Bio-Engineering of Sports Turf Seed

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Turfgrass enhanced through biotechnology will soon be commercially available. The first wave of products that are set to radically change management practices for sports fields and golf courses are now making their way through development and regulatory review. This article was first published in *Stadia* magazine, January 2001, Issue 7.

Science and technology are providing us with wonderful opportunities to enrich our lives and improve the environment. It was through the continuous discovery of the basic elements of chemistry, physics and biology that impressive advances in technology have occurred. Is such a bright future in store for the common blades of grass that comprise our sports fields, golf courses, parks and lawns?

Grasses are too important and the needs are too great for us not to utilize the best advances in technology for turfgrass improvement. Biotechnology has contributed exciting new opportunities to improve turfgrass.

Turfgrass may be common but the positive impact it has on the environment and human health is anything but. Turfgrasses provide many functional, recreational, aesthetic and environmental benefits. For example, turfgrass helps reduce soil erosion and agricultural runoff and it absorbs carbon dioxide and ozone while at the same time releasing life-sustaining oxygen. Turfgrasses trap an estimated 12 million tons of dust each year and an average lawn has the cooling effect of about 10 tons of air conditioning.

Many outdoor sports and recreational activities utilize turfgrasses, including baseball, cricket, football, golf, soccer, softball, track and field, and volleyball. The surface on which the game is played contributes a great deal to the outcome of the contest, the safety of the players and the aesthetic enjoyment of the fans.

Turfgrass provides resiliency and durability that add to the quality of play as well as to the safety of the players. Natural turf provides good traction between the ground and the shoe sole. This means safe footing on sports fields, home lawns and playgrounds. In addition, turfgrass is cooler than artificial surfaces, thus it is more comfortable to play on. Injuries on natural grass and well-maintained playing fields are fewer and less severe than on other surfaces.

Plant Biotechnology at Work

There have been many technological advancements in biology in recent decades that have been pivotal to the research into the genetic engineering of sports turf seed today. Although the structure of DNA was determined in 1953, the first transgenic plant was not developed until 1984. The world had to wait another 10 years to witness the release of the first plant enhanced by biotechnology.

So how does plant biotechnology work? Simply put, it is a three step process. The first is to develop an information-containing DNA cassette. This must be inserted into a single cell before it is grown into a whole new plant.

Three major components are present in a DNA cassette. At the beginning of the cassette, a promoter sequence is needed to instruct when, where and how much of the gene is expressed. The next DNA segment comprises the functional gene that delivers the trait, and finally, at the end of the cassette, a stop sequence is required to provide signals to end the gene expression. To introduce a DNA cassette into a single cell, state-of-the-art gene insertion technologies such as gene gun, protoplast transformation and Agrobacterium transformation are commonly used to produce biotechnology enhanced plants.

After the DNA cassette is inserted into the chromosome of a single cell, the growth of cells that did not incorporate the DNA cassette are selected against, while the cell with the new DNA is nurtured in tissue culture until a whole plant is generated. Only plants that show the influence of newly inserted information and good agronomic performance are advanced to future development and possible commercialization.

Turfgrass management is under constant pressure from biotic stresses such as weeds, insects, fungi and bacteria, and abiotic stresses such as heat, cold and drought. By protecting turfgrass from such

EARLY TRIALS OF HERBICIDE TOLERANT TURFGRASS

Herbicide tolerant creeping bentgrass callus is growing into a whole new plant in tissue culture.

Herbicide tolerant creeping bentgrass, unaffected by herbicide spray, continues healthy growth while the control creeping bentgrass is killed.

Herbicide tolerant Kentucky bluegrass continues healthy growth after herbicide spray has killed the control Kentucky bluegrass in a greenhouse.

stresses, it is possible to increase the health and performance of sports fields and golf courses.

Turfgrass biotechnology can produce transgenic plants with desirable traits to improve management practices. The tools are in place and development experts are busy at work. But what will be the first enhanced product?

Herbicide Tolerant Creeping Grass

The first turfgrass product enhanced by biotechnology is likely to be herbicide tolerant creeping bentgrass (*Agrostis stolonifera*). Over 10,000 golf courses in the US use creeping bentgrass for their greens and/or tees and fairways. Effective weed control against the grass weeds *Poa annua* and Poa *trivialis* is not currently available. By introducing the glyphosate resistant gene into creeping bentgrass, a golf course superintendent may eliminate a severe problem by simply spraying the environmentally safe herbicide Roundup®.

Roundup, the brand name for glyphosate, is a broad-spectrum, nonselective, post emergent, systemic herbicide that offers users weed control of essentially all annual and perennial plants. It has been the preferred herbicide since its first introduction in 1974 because of its effectiveness. The mode of action of glyphosate is to inhibit the enzyme EPSP (5-enolpyruvoyl-shikimate 3-phosphate) synthase and prevent plants from manufacturing three essential aromatic amino acids. Animals and humans obtain these amino acids through their diet and do not use this enzyme, thus providing a basis for specific selective toxicity only to plant species. In addition to glyphosate's highly specific mode of action, it does not persist in the environment nor bioaccumulate in the food chain. Glyphosate is essentially immobile in almost all types of soils, where it is degraded by naturally occurring microbes.

The gene gun technology has been successfully used to introduce glyphosate resistance into turfgrasses. Glyphosate resistant turfgrass should provide a useful tool for controlling unwanted weed grass species, such as *Poa annua*, in the turfgrass of sports fields, golf course putting greens and fairways. When weeds occur in these areas, a quick herbicide spray will kill the weeds but not the glyphosate-resistant turfgrass. This useful tool will simplify turfgrass management practices and reduce the use of other herbicides. It will create a healthy stand of turfgrass with less environmental impact.

The use of herbicide-tolerant creeping bentgrass can, for instance, positively impact on current golf course management practices by:

- Offering golf course superintendents the ability to selectively control weeds which currently cannot be controlled in creeping bentgrass, such as *Poa trivialis*, *Poa annua*, quackgrass, velvetgrass, kikuyugrass and bermudagrass;
- Providing improved turf management, resulting in higher uniformity and quality of turf with increased aesthetics and playability;
- Allowing the use of an environmentally acceptable herbicide that also reduces workers' exposure to the more toxic herbicides;

- Reducing herbicide usage through the increased flexibility to treat only as needed for weeds;
- Reducing fungicide, insecticide, water and fertilizer usage through the elimination of *Poa annua* and *Poa trivialis*;
- Eliminating the need for growth regulators to control *Poa annua*.

Regulatory Review Process

Before the benefits from products enhanced through biotechnology can be enjoyed, they must be vigorously examined and pass a thorough review by the Environmental Protection Agency and the US Department of Agriculture. The process can be summarized by addressing the following five issues:

- To determine that the product exhibits no plant pathogenic properties;
- To show that the product is no more likely to become a weed pest than traditional breed varieties;
- To prove that the product is unlikely to increase the weediness potential for any other cultivated plant or native wild species with which the product could interbreed;
- To ensure that the product is unlikely to cause damage to processed agricultural commodities;
- To show that the product is unlikely to harm organisms beneficial to farming and agriculture.

Data to address the topics above is developed over several years and in multiple locations. The analysis determines if the enhanced turfgrass is substantially equivalent (except for the introduced trait) to other turfgrass cultivars currently on the market. Herbicide tolerant creeping bentgrass is currently being examined with over 50 tests in 19 states by scientists from several disciplines and universities. This product may reach the sports market as early as 2003, dependent upon additional product testing and review by the regulatory agencies.

Better Turfgrass for Sports

Over 90 field test notifications have been acknowledged by the US Department of Agriculture APHIS since 1994. While most of the activity is focused on creeping bentgrass (75 notifications), a growing number of notifications are being submitted for Kentucky bluegrass (14 notifications), bermudagrass (2 notifications), tall fescue (2 notifications), and perennial ryegrass (1 notification). The traits being studied include herbicide resistance, modified growth rate, fungal disease resistance, drought tolerance and salt tolerance.

It is possible that one day soon, there will be a well-maintained stand of turfgrass that needs less watering, less fertilization, less mowing and no supplemental protection from insects or disease. The continued activity of turfgrass scientists, combined with the growing knowledge of gene function, provide great promise for impressive advances in turfgrass biotechnology to provide these valuable management tools. In addition to golf courses benefitting from these improvements, in five to 10 years biotechnology enhanced turfgrasses could provide a broad spectrum of impact on other sport turf fields such as football, soccer or baseball fields, or wherever natural turfgrass is used. ♦

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Welcome New Members to the Sports Turf Association of Ontario

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