



What is Herbicide Resistance?

Lesson 3

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Objectives

By the end of this lesson, you will:

Understand what herbicide resistance is and how it evolves in the field.



Recognize the factors that influence selection for herbicide resistance.



Define the different types of herbicide resistance.



Above: Redroot pigweed in an onion field. Redroot pigweed is a weed that is known to be resistant to several herbicides.

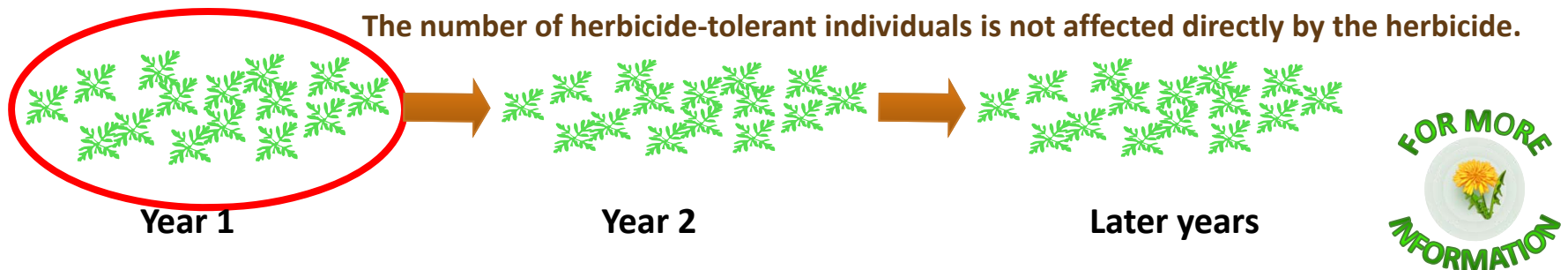
Image number 5362588 at www.invasive.org.

Herbicide Resistance Defined

Herbicide resistance can be defined as the acquired ability of a weed population to survive a herbicide application that previously was known to control it.

 The number of herbicide-resistant individuals in the population over time; it is no longer controlled by the herbicide.

Herbicide tolerance is the inherent ability of a species to survive and reproduce after herbicide treatment. There has been no selection acting on the tolerant weed species, and there has been no change in the weed species' lack of response to the herbicide over time.



Herbicide Resistance: Basic Principles

Herbicide resistance is the result of natural selection

Herbicide-resistant individuals or **biotypes*** are present naturally within the weed population at very low frequencies. These individuals have a herbicide resistance mechanism that allows them to survive the application of a herbicide.

Weed control failures do not automatically mean that the weeds are herbicide-resistant.

* Biotypes within a species have biochemical characteristics that are not shared by the population as a whole.

In general, weed populations are genetically diverse, and individual plants within a species can respond differently to the same herbicide rate. This does not mean, in all cases, that the least sensitive individuals are herbicide-resistant, but it is a possibility. Herbicide rates are initially established to be effective on the vast majority of the individuals in a population under normal growing conditions. This is why using labeled rates is important.

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Resistance can be passed on to the next generation.



Selection by Herbicides Changes the Population Over Time

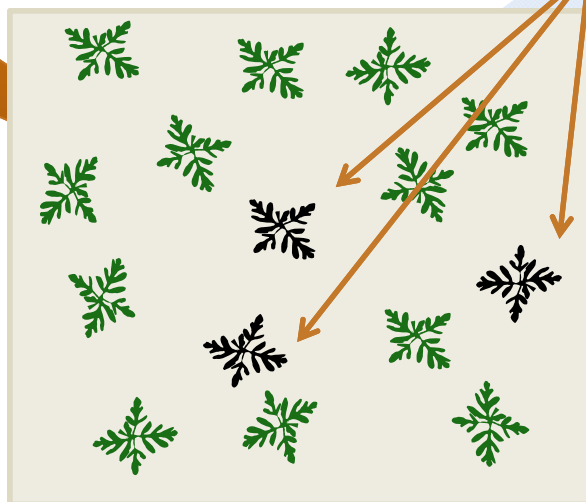
Year 2

Example

1 in a million
resistant to a
herbicide

Herbicide application

Year 2 begins
with more
resistant weeds

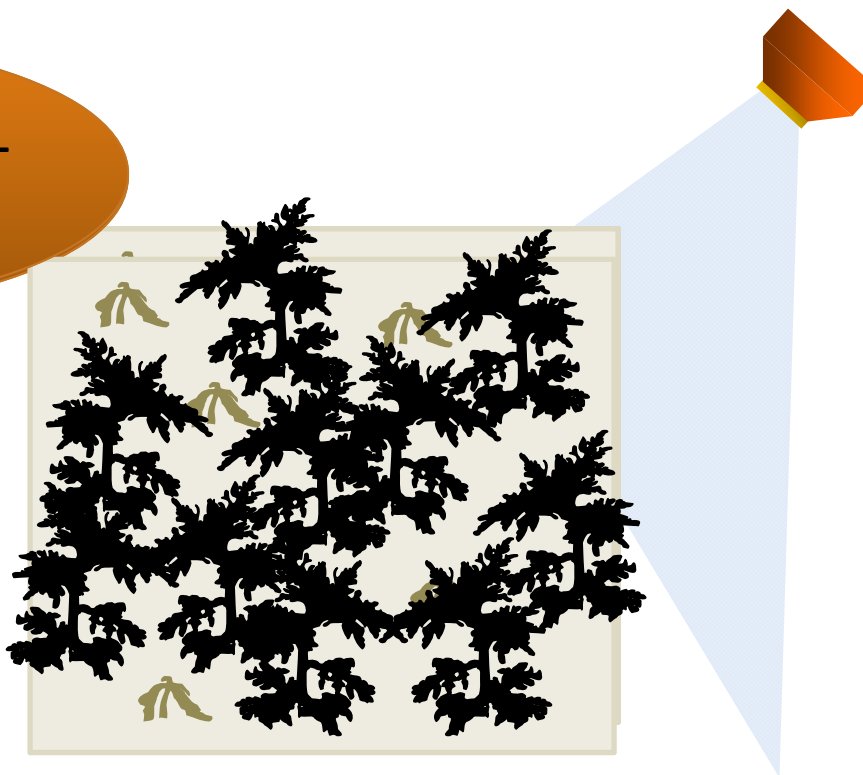


Selection by Herbicides Changes the Population Over Time

Year 2

Example

And in later years
even more herbicide-
resistant weeds are
present



Factors Affecting Speed of Selection

The length of time for selection of resistant biotypes depends on:

- Cultural practices
- Frequency of herbicide use
- Herbicide mechanism of action
- Biology of weed species
- Frequency of resistant biotypes among weeds

Another factor affecting the speed of selection is the mechanism of herbicide resistance. There are two general types of mechanisms: (1) exclusionary resistance (for example, differential uptake and translocation, compartmentalization and metabolic detoxification) and (2) target site resistance (alteration of the targeted enzyme and overproduction of a specific enzyme). Exclusionary resistance generally takes longer to evolve in the field.

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Year 0

Year 2

Year 4

Year 6

Year 8

Year 10

Later



Level of Herbicide Resistance

The level of herbicide resistance in weeds varies by weed biology and resistance mechanism.

In some cases, resistance occurs when the species survives application of a labeled rate, while in other cases, the species can survive up to 1000 times the labeled rate. (1X equals the labeled rate.)

This is important in terms of being able to identify herbicide resistance in the field.

1X TO
1000X



Herbicide Resistance Characteristics

Low-Level Resistance

- A continuum of plant responses from slightly injured to nearly dead
- The majority of plants display an intermediate response
- Susceptible plants will be present in the population, especially when herbicide resistance is determined early

Examples

Roundup, etc.	GROUP	9	HERBICIDE
Reflex, Valor, etc.	GROUP	14	HERBICIDE
Clarity, 2,4 D, etc.	GROUP	4	HERBICIDE
Gramoxone, etc.	GROUP	22	HERBICIDE

High-Level Resistance

- Plants are slightly injured to uninjured
- Few plants have an intermediate responses
- Susceptible plants can be present in the population

Examples

atrazine, Sencor, etc.

GROUP	5	HERBICIDE
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Classic, Permit, FirstRate, etc.

GROUP	2	HERBICIDE
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Select, Assure, etc.

GROUP	1	HERBICIDE
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Herbicide Resistance Types

Single Herbicide Resistance

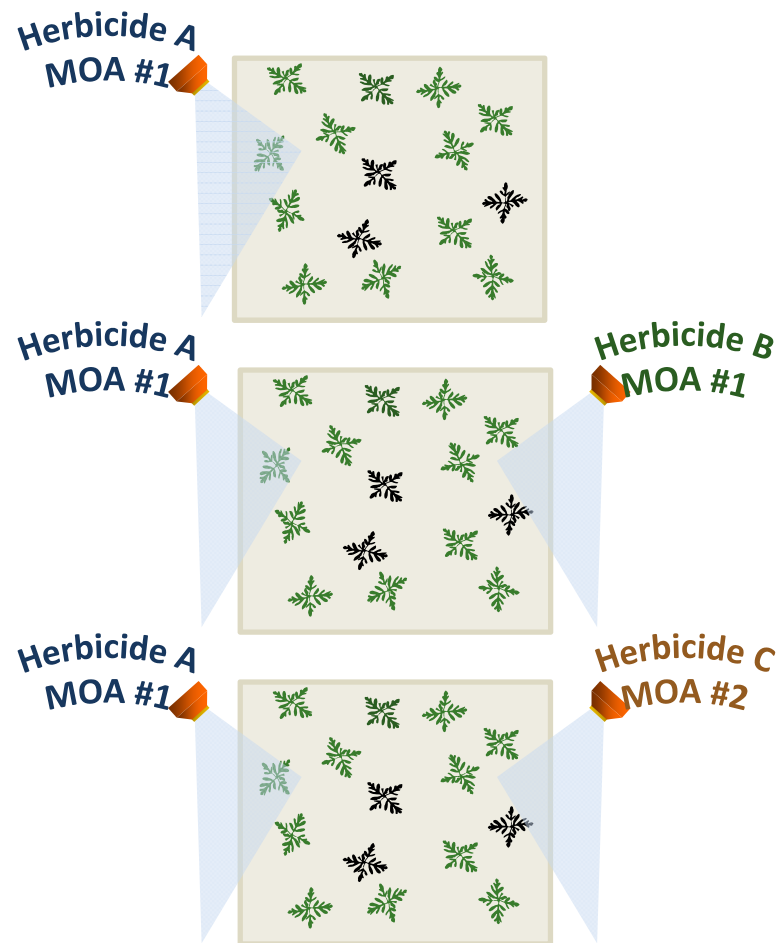
- Resistant to only one herbicide

Cross Herbicide Resistance

- Resistant to two or more herbicide families with same mechanism of action
- Single resistance mechanism

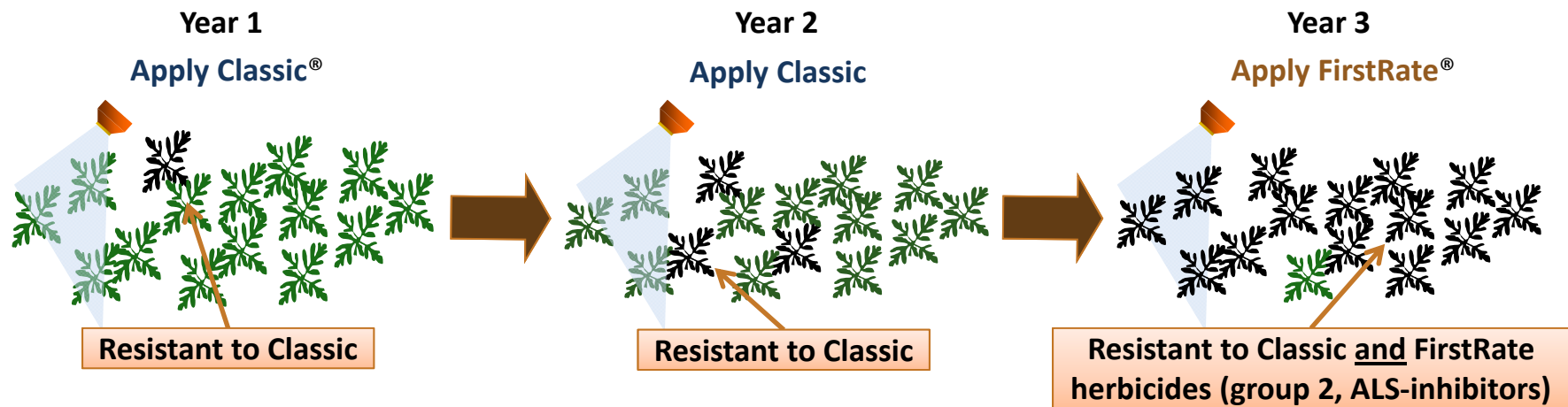
Multiple Herbicide Resistance

- Resistant to two or more herbicides with different mechanisms of action
- May be the result of two or more different resistance mechanisms



Herbicide Resistance Types: Cross Resistance

An example with common ragweed

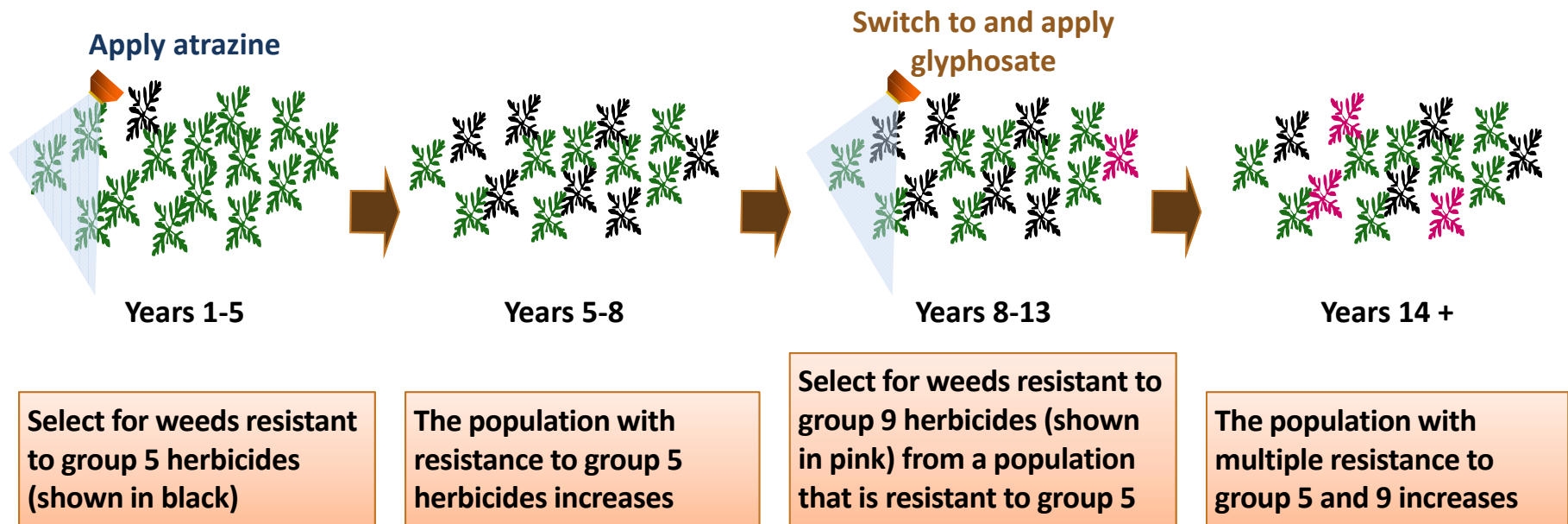


Classic, a sulfonylurea, and FirstRate, a triazolopyrimidine, both belong to the ALS-inhibitors, or group 2 herbicides. Both herbicide products have the same mechanism of action.

CAUTION: Weeds that are herbicide-resistant to one member of a herbicide mechanism of action group may or may not be cross-resistant to all herbicides within that group. Consult your local extension specialist for more information.

Herbicide Resistance Types: Multiple Resistance

Example



Multiple resistance can occur following repeated applications of a single herbicide and selection for herbicide-resistant biotypes followed by repeated applications of another herbicide and selection for herbicide-resistant biotypes.



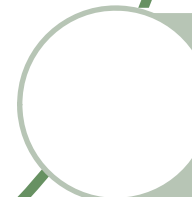
Conclusions



Repeated use of a herbicide selects for herbicide-resistant biotypes. Over time, the number of resistant individuals in the weed population increases until the majority of the population is herbicide-resistant.



Several factors in the field can affect the selection of herbicide-resistant weeds.



Once a weed is resistant to a single herbicide, it is possible for it to be resistant to another herbicide, with either the same or a different mechanism of action.

Credits:

This lesson was developed by a WSSA sub-committee and reviewed by the WSSA Board of Directors and other WSSA members before being released. The sub-committee was composed of the following individuals.

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- Les Glasgow, PhD (Syngenta Crop Protection)
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- David Shaw, PhD (Mississippi State University)
- John Soteres, PhD (Monsanto Company) (Sub-committee chairman)
- Jeff Stachler, PhD (North Dakota State University and University of Minnesota)
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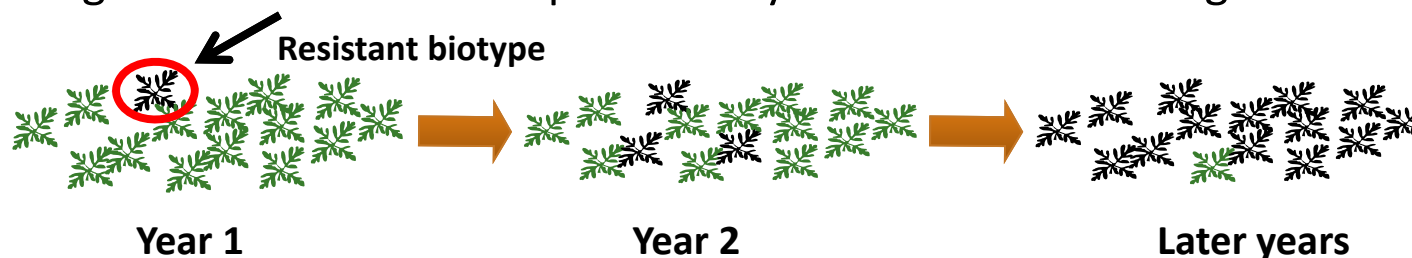
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Herbicide Resistance WSSA Definitions



"**Herbicide resistance** is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis."



"**Herbicide tolerance** is the inherent ability of a species to survive and reproduce after herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant."

