

BIOTECHNOLOGY IN TURF, CURRENT STATUS OF ROUNDUP READY BENTGRASS

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Introduction

Transgenic crops have grown from 4.2M acres planted in 1996 to over 167M acres in 2003, a forty fold increase. In 2004, over 90 percent of all soybeans grown in the United States were derived from the tools of biotechnology. Further, over 70 million farmers in thirty countries around the world are currently producing, importing, or growing biotech crops.

Benefits

Farmers are finding that biotech crops are less expensive and less labor intensive to produce. Over \$600 million of chemicals have not been applied to Roundup Ready soybeans. Canola farmers save 14 million gallons of fuel a year. Bt-cotton and corn have reduced insecticide use by 4.5 million pounds. It has been determined that Bt-protected corn has reduced insect feeding and the resulting molds and mycotoxins that are harmful to livestock and humans. In addition, No-till and conservation tillage is saving one billion tons of precious top soil per year. As an aside, over 80% of today's drugs are developed with the aid of biotechnology.

Issues in Turfgrass Management

Dr. Peter Dernoden of University of Maryland recently summarized his perspective on issues surrounding bentgrass management

(2000). He summarized his study with the following observations:

- Few herbicides are currently being registered for selective bentgrass control while several herbicides needed.
- Most herbicides have a more narrow range of safety to bentgrass requiring lower rates on bent relative to other turf species.
- Due to the lower rates often the outcome of control efforts is incomplete control of problem weeds.

Root pruning and associated plant phytotoxicity and other related issues ends-up with turf that has less tolerance to stress events, poorer aesthetics, and often result in more complaints from users. Finally, overseeding timing and success is negatively impacted by soils with carry-over issues from herbicides with long reseeding intervals.

The Development of Glyphosate Tolerant Creeping Bentgrass

Monsanto and Scotts Co. have cooperated on the development of Glyphosate Tolerant Creeping Bentgrass (GTCB). Results of this cooperation have produced commercial candidates that have shown the following characteristics.

Turf Quality – Composite of all Characteristics

shoot density appropriate to function (both fairway and greens-grade varieties)
disease tolerance
environmental tolerance
wear tolerance and recuperation from wear (a function of vigor)

Supporting Evidence

These lines were derived from existing cultivars that were of commercial quality. Regulatory studies submitted with the petition to APHIS showed that over twenty five studies were conducted over the last three years. This included variety trials equaling 113 location-years.

Golf course demonstrations were placed on more than thirty four locations across the country. Efficacy and weed control studies were conducted by university, Scotts, and Monsanto field scientists totaling over twenty-four locations.

GTCB Benefits

Researchers and golf course superintendents have identified through testing and observations important benefits for this new technology for golf including: simplified and selective weed management, reduced turf maintenance inputs chemistry, the ability to implement IPM principles including the inputs of fungicides, PGR's, fumigants, insecticides, and nematicides. They have also demonstrated the ability to have a focused species management using Best Management Practices (BMP's). They have determined the ease of establishment of new stands, and conversion of older stands to GTCB. They have shown reduced clippings collection with mowing due to weed presence, all resulting in greater player satisfaction.

Current Issues

The United States Agriculture, Plant Health Inspection Service (APHIS) concluded that issues brought forward from the U. S. Bureau of Land Management, and the United States Forest Service regarding pollen flow issues warranted the status of a 'major federal action' and deregulation was viewed as a "*precedent setting, controversial, and posing uncertain environmental impacts*", thus requiring an Environmental Impact Statement (EIS) to be prepared, prior to deregulation of the technology. Concerns from BLM rose primarily around gene escape issues and desire for effective and labeled alternate controls should escapes occur. The EIS enables a full vetting of issues by all interested parties and enables APHIS to approve GTCB with conditions, if needed. This action by APHIS is consistent with direction that the agency has with respect to the regulation of "novel" GM plants. The EIS sets a procedure for future generations of turf/grass candidate petitions to the agency and should greater certainty in process, timing, and future agency decision making.

Regarding the area of research to satisfy APHIS and ensure a sustainable technology surrounds the issues of acceptable alternate controls, Monsanto researchers have identified several effective herbicides capable of controlling GTCB. Among those identified include some of them listed here: Generally, pollen flow is not anticipated in golf course management due to mowing heights on putting greens and in fairways where flowering would not occur. In the case where pollen would be an issue in grass seed production, effective buffers are established, and sites monitored to measure for any escapes. When found plants could simply be dug and devitalized, and desirable plants planted and established, or plants could be treated with one to several viable herbicides currently being screened for their effectiveness. Among those found to be effective: sethoxydim, diuron, clethodim, sulfosulfuron, glufosinate, fluazifop-methyl, and imazapyr. Other herbicides are still under review. In addition to determining control, products are being used in various application regimes, and evaluated for issues of bentgrass control, soil residual, plant-back, use in riparian or wetland areas, and overseeding issues.

Glyphosate Tracking Study

Previous studies showed that tracking was temporary in duration and was observed within 20 minutes of application. No serious long term turf damage was observed. The plot lay out consisted of an 8-10 foot band of treated area with a 60 foot area perpendicular to the treated area where tracking would be observed. Four quarts of glyphosate (RoundupPro®) was applied in the 8-10 foot band perpendicular to the untreated alternate first cut rough of tall fescue and Kentucky bluegrass. Sprayed length was determined by the size needed to accommodate three replications of tracking types and three types of tracking i.e. 0-5 minutes, 20 minutes (mins) and 18-24 hours post application under light dew conditions.

The objective of the study was to determine the potential of glyphosate tracking from treated glyphosate tolerant creeping bentgrass (GTCB) greens or fairway managed turf as a surrogate for GTCB vegetation growing adjacent areas of conventional fescue (fine or tall), perennial ryegrass or Kentucky bluegrass first cut roughs.

The treatments were laid out in a split plot design with two factors. The primary factor was types of traffic and the secondary traffic was post tracking timing after application. Three types of traffic were tested; (a). Foot traffic, (b). Weighted hand pull cart and (c). Motorized golf cart. The secondary factor was laid out as sub-plots where the three types of traffic were taken through the glyphosate treated area at three different timing intervals [(i). 0-5 mins (ii). 20 mins and (iii). 18-24 hours after the glyphosate application. All tracking equipment were cleaned and dried between treatments. A pressure hose water sprayer was used to rinse the treated tires and shoes to prevent any cross contamination. The trial was established under mid day turf conditions and the glyphosate was applied with a carrier volume of 30 gallons per acre. A 3 foot width for each tracking event and 8-10 sprayed zone was established. The 'tracking zone' (untreated adjacent area) extended 60 feet from the treated zone. The tracking treatments passed through the treated area into and through the entire 'tracking zone' within the time sequences identified. The tracking devices were cleaned and dried between passes through the treated areas.

The following data was taken:

- a) Levels of turf injury were rated on a 0-10 scale by methods of tracking, herbicide and timing after application at 7, 14, 30 and 60 DAT, where 0=no injury and 10=dead turf.
- b) Percent injury in 5 foot segments through the tracking zone was rated.
- c) Length of tracking was measured.
- d) The extent and levels of injury were described.
- e) Pictures of treatment effects showing the extent and types of injury symptoms at 14 and 21 DAT were taken.

Table 1. Tracking of glyphosate onto untreated first cut roughs of tall fescue and Kentucky bluegrass.

Treatment	5 ft		10ft		5ft		10ft		5ft		10ft	
	7 DAT*		14 DAT		21 DAT		30 DAT		60 DAT			
Foot Traffic After 0-5 minutes	0.0 a§	0.0 a	1.67a	0.00a	2.0ab	1.3ab	1.3a	1.0 a	0.7ab	0.7 a		
Foot Traffic After 20 minutes	0.0 a	0.0 a	0.67a	0.00a	1.0 b	0.7 b	1.0 a	0.7 a	0.3ab	0.3 a		
Foot Traffic After 18-24 hours	0.0 a	0.0 a	0.00a	0.00a	1.0 b	0.3 b	0.7 a	0.3 a	0.0 b	0.0 a		
Weighed Pull cart After 0-5 minutes	2.7 a	2.0 a	2.33a	1.00a	4.0 a	3.0 a	2.7 a	2.0 a	2.0ab	1.0 a		
Weighed Pull Cart After 20 minutes	1.0 a	0.3 a	0.67a	0.33a	1.7 b	1.7ab	2.3 a	0.7 a	1.0ab	0.0 a		
Weighed Pull Cart After 18-24 hours	0.3 a	0.0 a	0.33a	0.00a	1.0 b	0.0 b	1.0 a	0.0 a	0.0 b	0.0 a		
Golf Cart After 0-5 minutes	1.3 a	1.0 a	1.43a	0.50a	2.7ab	1.3ab	3.7 a	2.0 a	2.3 a	1.0 a		
Golf Cart After 20 minutes	1.3 a	1.3 a	1.50a	1.67a	3.0ab	3.0 a	2.7 a	1.3 a	1.3ab	0.3 a		
Golf Cart After 18-24 hours	0.3 a	0.3 a	0.33a	0.33a	1.0 b	0.7 b	0.7 a	0.0 a	0.0 b	0.0 a		

*DAT indicates days after treatment of glyphosate.

§Means were separated using Duncan's New Multiple Range Test ($\alpha = 0.05$). Means within a column followed by the same letter do not differ significantly.

The weighed pull cart treatment within 0-5 minutes of application at 7 days after treatment (DAT) resulted in highest injury (2.7%) in the first 5 foot segment closest to the treated zone, but the level of injury was not significantly different than the control or any of the other treatments (Table 1). The effect of glyphosate injury by tracking was observed as a temporary stunting and yellowing and the injury did not exceed 4% with any of the treatments.