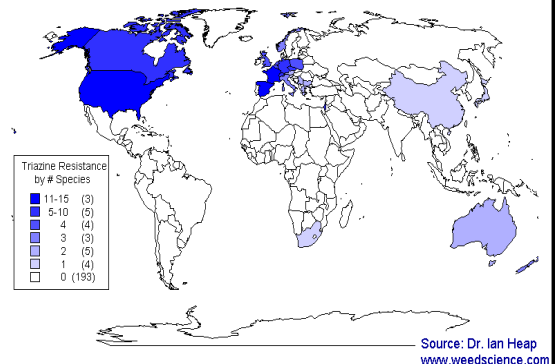
Resistance

- What makes these species resistant?
 - Wide distribution
 - Diverse genetic background
 - A requirement for cross-pollination
 - High selection pressure

Resistance by herbicide family

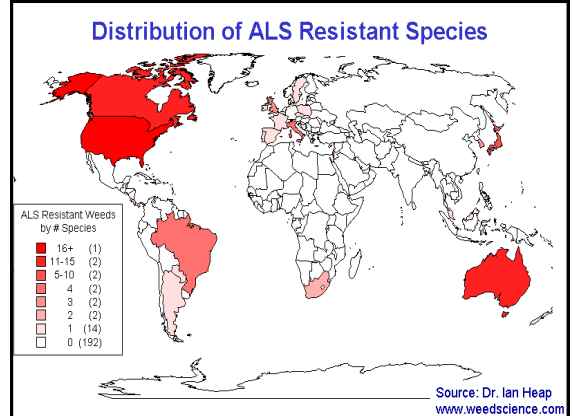


Distribution of Triazine Resistant Species



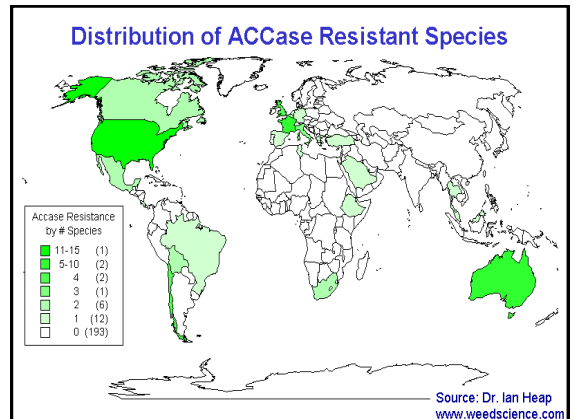
Triazine Resistance

- First Identified
 - 1970's in the United States
 - Common groundsel
 - Pigweed spp.
 - Lambsquarters
 - Wild mustards
 - 1982 in Colorado
 - Stratton
 - Pigweed
 - Kochia



ALS Resistance

- First Discovered
 - 1987 in the United States
 - Prickly lettuce
 - Kochia
 - About the same time in Colorado
 - 2001 greater than 50% of kochia in Colorado was resistant to ALS herbicides.

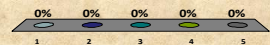


ACCase Resistance

- First discovered
 - 1991 in the United States (Wisconsin)
 - Giant foxtail
 - Large crabgrass
 - Has been observed in Colorado.

How many years passed before resistance to ALS herbicides was confirmed?

1. 12
2. 9
3. 5
4. 3
5. 2



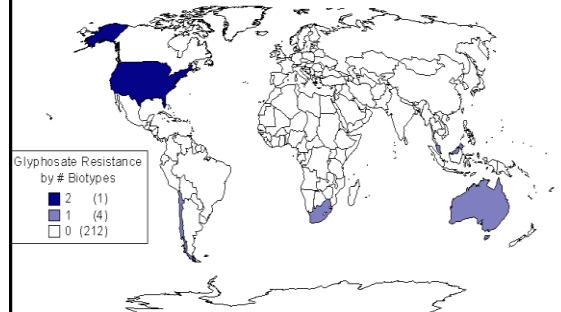
How many applications of ALS herbicides are required before resistance may occur?

1. 10
2. 7
3. 5
4. 3
5. 2

0%

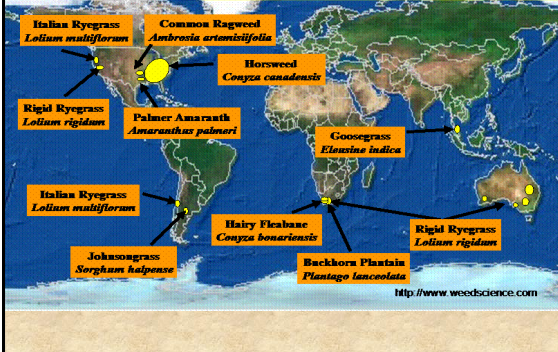
0 1 2 3 4 5

Distribution of Glyphosate Resistant Species

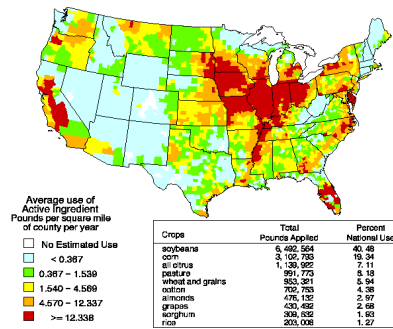


Source: Dr. Ian Heap
www.weedscience.com

Glyphosate Resistant Weeds – September 2006



GLYPHOSATE ESTIMATED ANNUAL AGRICULTURAL USE



Glyphosate Resistance

- First observed
 - 1996 (Australia)
 - Rigid ryegrass
 - 2000 (United States) (Deleware)
 - Horseweed
 - Confirmed in Colorado 2011.

What we are faced with....

- Repeat glyphosate applications
 - Chem fallow, multiple applications (3-6)
 - Pre-plant burndown
 - 3 weeks after planting (early season)
 - (5-6) weeks after planting (mid season)
 - Reduced rate applications.

↑ Selection pressure for resistant biotypes

Resistance Confirmation

- Has a herbicide with the same mode of action been used in the same field or in the same general area for several years?
- Has the uncontrolled species been successfully controlled in the past by the herbicide in question?
- Is the weather overly hot or dry?

Resistance Confirmation

- Has a decline in control been noticed in recent years?
- Are there known cases of resistant weeds in adjacent fields, farms, or roadsides?
- Is the level of control generally good on other susceptible species except for the ones not controlled?

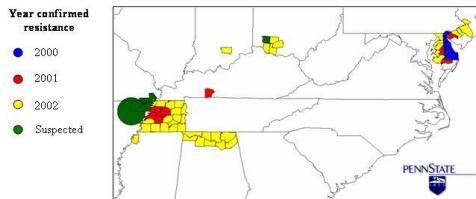
Examples of glyphosate resistance

- **Italian ryegrass** in Chilean orchards. Perez and Kogan, **2002**. Weed Research. (3 times per year for 8-10 years; 5-6 fold resistance).
- **Rigid ryegrass** in Australian orchards. Powles et al. **1998**. Weed Science. (2-3 times per year for 15 years; 7-11 fold resistance).

Examples of glyphosate resistance

- **Horseweed** in continuous RR soybean in Delaware. VanGessel, 2002. Weed Science. (3 times per year for 3 years; 8-13 fold resistance).

Glyphosate Resistant *Conyza canadensis* L. in the Eastern United States – by County



Compiled by Dauer (PA) from information provided by Patterson, (AL), Van Gessel (DE, MD), Rogers (KY), Kendig (MO), Koger (MS), Majek (NJ), Loux (OH, IN), Hayes (TN)

Updated 4 August, 2003
If there is additional information to be added, please e-mail Joe Dauer at jd152@psu.edu

What can you do?

Integrated Weed Management-

The use of a range of control techniques, embracing the physical, chemical and biological methods in an integrated fashion without excessive reliance on any one method (Powles and Matthews, 1992)

What can you do?

- Different crops will allow rotation of herbicides having a different mode of action
- Growth season of the weed can be avoided or disrupted
- Crops with different planting times and different seedbed preparation can lead to a variety of cultural techniques to manage a particular weed problem

What can you do?

- A strongly competitive crop will provide a better chance to restrict weed seed production.....increased seeding rates to accomplish the same thing.
- Delay planting so that initial weed flushes can be controlled with a non-selective herbicide
- Use certified seed free of weed seed

What can you do?

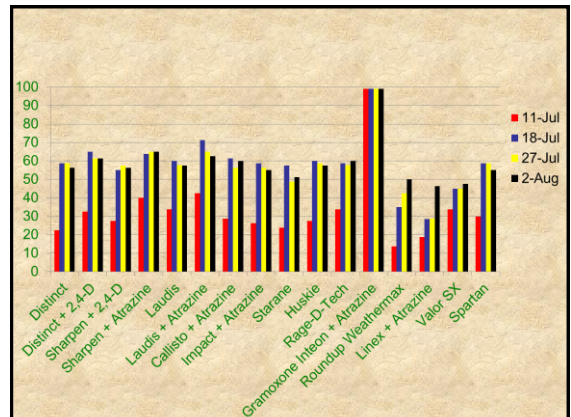
- Post harvest grazing, where practical
- In extreme cases of confirmed resistance, fields can be cut for hay or silage to prevent weed seed set.
- Avoid using the same herbicide or herbicides having the same MOA.

What can you do?

- If possible, tank mix products with different MOA's that have the good activity on the target weeds
- Maintain detailed field records so that cropping and herbicide history is known

Burndown Options

1 Distinct Ammonium Sulfate NIS	7 Calisto Atrazine COC	13 Roundup Weathermax Ammonium Sulfate
2 Distinct 2,4-D Ester Ammonium Sulfate NIS	8 Impact Atrazine Methylated Seed Oil Ammonium Sulfate	14 Linex Atrazine COC
3 Sharpen 2,4-D Ester Methylated Seed Oil Ammonium Sulfate	9 Starane NIS	15 Valor SX COC
4 Sharpen Atrazine Methylated Seed Oil Ammonium Sulfate	10 Huskie Ammonium Sulfate NIS	16 Spartan COC
5 Laudis Methylated Seed Oil Ammonium Sulfate	11 Rage-D-Tech Methylated Seed Oil Ammonium Sulfate	
6 Laudis Atrazine Methylated Seed Oil Ammonium Sulfate	12 Gramoxone Inteon Atrazine COC	



Comparisons 7/11

