NEW HERBICIDE TOLERANCE TECHNOLOGY FOR GLYPHOSATE RESISTANT WEED MANAGEMENT IN COTTON

Jonathan Holloway
Linda Trolinder
Bayer CropScience
Lubbock, TX
Jeff M. Ellis
Bayer CropScience
Leland, MS
Scott Baker
Bayer CropScience
Lubbock, TX

Abstract

Roundup Ready®, Roundup Ready Flex® and LibertyLink® herbicide tolerant cotton technologies have enabled US cotton growers to make significant advances in weed management. Roundup Ready Flex® cotton (event Mon 88913) and LibertyLink® cotton (event LLCotton25) provide growers with a wide window for over-the-top applications of glyphosate (Roundup®) and glufosinate ammonium (Ignite®) herbicides, respectively. Ignite® (herbicide group H) and Roundup® (herbicide group G) herbicides not only have distinct modes of action, but also have broad and complementary weed spectra (Hopkins *et al.* 2004).

Bayer CropScience has developed in-house glyphosate tolerant cotton, GlyTol® (event GHB614). Contingent upon regulatory approval, GlyTol® cotton is planned for commercial release in 2009 and will provide US cotton growers with new cotton varieties with robust, season-long tolerance to glyphosate. Agronomic performance field trials have been conducted with GlyTol® cotton across the US cotton belt since 2001. Extensive field testing of GlyTol® cotton was conducted in 2004 and 2005 to support submissions to US regulatory agencies and collaborative trials with University Weed Scientists were conducted across the US cotton belt in 2006 and 2007. These trials have recorded no negative effects on GlyTol® cotton plant establishment, plant height, maturity, vigour, yield or quality following multiple applications at full rates of a number of commercial formulations of glyphosate (Trolinder *et al.* 2008).

LibertyLink® cotton (event LLCotton25) expressing the *bar* gene, and GlyTol® cotton (event GHB614) expressing the 2*mepsps* gene, have been introgressed into a FiberMax® varietal background by backcrossing, resulting in cotton with robust herbicide tolerance to both glyphosate and glufosinate ammonium herbicides. Once approved and available in elite germplasm, LibertyLink® + GlyTol® cotton will provide US cotton growers with the flexibility of over the top applications of more than one mode of action to control their troublesome and glyphosate resistant weeds, without losing the benefits of their established herbicide tolerant management practices. Results of replicated field trials conducted with LibertyLink® + GlyTol® cotton in the Mid-South and Southeast in 2007 are presented here.

Introduction

Weeds impose severe limitations on profitable cotton production in the US. Despite the considerable success of current herbicide tolerant technologies, no single herbicide tolerant cotton technology has proved to be the silver-bullet for weed control. Changes in weed spectra, including an increase in the importance of troublesome weeds, has been a major concern for cotton growers in the US. Troublesome weeds in US cotton crops include broadleaf weeds (*Amaranthus* spp. *Ipomea* spp., horseweed, sicklepod and common cocklebur), grasses (Bermuda grass, Johnson grass and crabgrass) and nutsedge spp. (Hopkins *et al.* 2004).

The widespread adoption of glyphosate tolerant cotton, corn and soybean and emergence of weed management programs heavily reliant on glyphosate herbicide, make herbicide resistance a serious concern for sustainable cotton production (Everman *et al.* 2006).

Rotation of herbicides with different modes of action, such as glyphosate and glufosinate ammonium will be able to assist with the management of troublesome weeds and herbicide resistant weeds in US cotton (York and Culpepper 2004). However, progress with rotations of over-the-top applications of herbicides has been hampered by the relatively limited choices of LibertyLink® varieties in the Southeast where glyphosate resistant weeds are well established (Culpepper *et al*. 2006) and more importantly, by the availability of preferred cotton varieties with tolerance to only a single herbicide group.

Ignite® (herbicide group H) and Roundup® (herbicide group G) herbicides not only have distinct modes of action, but also have broad and complementary weed spectra (Hopkins *et al.* 2004). Many weed species in cotton remain susceptible to glyphosate and there is no documented record of weed resistance to glufosinate ammonium. Over-the-top applications of glyphosate (Roundup®) and glufosinate ammonium (Ignite®) herbicides will remain an important part of profitable cotton production in the US in the foreseeable future.

Bayer CropScience is developing cotton varieties with robust herbicide tolerance to both glyphosate and glufosinate ammonium herbicides. This technology will provide US cotton growers with a new tool for managing troublesome and glyphosate resistant weeds. Results of replicated field trials conducted with this technology in the Mid-South and Southeast in 2007 are presented here.

Materials and Methods

LibertyLink® cotton (event LLCotton25) expressing the *bar* gene, and GlyTol® cotton (event GHB614) expressing the *2mepsps* gene, were introgressed into a FiberMax® varietal background by backcrossing. Replicated field trials were conducted at Bayer CropScience research farms in Leland MS, and Sellers SC in 2007 under USDA permit # 07-065-110n. LibertyLink® + GlyTol® cotton was planted at both locations in a randomised complete block design, with 4 replicates and 8 plots per replicate. Each plot was 4 rows wide by 30ft. Plots were treated with repeated applications (4) of herbicide using a 2 row hand boom and $C0_2$ backpack sprayer (Spray Systems, LA) calibrated to deliver an application volume of 15 gallons of water per acre.

Table 1: Herbicide treatments, application timings and rates in the 2007 trials

Treatments	Application timings and rates g ai/ha			
	6-8 true leaf	Early flowering	Lay-by	50% open bolls
UTC	UTC	UTC	UTC	UTC
EXP Glufosinate 1	600 g ai/ha	600 g ai/ha	600 g ai/ha	600 g ai/ha
Ignite 280SL	600 g ai/ha	600 g ai/ha	600 g ai/ha	600 g ai/ha
Glyfos X-Tra	1121 g ai/ha	1121 g ai/ha	1121 g ai/ha	1121 g ai/ha
EXP Glyphosate 1	1121 g ai/ha	1121 g ai/ha	1121 g ai/ha	1121 g ai/ha
EXP Glufosinate 1+ Glyfos X-Tra	600 + 1121 g ai/ha	600 + 1121 g ai/ha	600 + 1121 g ai/ha	600 + 1121 g ai/ha
Ignite 280SL + Glyfos X-Tra	600 + 1121 g ai/ha	600 + 1121 g ai/ha	600 + 1121 g ai/ha	600 + 1121 g ai/ha
Ignite 280SL + Glyfos X-Tra	600 + 112 g ai/ha	600 + 112 g ai/ha	600 + 112 g ai/ha	600 + 112 g ai/ha

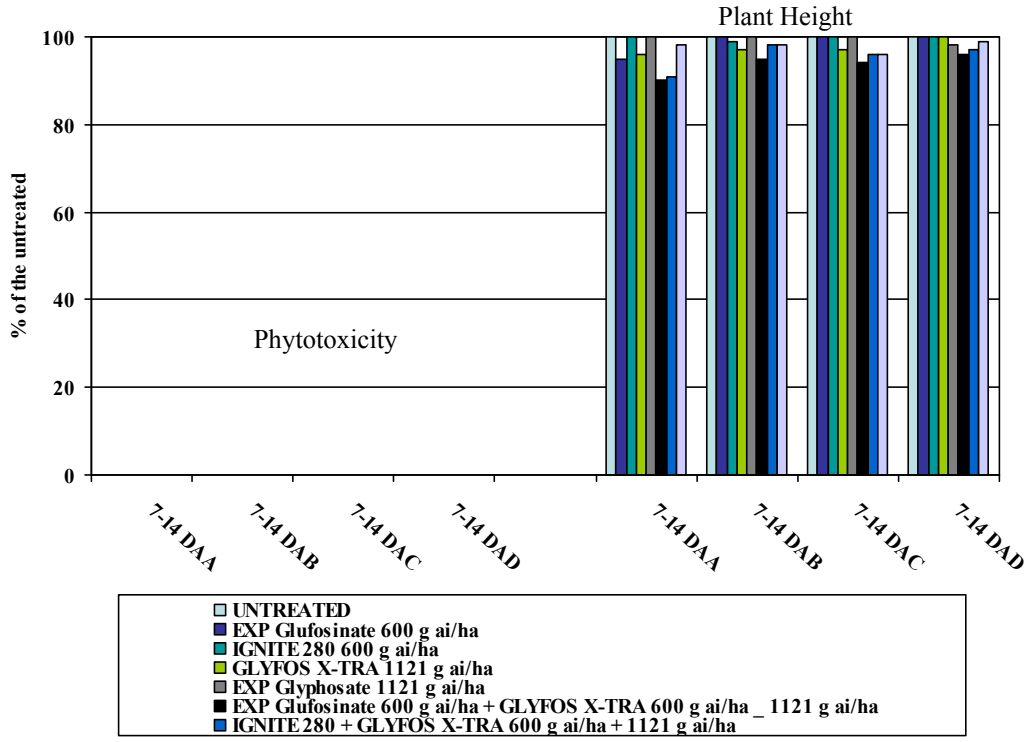
Assessments

LibertyLink® + GlyTol® cotton plots were rated for plant stand at 14 days after planting (DAP), for plant height at 60 DAP and for phyto-toxicity using a 1-5 scale 14 days after each herbicide application. Plots were individually harvested and ginned to estimate seed cotton and lint yields. Fiber samples from each plot were analyzed by HVI for quality parameters by Louisiana State University fiber lab. Data were analyzed using SCOUT, the Bayer CropScience version of ARM software (Gylling data management, SD).

Results

No adverse effects on LibertyLink® + GlyTol® plants were recorded for plant establishment, plant height, maturity, vigour, yield or quality were recorded following multiple (4) applications of full label rates of several formulations of glyphosate and glufosinate ammonium, alone and in mixtures (Figure 1).

Figure 1: Phytotoxicity and plant height ratings of LibertyLink® + GlyTol® cotton after 4 applications (A-D) of herbicide treatments. Data for Sellers, SC only, data for Leland, MS not yet available. No significant differences were recorded between treatments (P = 0.05 Duncan's New MRT).



No adverse effects on yield or fiber quality parameters of LibertyLink® + GlyTol® cotton were recorded following multiple (4) applications of full label rates of several formulations of glyphosate and glufosinate ammonium herbicides, alone and in mixtures (Table 2).

Table 2: Yield and fiber quality data from LibertyLink® + GlyTol® cotton following 4 applications of herbicide treatments. Summary across two trials, Leland MS and Sellers SC.

Treatments	Yield lint lb/acre	Gin Turnout %	Length 1/32	Strength g/Tex	mic
UTC	830.1a	41.4a	1.111a	23.9a	5.4a
EXP Glufosinate 1	787.3a	41.6a	1.109a	23.9a	5.4a
Ignite 280SL	766.6a	40.9a	1.113a	24.8a	5.4a
Glyfos X-Tra	753.7a	41.4a	1.085a	22.8a	5.2a
EXP Glyphosate 1	751.9a	40.9a	1.110a	23.9a	5.1a
EXP Glufosinate 1+ Glyfos X-Tra	795.1[a]	42.4a	1.118[a]	23.6[a]	5.3a
Ignite 280SL + Glyfos X-Tra	783.6[a]	41.8a	1.089[a]	24.2[a]	5.3a
Ignite 280SL + Glyfos X-Tra	771.5a	41.3a	1.103a	25.9a	5.4a

Means followed by same letter do not significantly differ (P=0.05, Duncan's New MRT)

Discussion

LibertyLink® cotton (event LLCotton25) expressing the *bar* gene, and GlyTol® cotton (event GHB614) expressing the 2*mepsps* gene, were introgressed into a FiberMax® varietal background by backcrossing. Replicated field trials conducted with this technology in the Mid-South and Southeast in 2007 have recorded no negative effects on plant establishment, plant height, maturity, vigour, yield or quality following multiple (4) applications of several formulations of glyphosate and glufosinate ammonium, alone and in mixtures. Extensive field testing of LibertyLink® + GlyTol® cotton is planned for 2008.

The widespread adoption of glyphosate tolerant crops including cotton and the emergence of weed management programs heavily reliant on glyphosate herbicide, make herbicide resistance a serious concern for sustainable cotton production (Everman *et al.* 2006).

Table 3: Confirmed cases of herbicide resistance to groups B, O, G and H. The expanded view shows confirmed cases of resistance to group glycine group G – (glyphosate).

Herbicide group	Resistant Weed Species
ALS [group B]	95
Auxin [group O]	25
Glycines [group G]	12
Glutamine Synthase [group H]	0
HPPD [group F2]	0

Year	Common Name	Scientific Name
1996	Rigid ryegrass	*Lolium rigidium*
2000	Horseweed	*Conyza canadensis*
2001	Italian ryegrass	*Lolium multiflorum*
2001	Goosegrass	*Eleusine indica*
2003	Hairy fleabane	*Conyza fleabane*
2003	Buckthorn plantain	*Plantago lanceolata*
2004	Common ragweed	*Ambrosia artemisiifolia*
2004	Giant ragweed	*Ambrosia trifida*
2005	Johnson grass	*Sorghum halepense*
2005	Common waterhemp	*Amaranthus rudis*
2005	Palmer amaranth	*Amaranthus palmeri*
2007	Jungle rice	*Echinochloa colona*

http://www.weedscience.org/summary/MOASummary.asp

Preservation of as many useful tools for weed management as possible will be a key to weed management systems for cotton and other crops in the future. Cottons expressing herbicide tolerance to more than one herbicide group will provide greater flexibility to cotton growers and new opportunities for resistant weed management. Rotation of herbicides with different modes of action, such as glyphosate and glufosinate ammonium will assist with the management of troublesome weeds and resistant weeds in US cotton (Burgos *et al*. 2006).

No herbicide tolerant cotton technology is a stand alone technology for weed control. Diversifying crop production practices, using pre-emergent herbicides, targeting appropriate weed sizes, using full recommended rates of herbicides and the rotation of different modes of action are general principles for delaying herbicide resistance (Burgos *et al.* 2006). There is no documented record of weed resistance to glufosinate ammonium. Robust herbicide tolerance to glufosinate ammonium as well as glyphosate provides an alternative to a 'glyphosate only' system, and an opportunity for US cotton growers to take a more proactive approach to the management of their troublesome and glyphosate-resistant or tolerant weeds (Mueller *et al.* 2005).

Once approved and available in elite germplasm, LibertyLink® + GlyTol® technology will provide US cotton growers with the flexibility to rotate two different herbicide modes of action, over the top of the same cotton variety. This technology should help growers manage their troublesome and glyphosate resistant weeds, without losing the benefits of their established herbicide tolerant management practices.

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