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Biological Control of Turfgrass Diseases

Foliar Disease Control

Currently there are between 20 and 30 million acres of turfgrass in the United States, consisting of lawns, parks, golf courses, sod farms, industrial and institutional grounds, right-of-ways, etc. Fungal diseases represent one of the most important limiting factors to maintaining the aesthetics and functional quality of turfgrass plantings. Managing diseases is particularly difficult on golf course turf where agronomically unrealistic cutting heights, high traffic and compaction, and low nutrient inputs to maintain unnecessarily high green speeds, have placed unprecedented stresses on turfgrass plants, making them highly susceptible to infection by plant pathogens.

For over 80 years, traditional turfgrass management programs have relied heavily on synthetic chemical fungicide applications for disease control. Because of the ideal conditions for disease development, golf course turfgrasses receive more fungicide inputs than any other agricultural or horticultural crops, with total dollars spent exceeding 20% of the total U.S. fungicide market. The vast majority of those applications are to golf course putting greens and tees, making the amount of fungicides applied per unit area quite high. It has only been since the late 1980's that a more visible trend toward non-chemical strategies has become apparent. Not only are turfgrass managers seeking alternatives to fungicides, but also an increasing number of research laboratories around the world are now focusing studies on non-chemical methods of disease control.

Turfgrass managers view biological control as a desirable alternative to fungicide treatments for a number of reasons. One of the more important reasons is that biological control is viewed as a rational means of extending and augmenting the efficacy of fungicides and, at the same time, reducing the environmental load of pesticides. Most importantly, however, biological control is viewed as an effective sustainable solution for maintaining turfgrass health.

Research on biological control of turfgrass diseases has followed two important lines of investigation. One area of research has involved studies of microbial inoculants, usually applied individually, to control particular turfgrass diseases. The other major area of research has involved the application of organic amendments, usually in the form of composted materials, for the control of a range of turfgrass diseases. The goal with both of these strategies is to increase the populations and activity of disease-suppressive microbes associated with turfgrass plants. However, each approach differs fundamentally in mechanisms and sustainability.

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A Healthy Ecosystem

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Microbial Inoculants for Turfgrass Disease Control

Disease control strategies utilizing microbial inoculants attempt to temporarily and dramatically increase soil or plant populations of specific disease suppressive microbes. Generally the microorganisms used as inoculants have specific pathogen targets and operate under relatively narrow modes of action. As with fungicide applications, the use of inoculants requires repeated applications to maintain populations of introduced microorganisms at levels necessary for disease control. In contrast, however, the application of inoculants must be handled quite differently from fungicides since precautions must be taken to maintain maximum viability of the inoculant along with creating conditions that allow biological control properties to be expressed at times when the target pathogens are accessible.

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Microbial inoculants have been studied for a number of years in a turfgrass management context for disease control. Studies have generally focused on the following areas: general efficacy, population behavior and persistence, and mechanisms of biological control. Other important but limited areas of investigation include compatibilities with fungicides and other pesticides, and application timing and frequency.

Efficacy of Microbial Inoculants for Control of Foliar Turfgrass Diseases

Over the past 20 years, many studies have demonstrated the efficacy of various microbial inoculants to a variety of above ground and below ground turfgrass diseases. Successes in greenhouse, growth chamber or laboratory tests are extremely promising. Even results from a rather limited number of field experiments illustrate the potential for many different types of microorganisms to suppress turfgrass diseases. However, many studies have not continued beyond initial discovery and efficacy documentation thus limiting our efforts to understand how to enhance the overall level and consistency of performance of individual inoculants. Furthermore, in-depth studies of biological control have been limited to relatively few diseases.

Despite more concentrated efforts targeting these diseases, relatively few field studies have been conducted to identify or verify efficacy of inoculants under a wider range of turfgrass management conditions.

Much of our knowledge of biological control of turfgrass diseases comes from studies aimed at controlling dollar spot disease caused by *Sclerotinia homoeocarpa* and brown patch disease caused by *Rhizoctonia solani*. Despite more concentrated efforts targeting these diseases, relatively few field studies have been conducted to identify or verify efficacy of inoculants under a wider range of turfgrass management conditions.

In one of the first studies on the biological control of turfgrass diseases, Burpee and Goulty introduced nonpathogenic binucleate isolates of *Rhizoctonia* spp. into plots of Penncross creeping bentgrass inoculated with *R. solani*. Plots were covered with polyethylene chambers to maintain high relative humidity and nighttime temperatures. In some experiments, some strains provided over 80% disease control. Despite these very promising results, however, there was no follow-up to these initial studies. Yuen *et al.*, working with other isolates of binucleate *Rhizoctonia* spp. again found similar results but no follow up studies were conducted.

Even more promising results have been obtained with field studies of microbial inoculants for dollar spot control where disease control under field conditions can be effectively maintained at levels equivalent with fungicide controls. For example, in field studies with natural inoculum of *S. homoeocarpa*, strains of *Enterobacter cloacae* provided up to 63% disease control when applied in a solid matrix as a topdressing to creeping bentgrass/annual bluegrass turf. Effective control was achieved with either preventive or curative applications made at 2-week intervals and control persisted for up to 2 months after application. Populations of introduced strains generally declined from ~10^8 cells/g soil to around 10^6 cells/g soil after 2 months.

In similar studies, Goodman and Burpee observed similarly high levels of disease control when various strains of fungi and bacteria were applied in a solid matrix as a topdressing to creeping bentgrass turf. *Fusarium heterosporum* was the most effective fungal isolate tested, providing between 86-93% disease control over a 2-year period.

In yet another impressive field study, the application of hypovirulent strains of *S. homoeocarpa* to creeping bentgrass artificially infested with virulent strains reduced dollar spot

development by up to 80% and the control persisted for up to 1 year after application. In these field studies the control achieved with the hypovirulent *S. homoeocarpa* strains was equivalent to that achieved with chlorothalonil. It is rather disappointing that, despite the impressive results from among these and many other studies, none of these strains have become commercial products for the turfgrass industry. To my knowledge, no follow-up studies have been done with many promising inoculants and no commercial biocontrol producers have expressed interest in licensing these strains.

An Exceptional Strain

One exception to this, however, is with strain 1295-22 (=T22; =KRL-AG2) of *Trichoderma harzianum*, commercialized under the trade name Biotrek 22G® over 5 years ago. A new formulation of this strain is now commercially available under the trade names Turf Shield® and Turf Shield Fairway®. Strain 1295-22 is a highly rhizosphere competent strain that has been studied for many years on a wide variety of horticultural and agricultural crops. In a series of turfgrass field trials over a 4-year period with two formulations, strain 1295-22 suppressed dollar spot by 38-64% when applied as a granular formulation and by 54-92% when applied as a conidial spray. Weekly applications were more effective than those made every two weeks and the level of control provided by weekly applications did not differ from that resulting from monthly applications of the fungicide propiconazole. In addition to the control of dollar spot, strain 1295-22 also controlled Pythium root rot and brown patch.

This strain has seen wide use in the golf turf industry as well as the floriculture and nursery industries in the United States. The commercialization of this product, however, was only possible because one of the principle scientists involved in the studies of strain 1295-22 co-founded the company (Bioworks, Inc., Geneva, NY) that now produces and markets the product line based on that strain. Even though various companies had licensed the strain at different points in time, strain 1295-22 was later dropped because of mergers or changes in company priorities. Had Bioworks, Inc. not been founded, this strain likely would have met the fate of so many other promising biological control inoculants.

Until recently, strain 1295-22 was the only commercially available biological control agent for turfgrass diseases in the United States. In 1999, EcoSoil Systems of San Diego California was granted a provisional registration for *Pseudomonas aureofaciens* (strain Tx-1), which was registered under the trade name SpotLess® (formerly Ping®) for the biological control of dollar spot. Unlike *T. harzianum*, this strain has not provided particularly impressive results (control efficacy variable and between 10-84%). This strain has also had a rather checkered registration history because of the conundrum the US EPA found themselves in when considering the application method through irrigation systems using the BioJect® system. As a result, not only did the strain have to be registered but the delivery system needed to be registered as well.

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