Herbicide Resistance Management

W. Thomas Lanini, University of California, Davis
wtlanini@ucdavis.edu

Herbicide-resistant weeds generally occur where the same herbicide or herbicides with the same site of action are used repeatedly. To prevent the appearance of herbicide-resistant weeds, you must know in which chemical family an herbicide belongs and which herbicides have the same site of action. Table 1 lists weeds resistant to herbicides in California, along with the site of action grouping, chemical name, and trade names. Herbicide families that have the same site of action are the same group number. An herbicide program to prevent resistance does not use herbicides from the same group more than once in 3 years.

Management can prevent or delay the appearance of herbicide-resistant weeds. The following practices can be used with the information on herbicide families provided in the table to form an herbicide resistance management strategy.

Prevention

Herbicide rotation —Avoid year-after-year use of herbicides that have the same site of action. At one time this meant not using herbicides from the same chemical family, but this is no longer the case. For example, two chemically different groups of herbicides, the sulfonylureas and imidazolinones, have the same site of action, ALS inhibitors. For another example, Prism and Poast belong to different chemical families but kill susceptible grasses in the same way.

Avoid repeated application of herbicides —Repeated applications within a growing season of an herbicide with no soil activity (e.g., glyphosate) has resulted in weeds resistant to the herbicide.

Crop rotation —Because different crops may require different herbicides, rotating crops can increase herbicide rotation. But with glyphosate resistant crops, crop rotation alone may not be enough to avoid weed resistance.

Cultivation/Hand weeding —In row crops, orchards, and vineyards cultivation can be an effective tool for eliminating weed escapes that may represent the resistant population. Tillage or hand weeding controls herbicide-resistant and herbicide-susceptible weeds equally as long as seedlings of the two biotypes emerge at the same time.

Accurate record keeping — To have an effective herbicide rotation or tank-mix system to prevent resistance, you must know which herbicides have been used in the past, at what rate, and how often.

Integrated weed management —This concept is important for all weed control, not just management of herbicide-resistant weeds. Integrated weed management uses all the tools available to control weeds, including cultural, mechanical, and chemical methods. An integrated approach to weed management, whether it is in crop or noncrop land, is an important environmental and economic consideration.

Monitor fields for weed escapes —Weed escapes are not necessarily resistant, but they may be. A resistance problem may not be visible until 30 percent or more of the weeds are no longer controlled. See whether escapes are only one species or a mixture. If only one species, the problem is more apt to be resistance, especially if the herbicide controlled the species in the past and if the same herbicide has been used repeatedly in the field.

Keep weeds from spreading —Prevent known resistant weeds from flowering and producing seed. After using machinery in fields or areas with known or suspected

Table 1. Weeds resistant to herbicides in California

Group Type and Site of Action[1]	Weed	Chemical	Trade names
Group A/1 Acetyl CoA carboxylase	Late Watergrass (*Echinochloa phyllopogon*)	fenoxaprop-p-ethyl	Puma, Whip, Acclaim
(ACCase) inhibitors	Barnyardgrass (*Echinochloa crus-galli*)	cyhalofop-butyl, fenoxaprop-p-ethyl, molinate, thiobencarb	Clincher, Whip, Ordram, Bolero
	Early Watergrass (*Echinochloa oryzicola*)	cyhalofop-butyl, fenoxaprop-p-ethyl, molinate, thiobencarb	Clincher, Whip, Ordram, Bolero
	Little Seed Canary Grass (*Phalaris minor*)	Fluazifop, fenoxaprop-p-ethyl, sethoxydim, clethodim	Fusilade, Whip, Poast, Prism, Select
Group B/2 Acetolactate	Perennial Ryegrass (*Lolium perenne*)	sulfometuron-methyl	Oust
synthase (ALS)	Smallflower Umbrella Sedge (*Cyperus difformis*)	bensulfuron-methyl	Londax
inhibitors	California Arrowhead (*Sagittaria montevidensis*)	bensulfuron-methyl	Londax
	Redstem (*Ammania auriculata*)	bensulfuron-methyl	Londax
	Ricefield Bulrush (*Scirpus mucronatus*)	bensulfuron-methyl	Londax
Group B/2 Acetolactate	Long-Leaved loosestrife (*Ammania coccinea*)	bensulfuron-methyl	Londax
synthase (ALS) inhibitors	Russian Thistle (*Salsola iberica*)	chlorsulfuron, sulfometuron-methyl	Telar, Oust
Group O/4 Synthetic auxins	Smooth Crabgrass (*Digitaria ischaemum*)	quinclorac	Facet
Group N/8 Lipid	Wild Oat (*Avena fatua*)	difenzoquat	Avenge
synthesis inhibitors	Late Watergrass (*Echinochloa phyllopogon*)	thiobencarb	Bolero
but not ACCase	Early Watergrass (*Echinochloa oryzicola*)	thiobencarb	Bolero
inhibitors	Barnyardgrass (*Echinochloa crus-galli*)	thiobencarb	Bolero
Group G/9 EPSP	Rigid Ryegrass (*Lolium rigidum*)	glyphosate	Roundup, Touchdown, etc
synthase inhibitors	Horseweed (*Conyza canadensis*)	glyphosate	Roundup, Touchdown, etc
	Hairy Fleabane (*Conyza bonariensis*)	glyphosate	Roundup, Touchdown, etc
	Junglerice (*Echinochloa colona*)	glyphosate	Roundup, Touchdown, etc

[1] Mode of action classification based on Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America systems.

infestations of herbicide-resistant weeds, thoroughly clean the equipment to reduce the spread of resistant weeds from one field or area to another.

Change crops and tillage systems —Crop rotation and altered tillage practices can affect the weed populations. Alternating spring and winter crops means that the field will be tilled at different times each year. During one of the field preparation operations, resistant as well as susceptible weeds will be killed.

Change herbicide program —If weed resistance occurs, herbicides with other sites of action and other weed management practices must be used.

Control of Roundup Resistant Ryegrass in Almonds

Ryegrass (*Lolium multiflorum or rigidum*) has been reported to be resistant to glyphosate (Roundup) in Sacramento Valley of California. An experiment was conducted in a mature almond orchard, located on the Pante Farm, near Durham, California, (N39º38.545, W121 º46.027) to assess ryegrass control.

Experimental plots were arranged in a randomized complete block and replicated 6 times. Individual plots were 10 ft. wide by 27ft. long, with a single almond tree in the center of each plot. Treatments were applied on November 22, 2006, using a CO_2 powered backpack sprayer. Visual evaluations of ryegrass control were made at 1, 2, 3, 4, 6, 12, and 20 weeks after application. Additionally, overall weed control was assessed at 20 weeks and 30 weeks after treatment.

At one week after treatment, ryegrass control was over 90% if Gramoxone was included in the treatment (Table 2). The addition of other herbicides with Gramoxone did not influence ryegrass control. Weather was relatively cool during the week after application and activity of the systemic herbicides was much slower. By two weeks after treatment, the Gramoxone treatments were still providing the best control, but other treatments were starting to show more activity, particularly the Chateau treatments. By three weeks after treatment, Roundup plus Poast treatments were also providing 90% control, with the exception of the Roundup plus Poast plus Princep treatment. The addition of Princep, a wettable powder, may have caused some binding of the active herbicide molecules, and thus a reduction in activity of both the Roundup and Poast, as has been reported previously.

By 12 weeks after application, all treatments except Roundup alone, were providing 90 percent or better ryegrass control. Roundup alone provided about 50% control, which probably represents the portion of the ryegrass population which was sensitive to glyphosate. The addition of Poast, Surflan, Princep, or Chateau, to Roundup, resulted in about 50% better ryegrass control.

In summary, Roundup alone would not be an effective treatment in situations where glyphosate resistant ryegrass was present. The addition of Poast can help to control the ryegrass. Gramoxone was effective against established ryegrass, but a residual material would help to improve residual weed control. Princep should not be added to Roundup treatments as antagonism would likely reduce activity.

Table 2. Ryegrass control (%) relative to herbicide treatment and evaluation date.

Treatment	11/29	12/6	12/13	12/20	1/2	2/12	4/13
Roundup 1.5 lb/A	3	22	42	48	53	51	48
Roundup 1.5 lb/A + Poast 0.375 lb/A	7	38	90	91	94	97	97
Poast 0.375 lb/A	1	13	26	42	79	97	94
Roundup 1.5 lb/A + Poast 0.375 lb/A + Surflan 4 lb/A	4	31	90	92	99	99	100
Poast 0.28 lb/A + Surflan 4 lb/A	2	10	25	48	88	99	98
Roundup 1.5 lb/A + Poast 0.375 lb/A + Princep 2 lb/A	2	12	53	70	90	97	92
Poast 0.375 lb/A + Princep 2 lb/A	4	10	22	37	75	98	97
Roundup 1.5 lb/A + Chateau 5.1 oz/A	6	52	72	82	97	96	96
Roundup 1.5 lb/A + Poast 0.375 lb/A + Chateau 5.1 oz/A	39	62	94	96	99	99	99
Gramoxone 1.0 lb/A	93	94	94	95	93	90	90
Gramoxone 1.0 lb/A + Surflan 4 lb/A	96	97	96	96	99	99	99
Gramoxone 1.0 lb/A + Poast 0.375 lb/A + Surflan 4 lb/A	94	98	96	98	99	99	99
Gramoxone 0.75 lb/A + Princep 2 lb/A	96	99	98	99	100	99	99
Gramoxone 0.75lb/A + Poast 0.375 lb/A + Princep 2 lb/A	93	96	99	99	99	99	99
Untreated	0	0	0	0	0	0	0
LSD .05	13	13	16	18	15	10	11