

Benefits & Problems of Herbicide Tolerant and Conventional Herbicides in Cotton and Corn

Steve Wright¹, Ron Vargas²

*¹University of California Cooperative Extension, Tulare & Kings Counties
4437B S Laspina St, Tulare, CA 93274, sdwright@ucdavis.edu*

*²University of California Cooperative Extension, Madera & Merced Counties
328 Madera Ave, Madera, CA 93637, rnvargas@ucdavis.edu*

Herbicide tolerant crop acreage has increased dramatically in the United States and amounts to approximately 42 percent of the California cotton and 50 percent of the corn acreage. The herbicide tolerant acreage of both cotton and corn should continue to increase as higher yielding varieties receive these traits. Because of air pollution concerns growers are given credits by reducing cultivations and other tillage as part of the San Joaquin Valley Air Pollution restrictions.

Integrating herbicide resistant crop technology and conventional herbicides makes sense for many reasons. One of the main concerns is preventing weed resistance. There is a high probability of developing resistant weed species and/or weed shifts when solely relying on one type of herbicide. For example, we have Roundup resistant annual ryegrass and horseweed in California. Cotton growers have also reported poor control of barnyardgrass and lambsquarter in some cases. Some of this reduction in control could also be due to applying glyphosate to drought stressed weeds. Resistance issues are not just unique to glyphosate. Herbicide resistance has shown up where there are many reports of reduced control of barnyardgrass with continual use dinitroanilines in cotton in the San Joaquin Valley. Some California growers have observed reduced nutsedge control with continuous use of thiocarbamate herbicides in corn.

Roundup Ready Technology in Cotton

The Roundup Ready technology has provided growers with an excellent tool for managing many annual and perennial grasses, broadleaves such as nightshades and annual morningglory, and nutsedge in cotton. Some of the advantages to this system include the following: 1) Glyphosate can be applied post emergence so growers can wait and see the weeds present. 2) There are no plant back restrictions. 3) Glyphosate has a wide spectrum of weed control controlling or suppressing many annuals and perennials.

Some of the problems associated with the older Roundup Ready system include the following: 1) there is a narrow window of application, 2) it must be applied before cotton has 5 leaves, 3) hooded sprayers were needed to safely apply later directed applications, 4) nutsedge and annual morningglory can still be a challenge and 5) variety selection can be limited in that the technology is somewhat behind. The highest yielding varieties often do not have this trait.

The new "Roundup Ready Flex" systems can be applied early and much later in the season. Even with the herbicide tolerant technology weeds like annual morningglory, lambsquarter, and barnyardgrass are increasing especially when growers are only relying on glyphosate. In other cotton growing states where Roundup Ready cotton is grown on greater than 70 percent of the acreage a weed shift has developed after 7 years of a reduced tillage systems coupled with extensive use of glyphosate. These weeds include amaranth, horseweed, giant ragweed, and tropical spiderwort.

Texas Extension Specialist Dr. Peter Dotray reported at the 2005 Beltwide Cotton conference that the adoption of glyphosate-tolerant cotton expressed in terms of percent of acres planted was approximately 20% in 1998, 68% in 2001, and 73% in 2004. The overall amount of herbicide active ingredients used in U.S. upland cotton has not changed much from 1996 to 2003. Reduced use of preplant and preemergence herbicides such as trifluralin (-22%), pendimethalin (-26%), prometryn (-28%), fluometuron (-84%), clomazone and norflurazon (both -97%) has been offset by the increased use of glyphosate (753%) and diuron (101%) from 1997 to 2003 when expressed in terms of percent of adjusted U.S. upland cotton acreage. In many regions, reduced tillage, spot treatments, early postemergence-directed applications, and hand hoeing has decreased because of this technology. Increased seed cost and technology fees are making this technology difficult to afford for many producers.

Dr. Dotray also stated that the number of herbicide options in the future excluding generics will likely decrease, but some of the traditional (standard) options will continue to play an important role in weed management. If glyphosate usage continues to increase, the industry incentive to support existing and older active ingredients may decrease. If glyphosate resistant weeds continue to develop and major shifts in weed populations occur, fewer herbicide options may be available due to the number of older herbicides lost to re-registration and the decline in the number of herbicides brought to market.

Dr. Stanley Culpepper reported that a recent survey of weed scientists focused on weed shifts in GR cotton systems. Six scientists in six states (AL, GA, FL, MO, NC, and TX) responded to the survey. All scientists noted weed shifts have occurred, and *Amaranthus* species, annual grasses, dayflower species (*Commelina* sp.), morningglory species (*Ipomoea* sp.), and winter annuals were becoming more problematic in response to currently utilized GR management systems. Four of six states noted these shifts are of economic concern and all specialists are addressing weed shift issues by recommending 1) the use of residual herbicides in current GR programs, 2) the addition of other herbicides in mixture with glyphosate, 3) rotation to other herbicide chemistry, and 4) rotation away from GR crops when feasible.

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, shifting away

from multi crop rotations towards mono cropping, reduced or no till productions systems, continuous or repeated use of a single herbicide or several herbicides that have the same mode of action, high and/or low herbicide use rate relative to the amount needed for weed control and growing an herbicide tolerant crop where the same herbicide is applied repeatedly

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 that lead to rapid development of herbicide resistance in weed biotypes include 1. a single site of action, 2. broad-spectrum control and 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.

Integrated Weed Management Costs

The herbicide tolerant cotton and corn systems have allowed growers to effectively control most annual and perennial weeds, to reduce or eliminate hand hoeing, and reduce the number of cultivations. Cost savings range from \$25 to \$120/acre is achieved. Even if growers use an herbicide tolerant system, it is still advisable to use one of the following preplant incorporated herbicides in cotton: Prowl, Treflan, Caparol, or Caparol + Treflan/Prowl. The cost is low (\$6-\$8/A) and controls most annual grasses and many broadleaves. Ultimately, the decision to use one herbicide tool over another and how to integrate different herbicides will depend on costs and effectiveness.

There has been considerable interest in reduced tillage corn. A crucial aspect of no-till corn management revolves around weed control. Keeping noxious weeds and grasses out of dairy silage is essential if the highest quality silage is to be harvested. Corn growers have used a variety of different herbicide programs, but the Roundup Ready® corn system is the easiest in terms of managing weeds when the tillage is eliminated or used less frequently. Interestingly, the market penetration for Roundup Ready corn technology is higher in California than in any Corn Belt state. It is the highest market penetration in the nation, according to Monsanto. Just a couple of years ago, Roundup Ready Corn was planted on just over 30 percent of the state's corn acres. By the 2003 season, we had planted Roundup Ready Corn on 50 percent or more acreage. Growers have a wide selection of corn hybrids available with Roundup Ready technology. The new Pioneer® corn varieties with the Roundup Ready gene will further fuel the adoption of transgenic corn.

Most no-till corn growers who use the Roundup Ready system do not use a pre-emergence herbicide, preferring instead to rely on over-the-top applications of Roundup UltraMAX® herbicide, often alone but sometimes in either tank mixes with 2,4-D, dicamba, halosulfuron (Sempra) or in conjunction with separate treatments of these herbicides. Corn growers who use dairy manure as fertilizer need to work extra hard to stay on top of weed control. Some tillage once in awhile, and combined with use of different herbicides, may be necessary where dairy manure is applied to fields.

Summary

The herbicide tolerant systems in cotton and corn has reduced weed control costs and given growers greater flexibility. This has allowed growers and researchers to explore alternative production systems such as conservation or reduced tillage, double row configurations, and ultra narrow row systems. We now have available Roundup Ready varieties that have more crop safety with a greater application window. Liberty Link Cotton by Bayer using glufosinate (Ignite) should have a good fit in California.

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.

A resistance management approach must incorporate crop/herbicide rotation and control of weed escapes by tillage or hand. An integrated weed management system supplements an existing transgenic or conventional weed control program and uses a variety of the available pre-plant, selective over-the-top and layby herbicides along with tillage. Keep in mind many of the weeds were not being easily controlled before herbicide tolerant technology was available.

Therefore, it will continue to be necessary to use every available tool in the future to economically control weeds in this year's crop and effectively control weeds from building up in the seed bank for future crops.

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