Benefits of Turfgrass Technology Are on the Horizon

By Bob Harriman and Lisa Lee

With more than 25 million golfers playing an estimated 550 million rounds of golf a year, turfgrass managers should feel proud about their impact on America's health, fitness and happiness. Unfortunately, today's turfgrass managers don't have the luxury to take a minute to appreciate the impact of their work. Time, budget and natural resource issues are constantly pulling them in different directions.

Superintendents are constantly striving to improve turf while being held hostage by both the clock and dollar, not to mention trying to reduce pesticide applications and water use.

Companies that supply products to turfgrass professionals have realized the presence of these pressures and are working diligently to develop products to minimize them. Breeders have been working to improve attractiveness, durability, pest resistance, stress tolerance and yield for decades (Barker and Kalton, 1989). However, many of the traits desired by turfgrass professionals are not attainable by traditional breeding.

For over a decade, biotechnology has been touted as the new tool that will help us use modern science to overcome many of the obstacles that face breeders. In fact, several reviews [Lee, 1996; Chai and Sticklen, 1998; Edminister, 2000] and a book [Sticklen and Kenna, 1998] have been written on the targets and potential of biotechnology. The Scotts Co. has been using biotechnology since 1995 to develop new turfgrass products that improve performance and reduce pesticide inputs.

While turfgrass biotechnology has certainly advanced since the development of transgenic orchardgrass in 1988, the industry still does not have a biotech-enhanced turfgrass on the market. Despite the lack of a current commercial product, biotechnology's future is bright.

In 1996, The Scotts Co.'s Lisa Lee presented an update on the current state of affairs of plant biotechnology and highlighted herbicide-tolerance as one of its important targets. Benli Chai and Mariam Sticklen from Michigan State University outlined four categories for "Application(s) of Biotechnology in Turfgrass Genetic Improvement" in their 1998 review article, including:

- applications of molecular markers to assist breeding practice;
- in vitro manipulations for regenerable tissue culture;
- genetic engineering by DNA transfer techniques; and
- the use of fungal endophytes to improve turfgrass performance.

These categories have not only remained pertinent, but significant scientific advancement has occurred.

At the Millennium Turfgrass Conference held in Melbourne, Australia, in June 2000, Craig Edminister of Cebeco International Seeds identified herbicide resistance, insect resistance, salt tolerance and disease resistance as important traits that would be extremely difficult (if not impossible) to deliver using traditional breeding methods.

In *Turfgrass Biotechnology*, edited by Mariam Sticklen (MSU) and Mike Kenna (USGA) in 1998, Mike challenged turfgrass scientists to "aim for the moon." For this article, we will focus on

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Here are biotechnology-derived bluegrass plants exhibiting dwarfing characteristics. The plant on the far right is a control plant. The second plant from the right has been modified but is not showing a response. The remaining plants are showing varying degrees of dwarfing right down to the bonsai bluegrass plant on the far left.

TABLE 1

Significant Milestones in Turfgrass Biotechnology

Event	Species	Year	Reference
1st Transgenic Grass	Orchardgrass	1988	[Horn et al.,]
1st Herbicide – tolerant event	Tall Fescue	1992	[Wang et al.,]
1st Field Trial	Creeping Bentgrass (GUS marker)	1993	[Zhong et al.,]
1st Petition to Deregulation	Creeping Bentgrass (RR)	2002	[this article]
1st Production acres planted	Creeping Bentgrass (RR)	2002	[this article]
1st Commercial Launch	??	??	??

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biotech-enhancement through gene insertion, often referred to as genetic engineering. Will science deliver on Edminister's list of traits? You decide if scientists are indeed aiming for the moon and likely to make a successful landing in efforts to develop improved turfgrass performance.

Herbicide resistance

As predicted [Lee, 1996] and suggested in an outline of significant biotechnology milestones (Table 1), the first turfgrass enhanced by biotechnology should be herbicide-tolerant creeping bentgrass.

Table 1 also points out the lengthy timelines involved in the development, testing and regulatory review needed to introduce a biotechnology-derived product. It often takes several years of research to develop even the well-understood, single-gene modifications currently on the market. New genes or complex traits can take a decade or more to identify, refine and develop.

Once a commercial candidate is identified, the regulatory process can take from five to seven years to navigate. Therefore, even for technology that is "proven," it will take six to nine years for a product's benefits to be experienced.

The development of Roundup Ready creeping bentgrass is certainly baring this out.

Disease resistance

Commercial-level disease resistance has proven elusive. Expression of single and even multiple forms of disease-resistance genes, such as chitinase, glucanase and anti-fungal proteins, slowed the rate of infection but have not resulted in long-lasting disease control.

New efforts aimed at expressing a battery of resistance genes or approaches that detoxify products generated by attacking pathogens hold promise that engineered resistance may one day be available to turfgrass managers [Hirt, 2002].

Insect resistance

Insect resistance in agriculture is a banner child of biotech's awesome potential.

The National Center for Food and Agricultural Policy has determined that biotechnological corn resulted in a 3.5 billion pound yield increase and $125 million in additional income, while biotechnological cotton contributed 185 million more pounds and $102 million in additional income (Council For Biotechnology Information — *www.whybiotech.com*).

While biotechnological advances are the primary sources of insect resistance, additional protein leads are being evaluated, such as cowpea protease trypsin inhibitor in oil palm [Abdullah et al., 2002]. In spite of agriculture's success with insect resistance, we are unaware of any turfgrass biotechnology group currently evaluating the potential of insect resistance.

Salt and drought tolerance

With the variable weather conditions superintendents experienced the past several years, drought tolerance would be a useful trait, so it should come as no surprise that researchers in universities and industry settings have been working to develop such technology. Another option to conserve is to develop grasses that are more salt-tolerant and could be irrigated with effluent water.

The scientific literature is loaded with papers on enhanced performance of transgenic plants under water and/or salt stress conditions. Several of these technologies are currently being tested in the field. Will these tests identify genes that could lead to drought and/or salt-tolerant fairways or lawns? Only time will tell.

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Nutrient use

Is it possible to develop a turfgrass that stays green even under low soil fertility? Early research results suggest that it may. Stay tuned while researchers focus the picture a little more clearly.

Have scientist's made significant progress towards delivering on Edminister's trait list? Have we aimed for the moon? If so, are we getting closer to making a successful landing?

Since there is no wrong answer, we will give you ours. We believe it is clear the aim has certainly been high, and significant progress has been made.

While the future is indeed bright, and we look forward to enjoying the benefits of biotechnology-enhanced turfgrass, we will continue striving to develop the "perfect" turfgrass.

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