

Cotton Field Check

June 20, 2004

A Cotton Management Update from UC Cooperative Extension

Herbicide Resistance Management

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Background

The use of herbicides in production systems have allowed growers to effectively and economically control weeds. Hard to control weeds, such as field bindweed and annual morningglory, can now be effectively managed in cropping systems. Selective herbicides have allowed the reduction, and in some cases, the elimination of hand weeding all together. Cultivation has been reduced in field and vegetable crops with movement toward reduced or minimum tillage systems. The new generation of herbicides are much more environmentally friendly, controlling weeds with only ounces of active ingredients per acre as opposed to pounds per acre required by some of the older herbicides. The introduction of herbicide tolerant crops has provided growers with an additional option for effective control. But, for herbicides to remain effective and to sustain their use, attention and consideration must be given to Herbicide Resistance.

Weed resistance to herbicides is not a new phenomenon (Table 1), but is somewhat less known and experienced than insecticide or fungicide resistance. The first report of herbicide resistance occurred in 1960 with the discovery of Trazine resistant common groundsel. Since that time 287 weed biotypes around the world have evolved resistance to herbicides. Both hairy fleabane and buckhorn plantain are resistant to glyphosate in South Africa. Hairy fleabane has become difficult to control with glyphosate in our California production systems, indicating possible development of resistance. Reports of poor or ineffective control of lambsquarter in our Roundup Ready cotton systems have surfaced in the last two years. And just recently, Roundup resistance horseweed (marestalk) has been confirmed in the eastern U.S.

In California the greatest herbicide resistance problems have occurred in aquatic weeds in rice production in the Sacramento Valley. Many of these weeds species have been selected for resistance to the sulfonylurea herbicide bensulfuron (Londax). Rigid ryegrass (*Lolium rigidum*) has exhibited resistance to glyphosate (Roundup) in northern California. Although there are few cases of resistance in California there are many herbicides in use that have selected resistance in many weed species throughout the U.S. With the use of Staple in cotton, Shadeout in tomatoes, Upbeat in sugarbeets, Londax in rice, Pursuit in alfalfa and Assert in wheat, all herbicides that lead to rapid selection for resistant weeds, it is probable that the number of cases in California will increase. In addition the availability of Roundup Ready cotton and corn, BXN (bromoxynil tolerant) cotton and the soon to be released, Roundup Ready alfalfa, may promote the sole reliance on one particular herbicide that will increase the selection pressure on weeds for resistance.

Definition of Resistance

“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 contrast, tolerance can be defined as the inherent ability of a plant to survive and reproduce with an herbicide treatment at a normal use rate. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering. Resistance may occur in plants by random and infrequent mutations; no evidence has been presented to demonstrate herbicide-induced mutation.

Through selection, where the herbicide is the selection pressure, susceptible plants are killed while herbicide resistant plants survive to reproduce without competition from susceptible plants.

Factors Leading to the Development of Herbicide Resistance

Most weed species contain a tremendous amount of genetic variation that allows them to survive under a variety of environmental conditions. The development of herbicide-resistant weed species is brought about through selection pressure imposed by repeated, often nearly continuous use of a herbicide. Long residual preemergence herbicides or repeated application of postemergence herbicides will further increase selection pressure. Factors that can lead to or accelerate the development of herbicide resistance include weed characteristics, chemical properties and cultural practices.

Weed characteristics conducive to rapid development of resistance to a particular herbicide include:

1. Annual growth habit.
2. High seed production.
3. Relatively rapid turnover of the seed bank due to high percentage of seed germination each year (i.e., little seed dormancy).
4. Several reproductive generations per growing season.
5. Extreme susceptibility to a particular herbicide.
6. High frequency of resistant gene(s), (e.g. *Lolium rigidum*).

Herbicide characteristics which lead to development of herbicide resistance in weed biotypes include:

1. A single site of action for the herbicide material
2. Broad spectrum control.
3. Long residual activity in the soil.

Cultural practices can also increase the selective pressure for the development of herbicide resistant biotypes. In general, complete reliance on herbicides for weed control can greatly enhance the occurrence of herbicide resistant weeds. Other factors include:

1. Shift away from multi crop rotations towards mono cropping (orchard and vineyard systems).
2. Reduced or no till productions systems.
3. Continuous or repeated use of a single herbicide or several herbicides that have the same mode of action (transgenic herbicide tolerant crops).
4. High and/or low herbicide use rate relative to the amount needed for weed control.

Resistant Management

The first step to preventing herbicide resistance is early detection. Scout fields and be on the lookout for patterns that would indicate resistance. Whole fields infested with weeds or strips of weeds does not typically indicate resistance. Patterns of resistance include: patches in fields, patches of dense populations with lessor population radiating out from the central patch and escapes scattered in no particular pattern throughout the field.

How to Prevent or Delay Herbicide Resistance

Weed management strategies that discourage evolution of herbicide resistance should include:

- Herbicide Rotation
- Crop Rotation
 - Plant to a crop having a different season of growth
 - Plant to a crop where different registered herbicides are typically used
 - Plant to a crop for which there are alternative, suitable methods of weed control
- Monitor After Herbicide Application
 - Check for weedy patches in fields in patterns consistent with herbicide application problems
 - Hand-weed patches of weeds that are present in patterns consistent with herbicide application problems
- Non-chemical Weed Control Techniques
 - Cultivate
 - Hand-weed. A 90 percent or greater rate of weed removal reduces the chances that a resistant plant will produce seed
 - Mulch with both synthetic and organic materials
 - Solarize the soil
- Use short-residual herbicides
- Use Certified seed to reduce potential weed seed load
- Clean any equipment used in the field that could be contaminated with weed seed or otherwise introduce weed species to fields
 - Use a power washer or compressed air to help remove seed and weed plant parts

How to Manage Herbicide-Resistant Weeds

To keep herbicide-resistant weeds under control, incorporate these strategies into your management plans:

- Herbicide Rotation
 - Go to www.wric.ucdavis.edu to guide your herbicide rotation decisions
 - Look at Table 2 in this article for “Herbicides registered for cotton”
- Fallow mechanical tillage practices
- Use of close cultivation practices where possible
- Use of hand weeding crews to remove weeds within the seeding row
 - Monitor hand weeding crew to insure that 90 percent or more of the within-row weeds are removed
- Prevent weed seed spread through the use of clean field equipment
 - If any of your fields have a history of herbicide resistant weeds, work those fields last in your use of farm equipment
 - Use a power washer or compressed air to thoroughly clean equipment to remove weed seeds
- Monitor initial evolution of herbicide resistance by recognizing patterns of weed escapes typical of resistant plants
 - Watch for small weed patches that appear in same place in the subsequent crops
 - Watch for weed patches that do not have regular shapes more indicative of a herbicide application problem
- Aggressively try to control weeds suspected of herbicide resistance before they can produce seed

If you suspect weed resistance where herbicide applications have failed to control weeds, to further confirm check the following: 1) only one weed species has escaped, 2) sprayer calibration, 3) were weather conditions favorable for herbicide performance, 4) confirm by respraying and, 5) report problem to UCCE Farm Advisor.

The potential for herbicide resistance should receive serious and thoughtful attention. As weed management systems change with new herbicides and herbicide resistant crops are introduced, resistant management must be an integral part of the production system. If selection pressure is maintained through the continuous use of the same herbicide, herbicide resistance will soon render it ineffective.

For more information go the University of California Weed Research and Information Center web site at www.wric.ucdavis.edu.

References

Prather, T., Ditomaso, J., and Holt, Jodie. Herbicide Resistance: Definition and Management Strategies. ANR Publication 8012.

International Survey of Herbicide Resistant Weeds. www.weedscienc.org/in/asp.

Weed Science Society of America. www.wssa.net

WSSA.2002. Herbicide Handbook, Eighth Edition.

Table 1. Most common genera of weeds developing resistance to herbicides worldwide and in California.

Genus	Common name	Number of documented occurrences of herbicide resistance	
		Worldwide	In California
<i>Amaranthus</i>	Pigweed	42	0
<i>Chenopodium</i>	Lambsquarters	25	0
<i>Conyza</i>	Fleabane or horseweed	22	0
<i>Lolium</i>	Ryegrass	21	2
<i>Setaria</i>	Foxtail	17	0
<i>Avena</i>	Wild oat	15	1
<i>Echinochloa</i>	Barnyardgrass or watergrass	15	3
<i>Alopecurus</i>	Blackgrass	13	0
<i>Senecio</i>	Groundsel	12	1
<i>Polygonum</i>	Knotweed or smartweed	12	0
<i>Solanum</i>	Nightshade	11	0

Table 2. Herbicides Registered for Cotton Production (including classification by mode of action and group assigned by WSSA (Weed Science Society of America))

Chemical Name	Trade Name	Mode of Action	WSSA Group
metham	Vapam	Fumigant	27
MSMA	MSMA	Organoarsenical	17
trifluralin	Treflan/Trifluralin	Mitotic Inhibitor	3
pendimethalin	Prowl	Mitotic Inhibitor	3
prometryn	Caparol	Photosynthesis Inhibitor	5
diuron	Karmex/Diuron	Photosynthesis Inhibitor	7
glyphosate	Roundup Ultra Max Touchdown IQ	Amino Acid Synthesis Inhibitor	9
pyrithiobac	Staple	Amino Acid Synthesis Inhibitor	2
metalachlor	Dual	Shoot and Root Inhibitor	15
paraquat	Gramoxone Max	Cell Membrane Disrupter	22
oxyfluorfen	Goal	Diphenylethes	14
flumioxazin	Valor	N. phenylphthalimide	14
bromoxynil	Buctril	Uracials	6
fluzafop-p-butyl	Fusilade	Lipid Biosynthesis Inhibitor	1
sethoxydim	Poast	Lipid Biosynthesis Inhibitor	1
clethodim	Prism	Lipid Biosynthesis Inhibitor	1

Use of trade names does not constitute an endorsement by the University of California. Read and follow all labels before use. *Same color and WSSA group letter indicates same mode of action.

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June 2004

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