



Principles of Managing Herbicide Resistance

Lesson 5

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Objectives

By the end of this lesson, you will:

Understand that diversity is an important concept in the management of herbicide-resistant weeds.



Identify the broad strategies and specific tactics for managing herbicide-resistant weeds.



Compare the value of proactive versus reactive management for herbicide-resistant weeds.



Above: Seedling stage of waterhemp, a weed that is known to be resistant to several herbicides.

Image number K8040-1 at the USDA-ARS online image gallery.

Diversity of Practices

The best strategies to manage herbicide resistance in weeds are established on the concept of diversity.

Diversity can be achieved by:

Using mechanical, cultural, and biological practices in addition to herbicides

and

Applying several mechanism of action (MOA) herbicides for control (each herbicide targets a different weed target)

Mechanical

Cultural

Mechanism of action (MOA) is the biochemical site within a plant with which a herbicide directly interacts. Herbicides with different MOAs are identified by different group numbers. For example, 2,4-D is a group 4 herbicide, and glyphosate is a group 9 herbicide.

[Click to close.]

A combination of tactics reduces the selection pressure imposed by any single practice.



Management Strategies

Proactive management is the implementation of tactics before herbicide-resistant weeds are apparent.

PROACTIVE: before confirmation



Reactive management is the implementation of tactics after herbicide resistance has been confirmed in the field.



REACTIVE: after confirmation

Proactive Management: Defined

Proactive management is a style of decision making that anticipates events or changes in the field, plans ahead for them, and should include weed management planning.

Examples of decisions to anticipate:

- ✓ Seed varieties and supply
- ✓ Equipment needs
- ✓ Fertilizer needs and availability
- ✓ Weed management



Above: Planning land management methods in a dryland cropping system.

Image number K5230-10 at the USDA-ARS online image gallery.

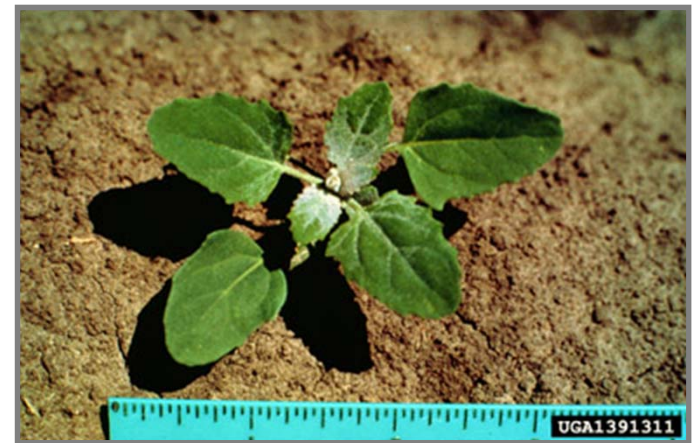
Proactive Management

PROACTIVE: before confirmation

Proactive management in the context of herbicide-resistant weeds is critical for the long term sustainability of effective herbicide options in all crops.

Advantages of proactive management:

- ✓ **Preserve** crop yield potential
- ✓ **Save money** compared to reactive methods
- ✓ **Prevent** the need for dramatic, short-term shifts in farm practices
- ✓ **Protect** herbicide options for future operations



Common lambsquarters is found in many agricultural systems. It is known to be resistant to several herbicides.

Photo: Image number 1391311 at image gallery www.invasive.org.

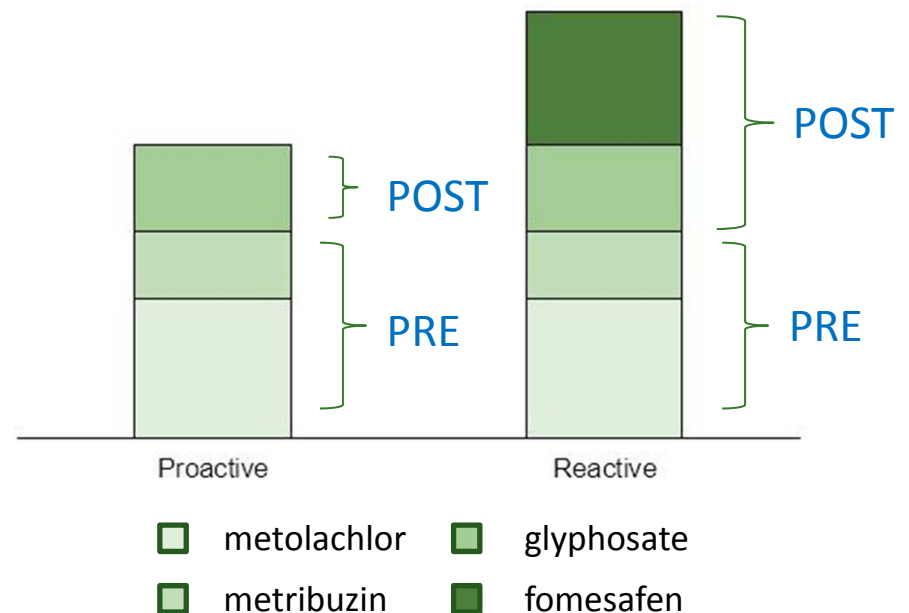
Proactive Management: Saves Money

Weed management decisions based on proactive management can be more cost-effective over time compared to programs based on reactive management.

Example

Relative Cost per Acre

PROACTIVE Management Program: Roundup Ready® soybeans <u>without</u> glyphosate-resistant pigweeds		
Application	Product	Group Number(s)
PRE	metolachlor + metribuzin	15 + 5
POST	glyphosate	9
REACTIVE Management Program: Roundup Ready® soybeans <u>with</u> glyphosate-resistant pigweeds		
Application	Product	Group Number(s)
PRE	metolachlor + metribuzin	15 + 5
POST	glyphosate + fomesafen	9 + 14



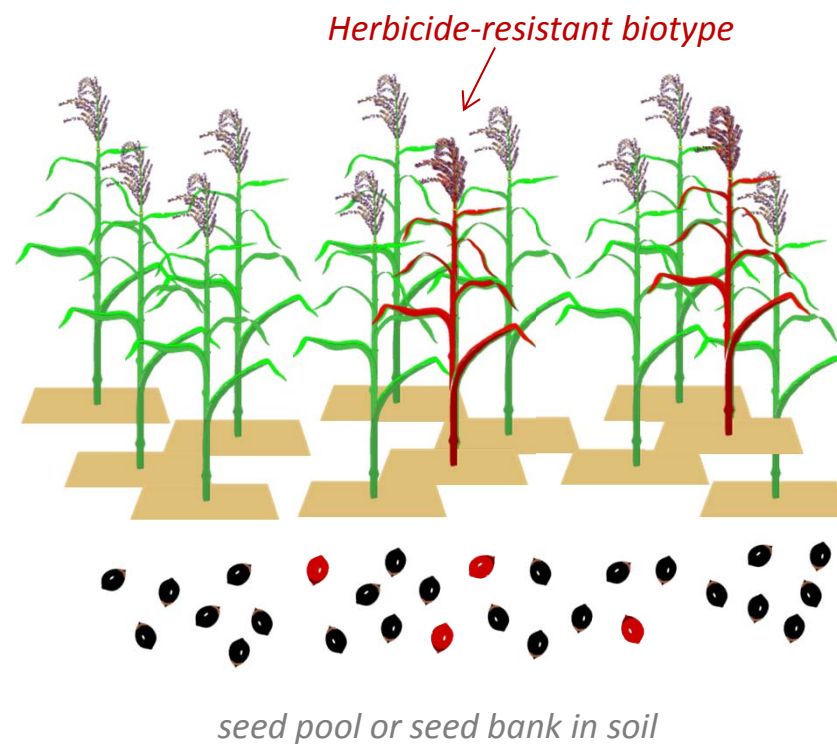
Progression of Weed Resistance

Weed resistance progresses logarithmically

Year 0

Credit: Mike DeFelice

Treatment	% Resistant Weeds in Population	Weed Control
0 Application	.0001	Excellent
1 st Application	.00143	Excellent



After first application, the herbicide kills individual weeds that are not resistant. The resistant weeds survive and their seeds are added to the seed pool.

Progression of Weed Resistance

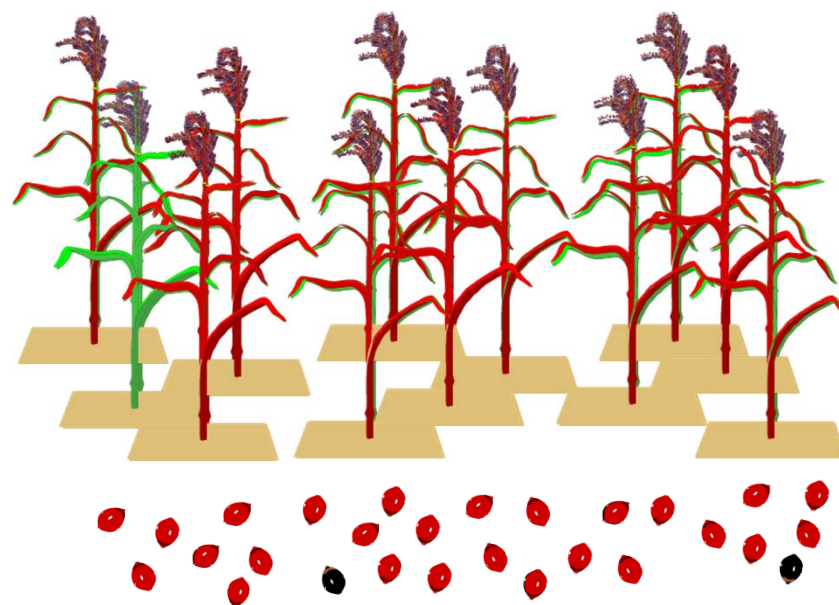
Weed resistance progresses logarithmically

Year 3

Credit: Mike DeFelice

Treatment	% Resistant Weeds in Population	Weed Control
0 Application	.0001	Excellent
1 st Application	.00143	Excellent
2 nd Application	.0205	Excellent
3 rd Application	.294	Excellent
4 th Application	4.22	Excellent
5 th Application	60.9	Excellent

Herbicide resistance cannot be reversed in a practical time frame. In many cases, the seed pool is unlikely to change back because there is no fitness penalty.



seed pool or seed bank in soil

Control may still be possible if the seed pool is almost completely composed of the susceptible type.

Proactive Management Tactics

Strategies to **proactively** delay herbicide resistance can include one or more of the following tactics:

Herbicide



- Multiple herbicides with different mechanisms of action
 - Mixes
 - Sequence
 - Across seasons

Mechanical



- Tillage
 - Pre-plant
 - In crop cultivation
 - Post harvest

Cultural



- Crop rotation
- Plant population
- Row spacing
- Planting date
- Fertilizer placement
- Cover crops

Photo credits from left to right: Flickr jwinfred; Deere Photo Library; Allianz



Proactive Management: Herbicide Tactics

Herbicide choice requires ***careful planning*** so that products with different mechanisms of action (MOA), or unique group numbers, and activity on the same target weeds, are intentionally combined with each other or other weed control practices.

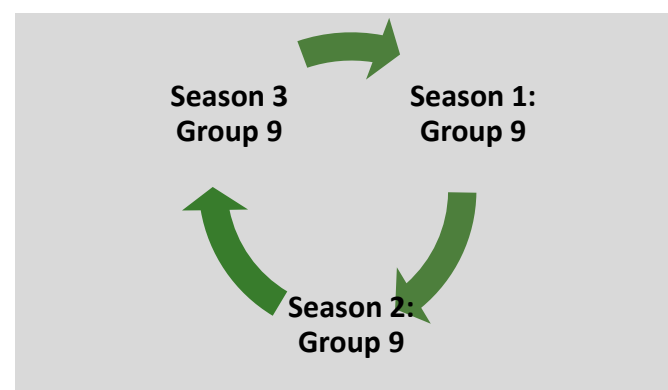
SUSTAINABLE



Note: For all herbicide applications, it is critical to apply the labeled rate at the correct time. Management strategies based only on a herbicide mechanism of action classification system, or herbicide group number, may not adequately address specific and local needs. Consult product labels and the assistance of your local extension specialist for more information.

Repeated annual use of a herbicide with the same MOA in the absence of other MOAs or different management strategies can lead to resistance.

NOT SUSTAINABLE

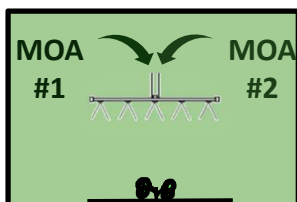




Proactive Management: Herbicide Tactics

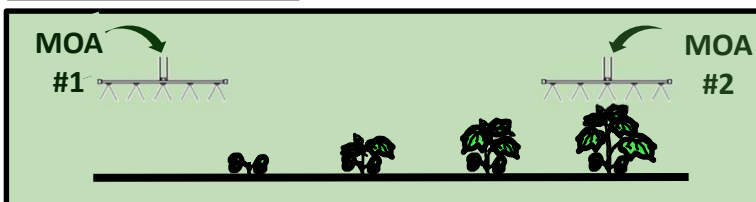
The main schemes for applying herbicides with different mechanism of action (MOA) to manage herbicide resistance are:

Mixture application

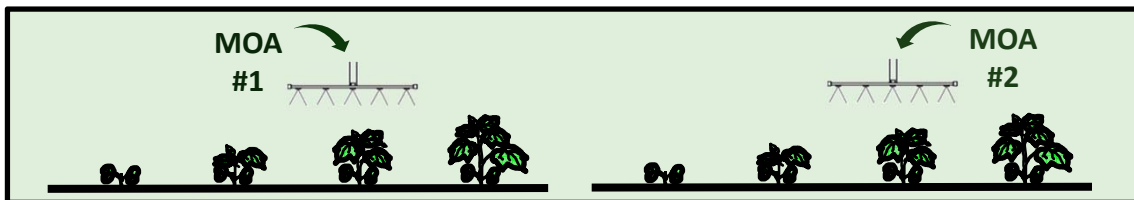


These options can provide the flexibility to choose the best fit or combinations of fit for local agronomic operations.

Sequentially throughout season



Across multiple seasons



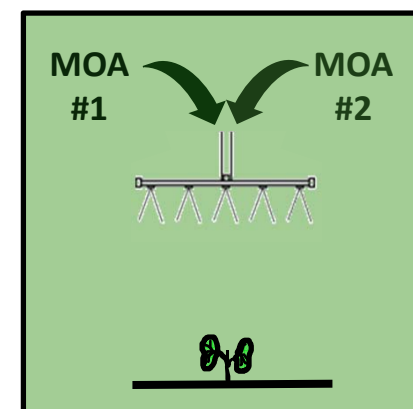
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Proactive Management: Herbicide Tactics

Tank mixing or the use of pre-mixed products with different mechanisms of action and activity on the same target weed or weeds can be effective at delaying the onset of herbicide-resistant weeds.

Herbicide mixtures contain more than one active ingredient.



Herbicide mixtures may be marketed as prepackaged formulations.

Note: For all herbicide applications, it is critical to apply the labeled rate at the correct time. Management strategies based only on a herbicide mechanism of action classification system, or herbicide group number, may not adequately address specific and local needs. Consult product labels and the assistance of your local extension specialist for more information.

Need for Full Label Rate

Definitions:

- “Labeled rate” = A rate or range of rates set by herbicide manufacturers to consistently provide effective control of weed species across growth stages and site conditions.
- “Low rate” = A rate applied below the labeled rate that may provide effective control at an individual location, but will not provide consistent control over a wide range of conditions.

Routine exposure to low herbicide rates can allow a portion of the weed population to survive, leading to the evolution of herbicide-resistant populations.

Weeds can be exposed to “low rates” due to:

- Intended use of low rates
- Spraying plants larger than those recommended on the label
- Inadequate coverage of weeds because of size, density and/or crop cover
- Inaccurate sprayer calibration, faulty or ineffective equipment, or mixing errors

Mechanical



Proactive Management: Mechanical Tactics

Mechanical tactics include techniques such as:

- ✓ Pre-plant tillage
- ✓ Strip or zone-tillage
- ✓ In-crop cultivation
- ✓ Post-harvest mowing and/or tillage
- ✓ Hand-roguing before seed set



*Photo: Image number K5197-3
at the USDA-ARS image gallery.*

Equipment sanitation is also important to slow the spread of herbicide-resistant weeds and weed seeds.



Proactive Management: Cultural Tactics

Crop Management. Agronomic practices, such as choice of hybrid or variety, differences in planting times, fertilizer management, row spacing, plant populations, seed bed preparation, and harvesting techniques can influence the growth cycle of weed species and therefore provide an advantage to the crop. For example, narrow crop row spacing can quickly shade sensitive weed species, while longer periods of weed control are generally required for wider row spacings.



*Photo credits: Flickr
Monsanto*

Crop Rotation. Natural differences exist among the abilities of crops to compete with weeds. The greatest benefit in crop rotation comes as a result of the most diverse crop rotations, because they provide the greatest opportunities for exploiting differences in tillage practices, competitiveness, and herbicide choices.



Proactive Management: Cultural Tactics

Cover Crops. Some cover crops, sown prior to the primary crop, may suppress weed growth through their physical presence or through the release of substances that can affect the germination and growth of some weed species.

Slowing the Spread of Herbicide-Resistant Populations. Managing weeds in the borders around fields before flowering is important to prevent pollen movement between resistant and susceptible plants. Preventing the movement of seeds and vegetative propagules from field to field by cleaning equipment before it is moved can slow the spread of herbicide-resistant weeds.

In general, cultural practices greatly influence the composition of weeds, and their germination and growth. These practices can also influence the amount of weed seed in the seed bank and the spread of herbicide-resistant weeds.

Reactive Management: Defined

Reactive management is a style of decision making that acts in response to events or changes in the field when they occur with little to no expectation or anticipation of the events or changes.

- ✓ A reactive action is a response to an unexpected problem.
- ✓ Reactive management is a necessary part of land management.
- ✓ There is no way to plan for everything that can possibly happen.

The proactive style of decision making is preferred in the context of herbicide-resistant weeds.



Above: Common ragweed, a weed that is known to be resistant to several herbicides. Photo: Image number 1391466 at image gallery www.invasive.org.

Reactive Management

REACTIVE: after confirmation

Reactive management can be utilized during two general times:

Tactics used within the same season
a population has been identified as
herbicide-resistant

or

Tactics used in seasons after a
population has been identified as
herbicide-resistant

The timing of the first reactive management tactics may affect the intensity and number of options necessary to manage herbicide-resistant weeds in the future.

Early detection and remediation prior to weed seed set within the same season (see above) will reduce weed density in subsequent years and can reduce weed management costs in later years.



Left: A small patch of glyphosate-resistant Palmer amaranth. Photo courtesy of Alan York, NCSU.



Reactive Management: Same Season

Same season management tactics are generally limited and **may not be effective** when dealing with herbicide-resistant weed populations. Because situations can vary widely, consult your local extension specialist for advice.

Herbicide Options:

- Apply the most effective postemergence herbicide with a *different mechanism of action*.
- If low-level herbicide resistance has been identified, **and no other options are available**, apply the maximum labeled rate of the same postemergence foliar herbicide.

Mechanical Options:

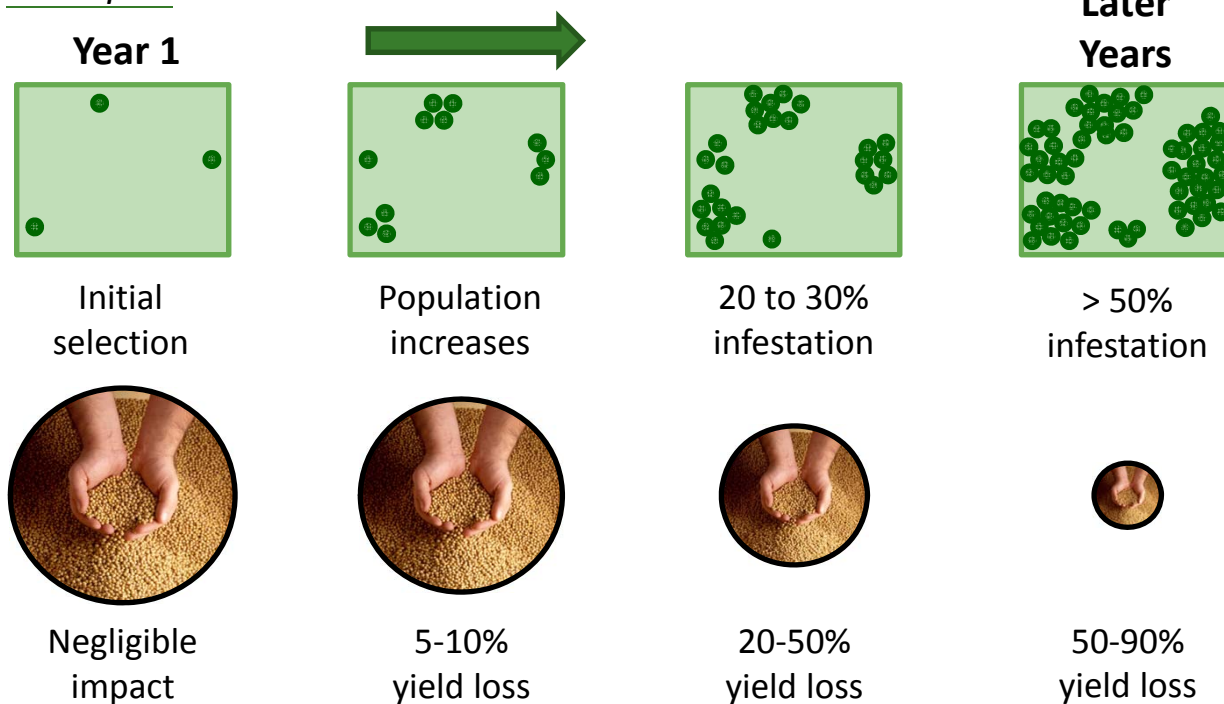
- Cultivation or hand-roguing may be the primary options in some agronomic environments and geographies.

In general, these options are limited in their effectiveness because of larger weeds and/or crop stage limitations later in the season.

Potential Yield Impact of the Failure to Manage Herbicide-Resistant Weed Populations

As a herbicide-resistant weed population increases in density and area, yield potential decreases.

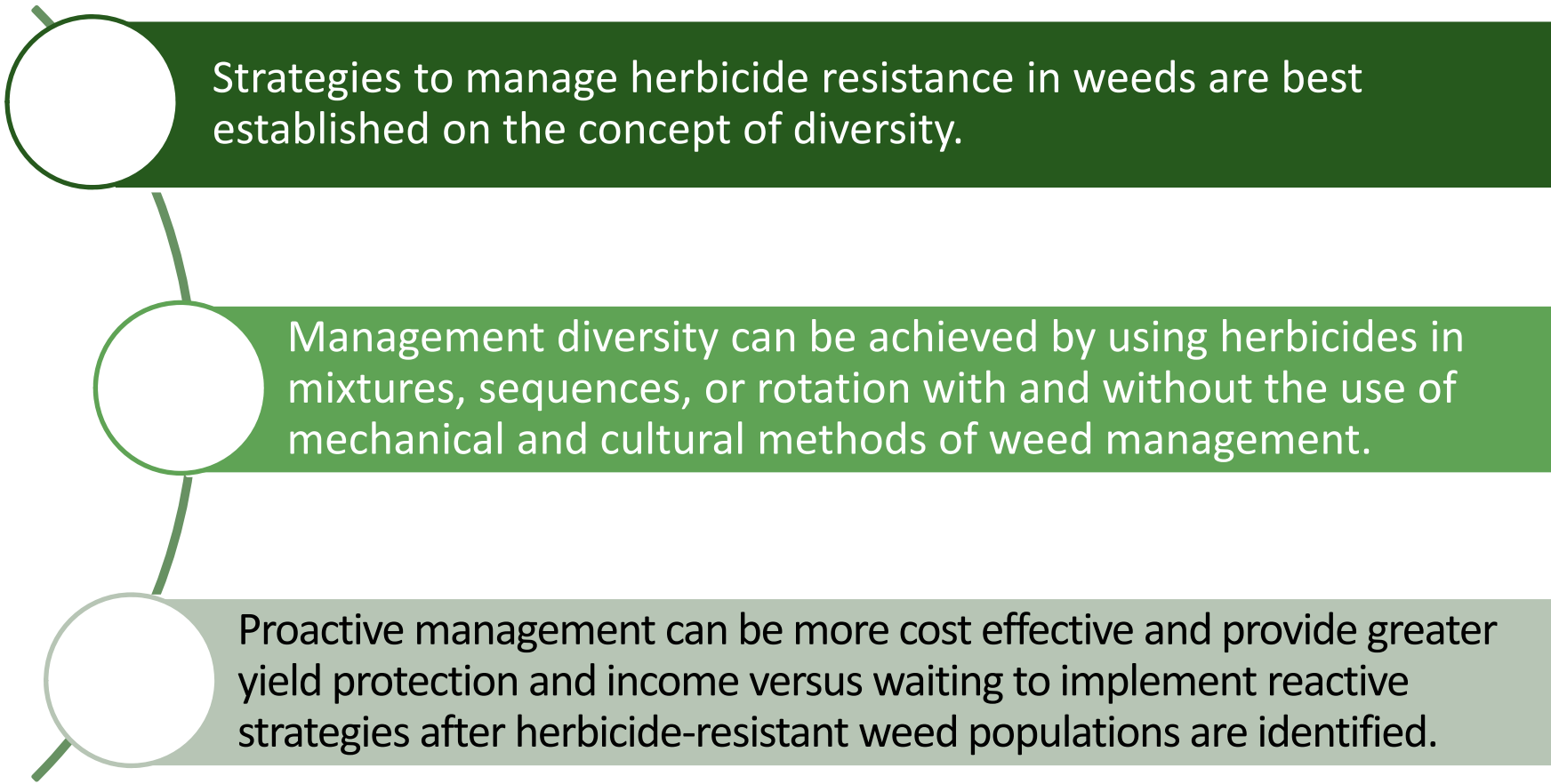
Example



When herbicide-resistant weed management practices are implemented early, the risks associated with these losses can be reduced.



Conclusions



Strategies to manage herbicide resistance in weeds are best established on the concept of diversity.

Management diversity can be achieved by using herbicides in mixtures, sequences, or rotation with and without the use of mechanical and cultural methods of weed management.

Proactive management can be more cost effective and provide greater yield protection and income versus waiting to implement reactive strategies after herbicide-resistant weed populations are identified.

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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