The Epidemiology of Herbicide Resistance

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Introduction

• The science of herbicide resistance
  – What is resistance?
  – Why does resistance occur?
  – How does resistance occur?
  – What would prevent resistance from occurring?

The first species discovered with evolved herbicide resistance
What is Resistance?

• Resistance
  – Naturally occurring ability of some plants to survive herbicide treatment at normal dosage

• Cross-resistance
  – Resistance to two or more herbicides with the same mechanism of action

• Multiple resistance
  – Resistance to several herbicides with distinct mechanisms of action
Resistance is Universal

- Bacteria
  - To antibiotics
- Fungi
  - To fungicides
- Insects
  - To insecticides
- Plants
  - To herbicides
Chronology of Resistance

- Plants were last due to:
  - Longer life cycle
  - Incomplete control
  - Soil seed reserve
  - Plasticity in growth and development
Why does Resistance Occur?

• Plants are living organisms
  – Resistance is a biological phenomenon
• Genetic diversity is high in weedy plants
  – Random mutations in genes are common
  – Resistant genes already exist
• Genetic traits are inherited from parents
  – Resistance is passed from parents to offspring
How Does Resistance Occur?

• Environment
  – Plants are adapted to particular environments

• Selection
  – The best adapted plants leave more offspring

• Evolution
  – Change in traits (genes) of a population over time
  – Results from selection by the environment
  – Weed control is a form of selection
Selection for Resistance

• Herbicide is used
  – S plants are killed
  – R plants survive and reproduce

• Same herbicide used repeatedly
  – R plants leave more progeny
  – Eventually all R plants

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Which Ones Are Resistant?

Palmer amaranth; Photo by Dr. Jill Schroeder

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Herbicide Resistance in Weeds

Resistant (R) biotypes are genetic variants of the same species as susceptible biotypes (S)

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Weed Resistance to More than One Herbicide Mode of Action
What Would Prevent Resistance?

- Weeds interact with the environment
  - Abiotic—resources and conditions
  - Biotic—natural and human-caused factors
- Agricultural practices/weed management
  - Part of the biotic environment of weeds
  - All practices select the best adapted weeds
  - Result is weed evolution or succession (shifts)
Weed Management Techniques

- Prevention
- Eradication
- Control
  - Biological
  - Chemical
  - Cultural
  - Mechanical, physical

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Examples of Weed Selection

• Mowed landscapes
  – Select prostrate growth form
• Annual tillage systems
  – Select annual weeds
• Perennial, no-till systems
  – Select perennial weeds
• Use of grass-specific herbicides
  – Selects broadleaf (dicot) weeds
• Repeated herbicide use
  – Selects herbicide resistance
Herbicide Risk Factors for Evolution of Resistance

• Any herbicide chemistry or use pattern that increases selection pressure for resistance
  – Single, specific target site
  – Very active, broad spectrum
  – Long soil residual activity
  – Frequent chronic use pattern
General Principles for Resistance Management

- Reduce selection pressure causing resistance to evolve
  - Don’t use the selecting herbicide exclusively
- Control both R and S biotypes equally
  - Use diversity of control methods
Conclusions

• Resistance is a biological phenomenon
  – Abundant heritable variation in weeds
  – Most successful survive and reproduce
  – Weed control selects weeds that are best able to survive the control method used
  – Resistance evolves

• Don’t manage weeds, manage selection pressure