HERBICIDE RESISTANCE STEWARDSHIP IN RICE

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What is Weed Resistance?

- Herbicide resistance is the ability of certain biotypes within a weed species to survive a herbicide treatment that would normally have killed it
- Herbicide-resistant biotypes are present within a weed species' population as a part of normal genetic variation
- Repeated use of the same herbicide or mode of action (MOA) will select for herbicide-resistant biotypes
- In California, we have two types of herbicide resistance: 1) **Target Site** resistance and 2) **Enhanced Metabolic Degradation** resistance
- Certain weed biotypes can be simultaneously resistant to herbicides that differ chemically and in their MOA
- Weeds that are not on the label will tolerate the herbicide, but are not resistant biotypes

Symptoms of Weed Resistance in the Field

Resistance needs to be ultimately confirmed by a specific test. Failure to control weeds can occur due to factors such as faulty spraying, incorrect dose or timing, weeds too large, subsequent weed germination after treatment, very large infestations, poor coverage, and other factors. The presence of resistance in the field is characterized by the following:

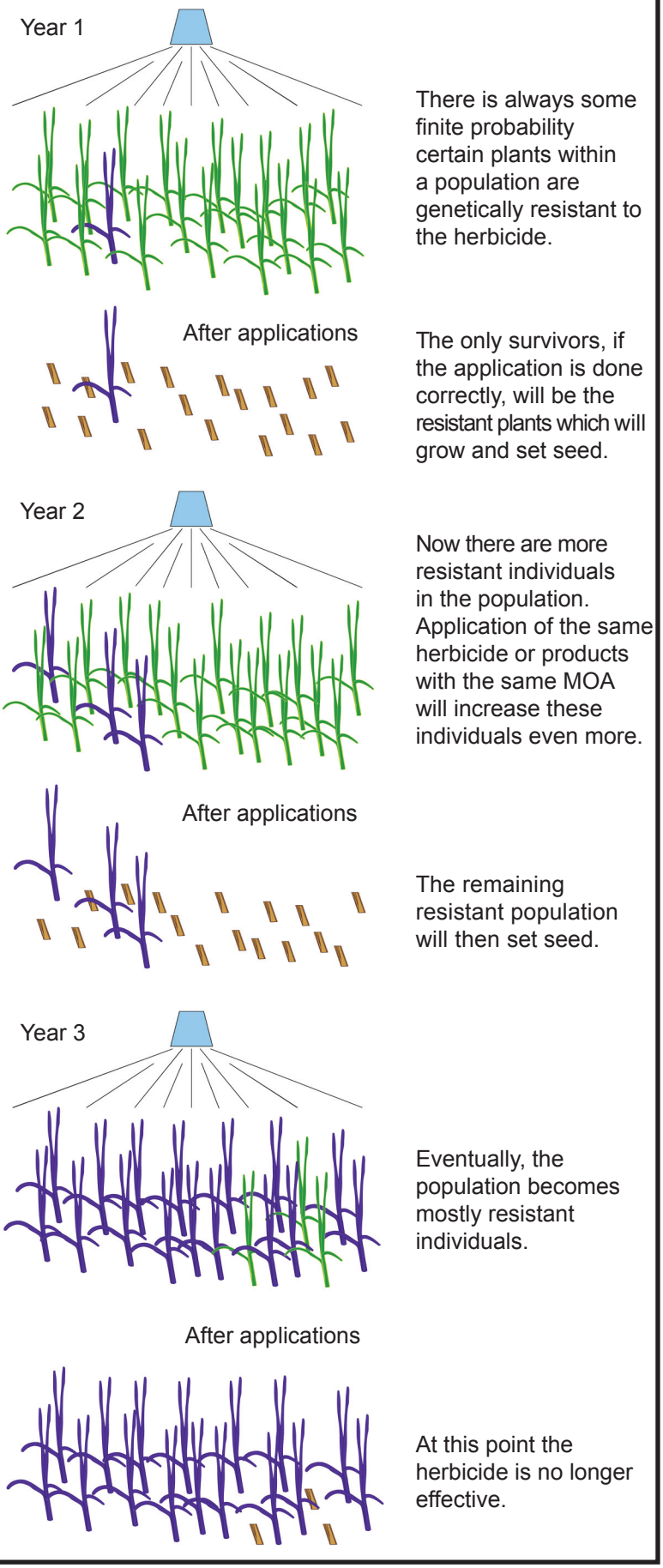
- There are healthy looking plants alongside dead plants of the same species after treatment
- One susceptible species is poorly controlled, while other adjacent susceptible species are well controlled
- The species was previously well controlled by the same herbicide and rate but a gradual decline in control has been noticed over time
- The same herbicide (or herbicides with the same MOA) has been used repeatedly on the same site
- Discrete patches of the target weed persistently survive treatment with a given herbicide(s)
- Resistance in the same weed species and herbicide occurs in neighboring fields

What Factors Favor the Evolution of Resistance?

- Excessive reliance on chemical control and repeated sequential use of the same MOA
- A monoculture of continuous rice production
- Weeds that produce lots of seeds with little dormancy and short longevity
- A herbicide that has high efficacy on a specific weed species
- A herbicide with prolonged residual activity

Endorsed by the California Rice Commission and the California Rice Research Board

How resistant biotypes are selected



Herbicide Susceptibility Chart

Herbicide: Grouped by Mode of Action	Barnyardgrass	Early Watergrass	Late Watergrass	Sprangletop	Smallflower	Ricefield bulrush	CA arrowhead	Ducksalad	Redstem	Monochoria
ALS Inhibitor*										
Londax	R	R	R		R	R	R	●	R	
Granite	r	r	R		R	●	●	●	●	●
Regiment	R	R	R			R	●	○	○	○
ACCase Inhibitor										
Whip	R	R	R	●						
Clincher	R	R	R	●						
Lipid Inhibitor										
Bolero/Abolish	R	R	R	●	●					
PSII Inhibitor										
Stam/Wham	●	●	●		●	●	○	○	○	○
Pigment Inhibitor										
Cerano	r	r	R	●						
Auxin Mimic										
Grandstand						●			●	
Protox Inhibitor										
Shark					●	●	●	○	○	○

Legend

Type resistance: **R** - TS; R - EMD

● control

○ suppression

R, R - resistant, poor control

r - **moderately** resistant, may escape

*Resistance evolves rapidly with the repeated use of ALS inhibitors. . Therefore, when resistance to a specific ALS herbicide is detected for a certain weed, its use for controlling other weeds in that field may accelerate resistance evolution for those weeds as well. It is best to use a herbicide with a different mode of action or if there is no other choice available, then the ALS inhibitor must be used in mixture or in sequence with a different mode of action active on all those weeds.

Use the colors in the chart to group by Mode of Action (MOA) and type of resistance. This is complicated by the fact that we have both Target Site (TS) resistance for the ALS and Enhanced Metabolic Degradation (EMD) resistance across groups of herbicides—EMD being particularly important for the "grass" herbicides. Avoid the same MOA twice in the same year or in consecutive seasons.

	Year 1	*Year 2*	*Year 3*
TS (broadleaf and sedges) R			
No!	Londax	Granite	Regiment
Yes!	Londax	Abolish	SuperWham
EMD (grasses) R			
No!	Clincher	Bolero	Granite
Yes!	**Any order of EMD resistant herbicides should be followed by propanil in the same season or rotated with propanil to protect against resistance.**		

The weed susceptibility chart on the left lists different rice herbicides grouped by color by their MOA. Herbicides with the same color have the same MOA. Herbicides with the "white R" exhibit EMD resistance across several MOAs. On the top is a list of the principal rice weeds. An effective tank mix or sequential program will include herbicides that have different MOAs as well as herbicides that do not have EMD resistance. Some may be tank mixed or applied sequentially. The application timing varies so a good program with different MOAs can be used to prevent or control escapes. The choices are more limited for some of the broadleaf weeds such as Redstem, with only two MOAs available. A successful weed resistance management program has to consider these factors both within a single season as well as over multiple cropping years. The same MOA or herbicide with EMD resistance used successively in a single season or in back-to-back cropping seasons should be avoided.

Herbicides are key tools that need to be protected, particularly the ALS inhibitors

- ❑ Resistance evolution is driven by your weed control decisions
- ❑ Resistance management requires keeping records of past herbicide use and planning of herbicide use in future years
- ❑ Dealing with resistance will require intensive management and higher costs

How to delay the Evolution of Resistance?

1. Cultural practices
   - Use of weed-free certified crop seed
   - Control all weeds that escape to prevent seed return to the field by cutting, roguing, or spraying weed patches with a non-selective herbicide
   - Avoid spreading resistant weeds: clean equipment, harvest resistant fields last, etc.
   - Alternate rice stand establishment systems to shift natural infestations and discourage the prevalence of specific resistance weeds (Use **stale-seedbed technique** whenever possible)
   - Practice crop rotation whenever feasible
   - Maintain adequate water depth for weed suppression

2. Herbicide use
   - Avoid using the same MOAs sequentially within the same or consecutive seasons. Control escaped weeds with sequential applications of alternate MOA herbicides
   - Use tank mixtures of two herbicides that are equally effective on the same weed and, if possible, with similar residual activity
   - With different residual activity, apply the tank mixtures when most weeds have emerged, and maintain adaquate water depth
   - Don't use the same tank mixture repeatedly
   - Practice the stale seed-bed technique whenever possible prior to seeding the crop
   - Do not use ALS inhibitors or ACCase inhibitors as the sole means of control
   - Keep yearly records of herbicide use within each field