Herbicide-Resistant Weeds: Preventative Management Tactics in Citrus

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Introduction

- Reasons for vegetation management
  - Reduce safety hazards
    - *Line-of-site/visibility*
    - *Remove fire hazards*
    - *Remove habitat for undesirable wildlife*
  - Prevent the disruption of services
    - *Transportation of goods*
    - *Utilities*




Strategies for managing vegetation

- Mechanical
  - i.e. mowing, pruning
- Cultural
  - i.e. controlled burning, fertilizing/liming, mulching
- Chemical
  - i.e. tree growth regulators
  - i.e. herbicides

Herbicides can fail

- **Weed Biology**
- **Life form**
  - **i.e. Broadleaves vs. grasses**
- **Morphology**
  - **i.e. Leaf surface area, angle and texture**
- **Growth and development**
  - **i.e. Plant size, plant maturity, plant responses to stress**
- **Genetics**
  - **Development of herbicide resistance**

Herbicides can fail if…

- **Environmental/Meteorological**
  - **Soil**
    - **Clay, OM can make herbicides unavailable**
    - **In less adsorptive soils, leaching can occur**
    - **Slope can lead to erosion or drainage**
- **Wind**
    - **Spray drift**
    - **Drought stress**
- **Temperature**
    - **Plant affects**
      - ***Plant growth rate***
      - ***Cuticle development/herbicide absorption***
      - ***Water/herbicide translocation***
    - **Herbicide affects**
      - ***Volatilization***
      - ***Degradation***

Horseweed Biology

- A close relative – horseweed or mare's tail (*Conyza canadensis*) has wide-spread glyphosate resistance

- wind-dispersed seeds that travel up to 3 miles and carry the herbicide resistance in them to new places.

Hairy fleabane Biology

- Resistance to the two most commonly used herbicides – glyphosate (Roundup) and paraquat - is widely reported in California

Effect of glyphosate rate and timing on control	
Hairy fleabane growth stage and lb ai/A for good control	**Horseweed growth stage and lb ai/A for good control**
3-6 leaf = 0.5	5-8 leaf = 1.0
7-12 leaf = 1.0	11 leaf to 4" bolted = 2.0
13-19 leaf = 1.5	4" to 12" bolted = 4.0
20-21 leaf = 2.0	
>25 leaf = erratic	
Prather, UC KAC 1999 and Shrestha et. al., UC KAC	

Palmer Amaranth Biology

- **Summer Annual Dicot**
  C_4 plant (Wang et al. 1992)
- **38 species of *Amaranthus* in U.S, 75 Worldwide** (Ward et al. 2013)
- **Rapid growth, up to 1-2 in. a day**
- (Klingaman and Oliver 1994)
- **Genetic Divesity- Dioecious obligate outcrosser** (Franssen et al. 2001)
- **Traits are passed through pollen** (Sosnoskie et. al 2012)
- **Prolific seed producers – 200,000-600,000 seeds per female plant**
  (Keeley et al. 1987)

- **Glyphosate-resistant (GR) populations of Palmer amaranth have been confirmed throughout the southeast U.S. since 2005 (Culpepper & Sosnoskie)**

- **Since 2012, growers in California's San Joaquin Valley (SJV) have observed poor control of Palmer amaranth in glyphosate-tolerant corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.).**

Kings Co. 2013

Tulare Co. 2012

However, it is not known if these are cases of GR populations

OR

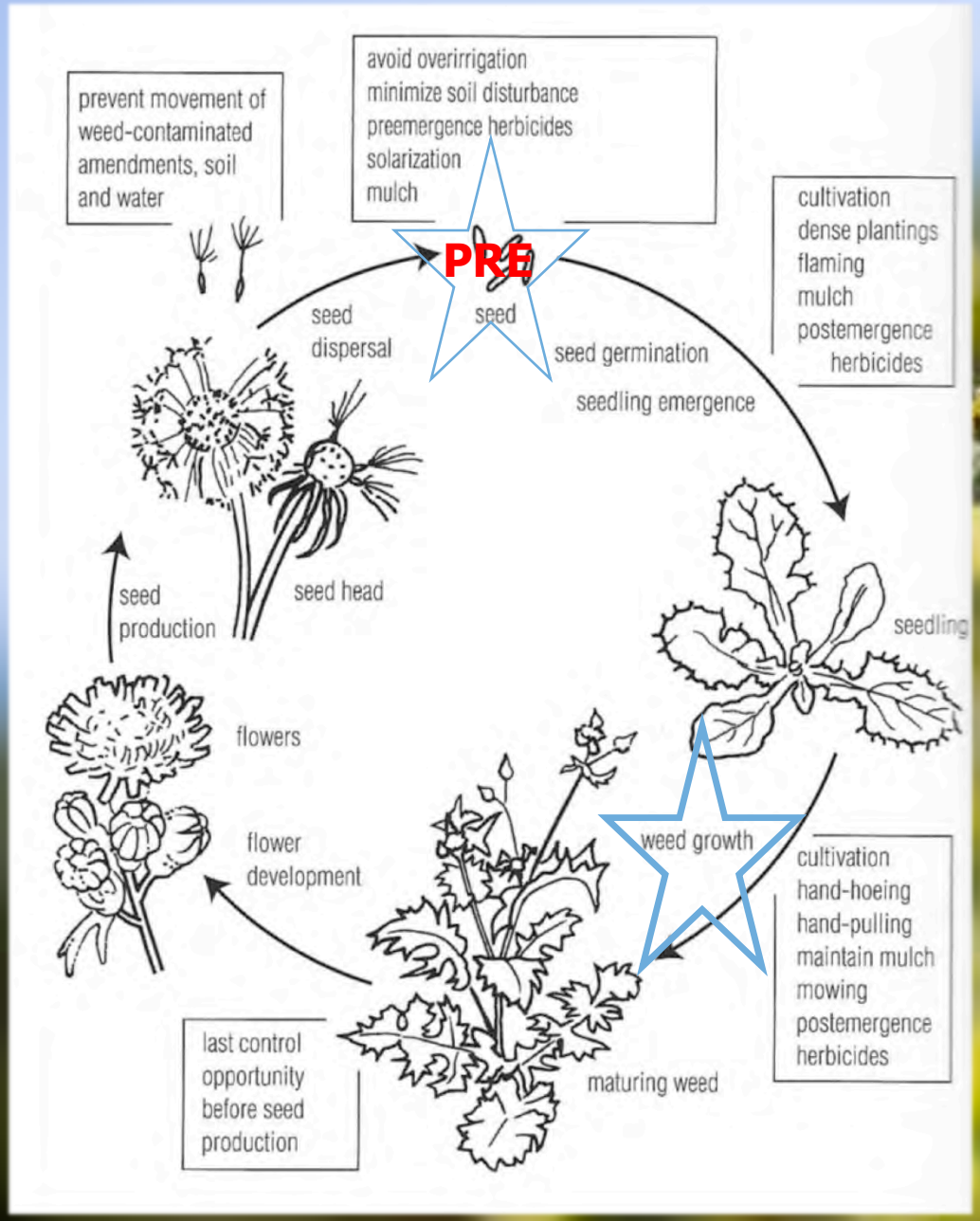
if these are cases of escapes due to glyphosate applications being made later at more tolerant stages of the weed - Poor application?

Fresno Co. (2013)

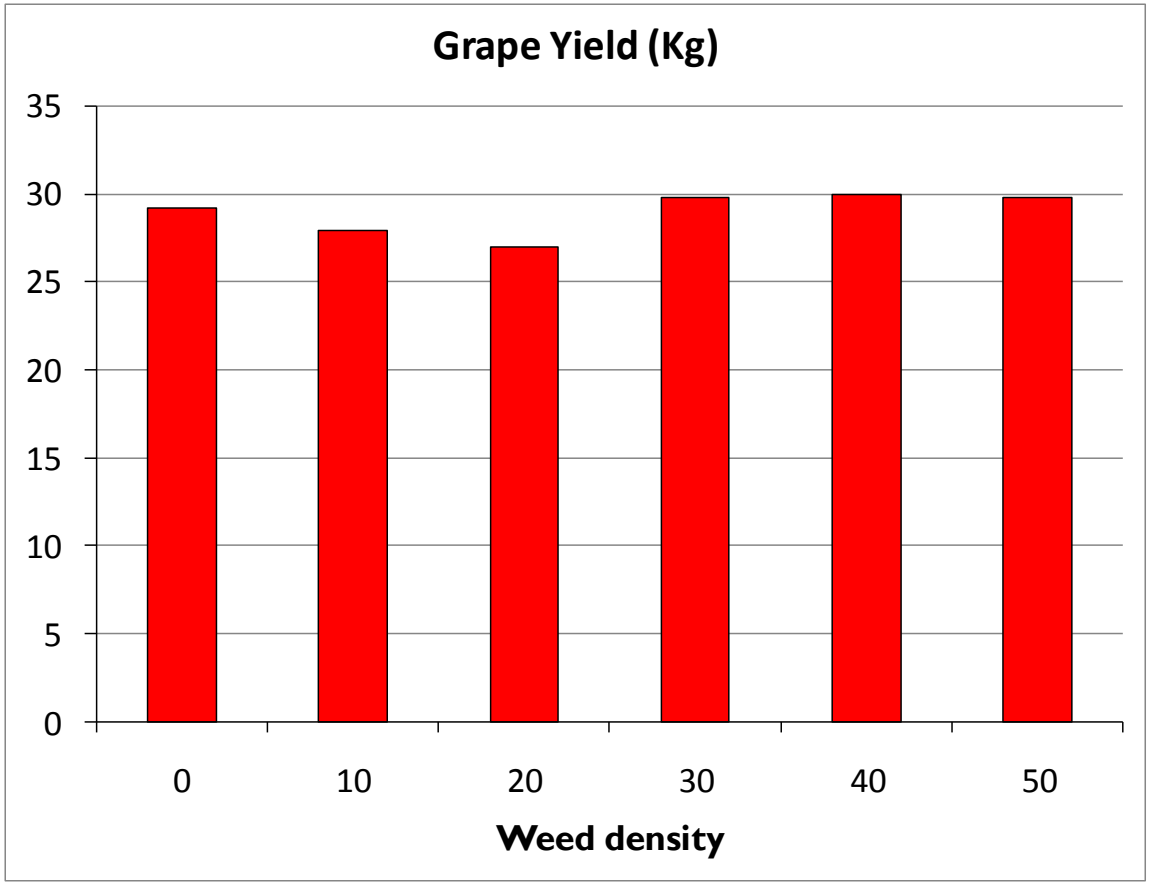
Tulare Co. (2012)

Do we have GR Palmer amaranth in CA?

Border and roads become the primary location for weeds.


prevent movement of weed-contaminated amendments, soil and water
avoid overirrigation
minimize soil disturbance
preemergence herbicides
solarization
mulch
PRE
cultivation
dense plantings
flaming
mulch
postemergence herbicides
seed
seed dispersal
seed germination
seedling emergence
seed head
seed production
seedling
flowers
flower development
weed growth
cultivation
hand-hoeing
hand-pulling
maintain mulch
mowing
postemergence herbicides
last control opportunity before seed production
maturing weed


WEED THRESHOLDS???



No effect on time to harvest or grape quality

Caution: This was a flood irrigated vineyard.

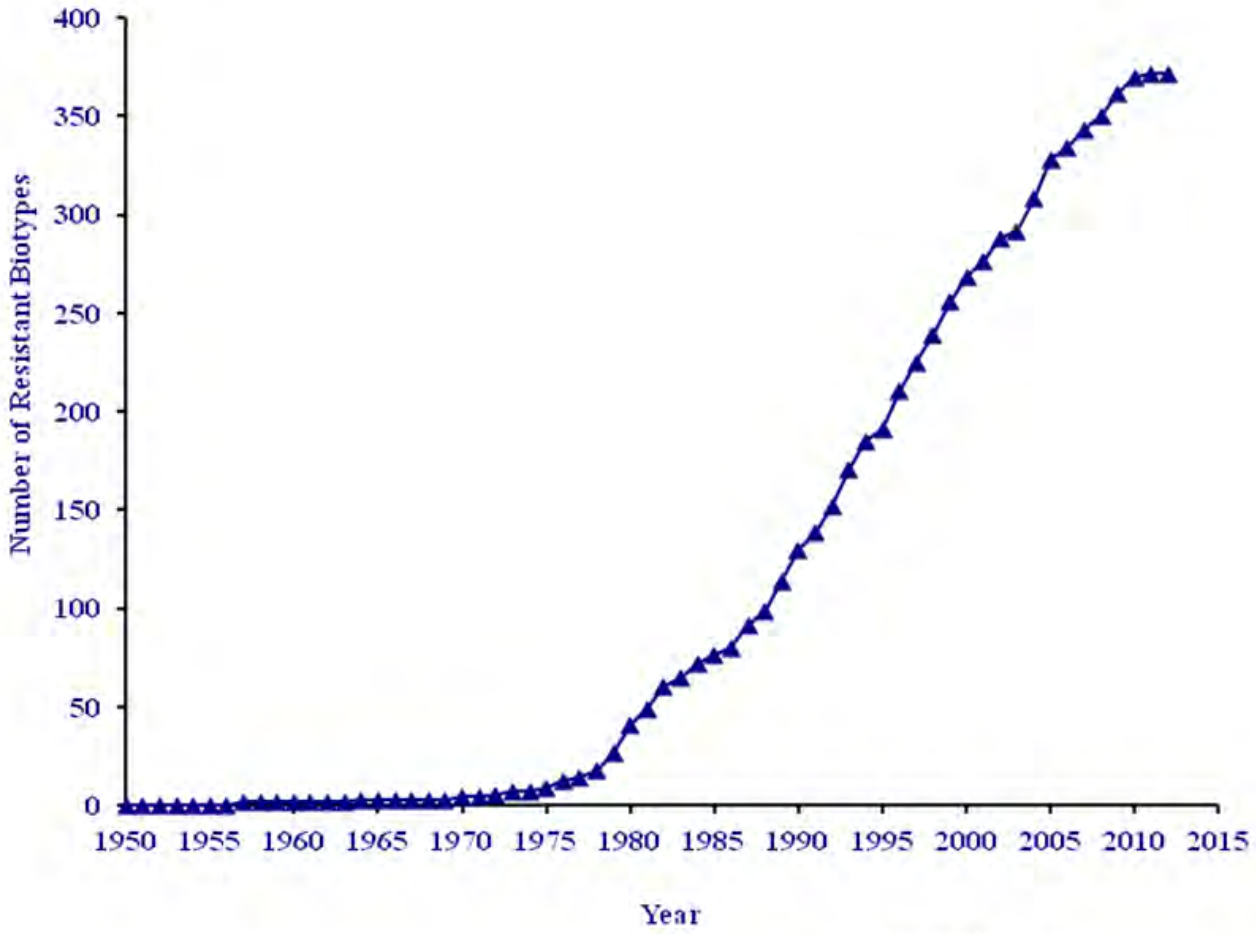

No effect on time to harvest


The CWPC in vineyards are the establishment years
established vineyards in the Valley have a higher threshold for weeds

The bottom line:

It's critical to maintain a weed-free environment around young vines for at least 2 years after planting to aid growth and production.

As of 2012,
396 herbicide-resistant biotypes (worldwide)
across 210 species



Source: Ian Heap
http://www.weedscience.com

Horseweed, also called mare's tail

Spread of resistant weeds in the US

Number of glyphosate-resistant species per state

7 6 5 4 3 2 1

ND MN MI OR WI MI PA NE IA OH IL IN DE DC CA KS MO KY VA NC TN OK AR NM MS AL GA LA

Source: Pioneer hi-bred international, spring 2012

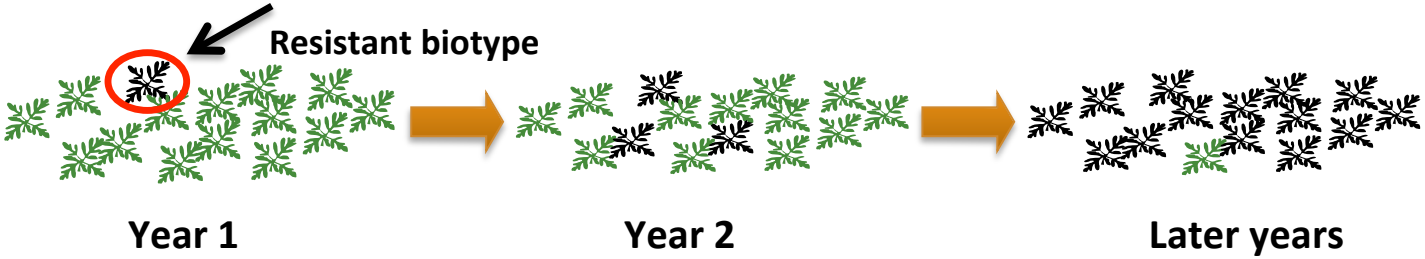
Junglerice

Hairy fleabane

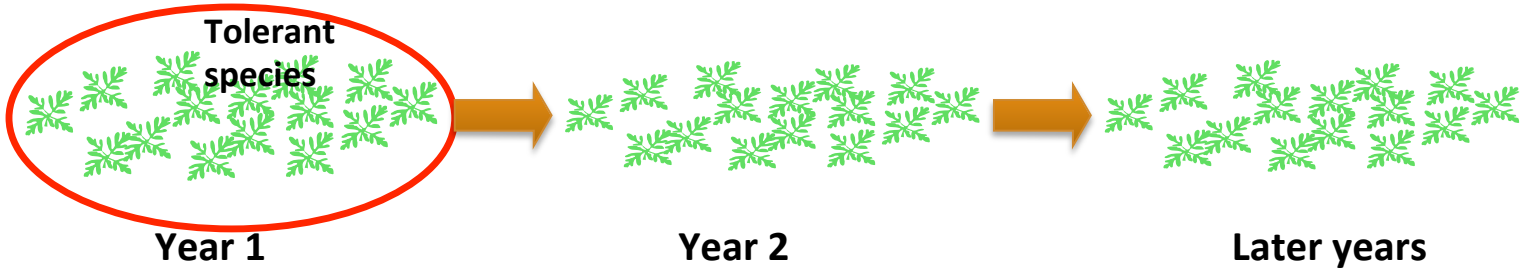
What is Herbicide Resistance?

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."



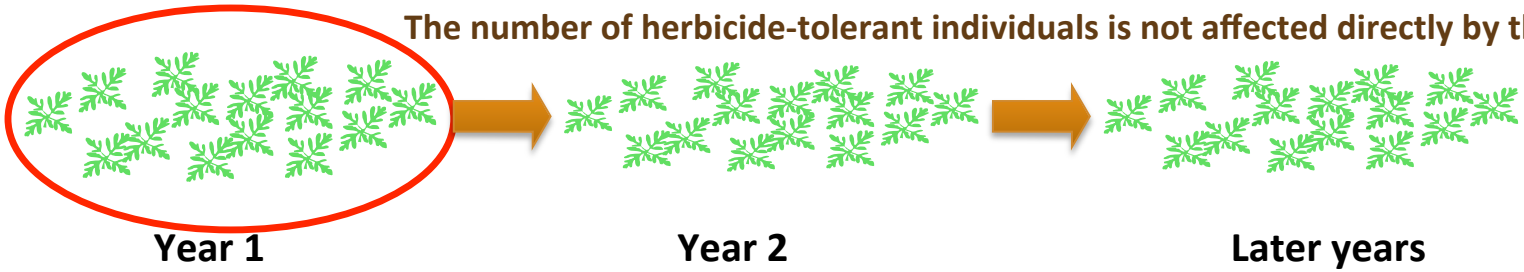
"**Herbicide tolerance** is the inherent ability of a species to survive and reproduce after herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant."



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 the population.

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 naturally occurring processes.

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 are plants within a species that have biological characteristics that are not common to the population as a whole.

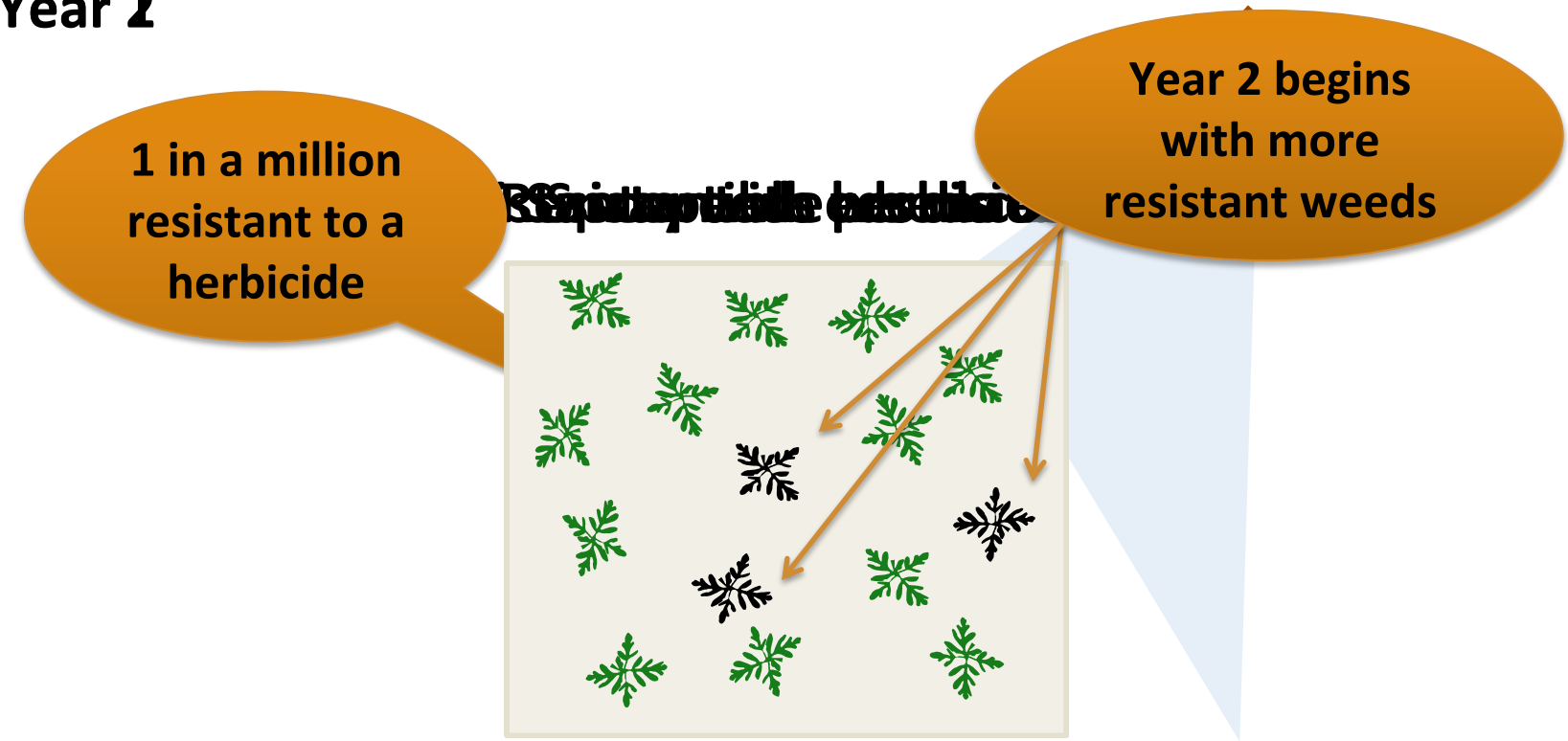
Resistance is **heritable**. It can be passed from one generation to the next.

FOR MORE INFORMATION

Selection by Herbicides Changes the Population Over Time

Example

Year 1

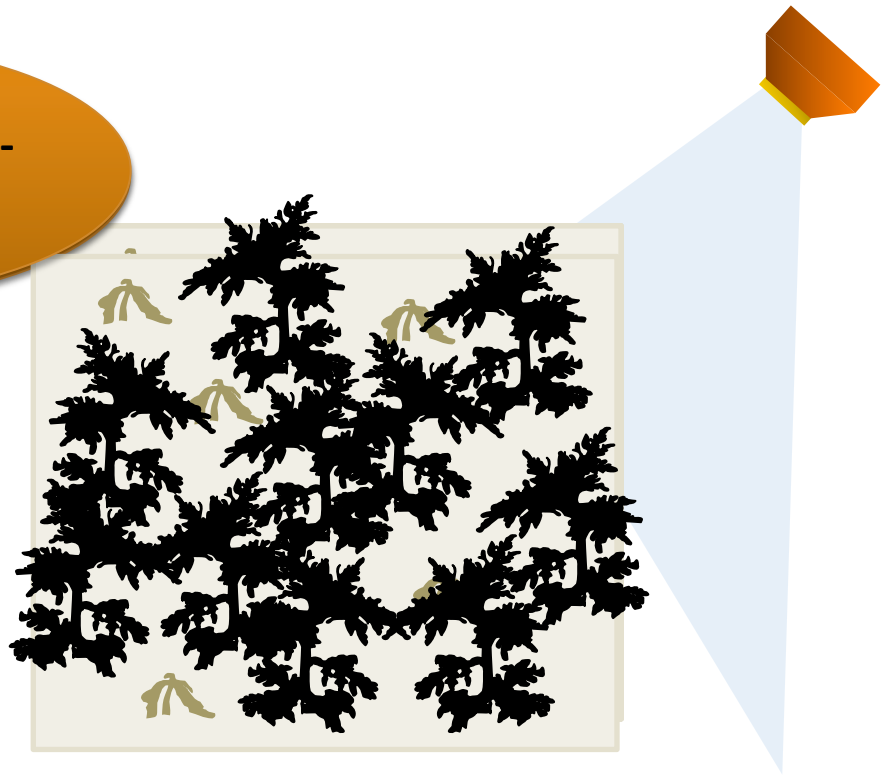


Selection by Herbicides Changes the Population Over Time

Example

Year 3

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



Factors Affecting Speed

The length of time for selection o

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

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.

[Click to close.]

FOR MORE INFORMATION

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.)

1X TO 1000X

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

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

Classic, Permit, FirstRate, etc.

GROUP	2	HERBICIDE

Select, Assure, etc.

GROUP	1	HERBICIDE

Herbicide Resistance Types

Single Herbicide Resistance

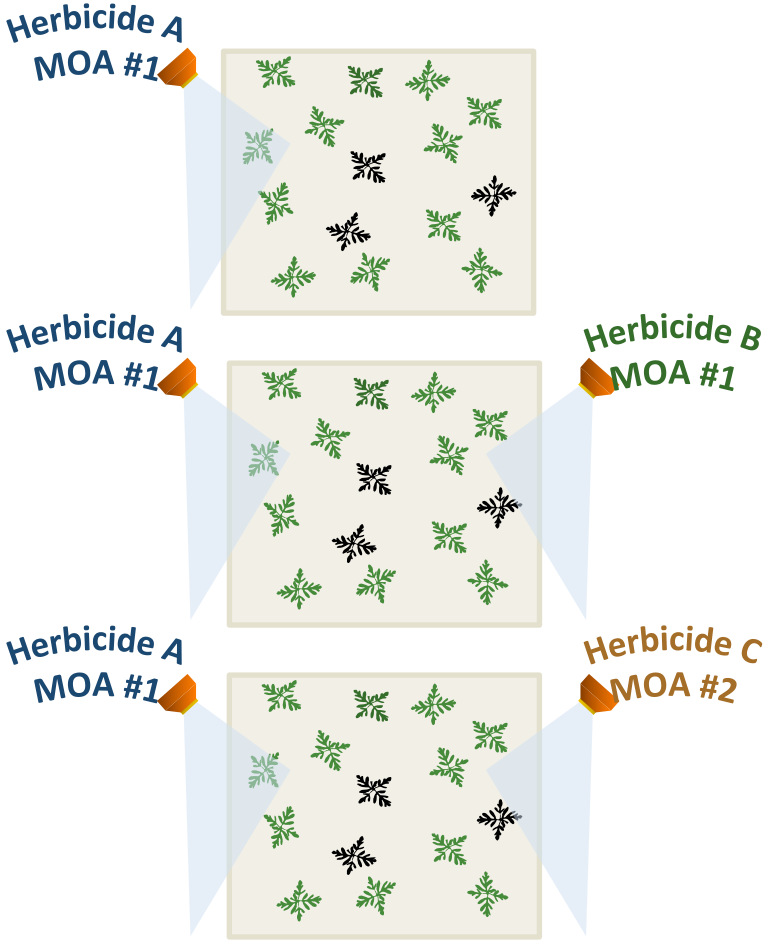
- Resistant to only *one* herbicide

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



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.

- Wes Everman, PhD (North Carolina State University)
- Les Glasgow, PhD (Syngenta Crop Protection)
- Lynn Ingegneri, PhD (Consultant)
- Jill Schroeder, PhD (New Mexico State University)
- 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)
- François Tardif, PhD (University of Guelph)

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UC IPM WEBSITE:
http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html.
(Help ID/Treat species in commodity)

http://www.wssa.net/Weeds/Resistance/WSSA-Mechanism-of-Action.pdf