

Microbial Products Turf Research History

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Soil Technologies Corp. (Soil Tech) is a pioneer in the development of microbial-based products for turfgrass and agricultural applications. Soil Tech's products evolved out of research projects originally conducted by N.A.S.A. (National Atmospheric and Space Administration) scientists during the 1960's. While working to create a food production system for extra-terrestrial space explorers, much attention was focused on the use of microorganisms to 'manufacture' biochemicals that could be used as food, fertilizers and/or pest controls.

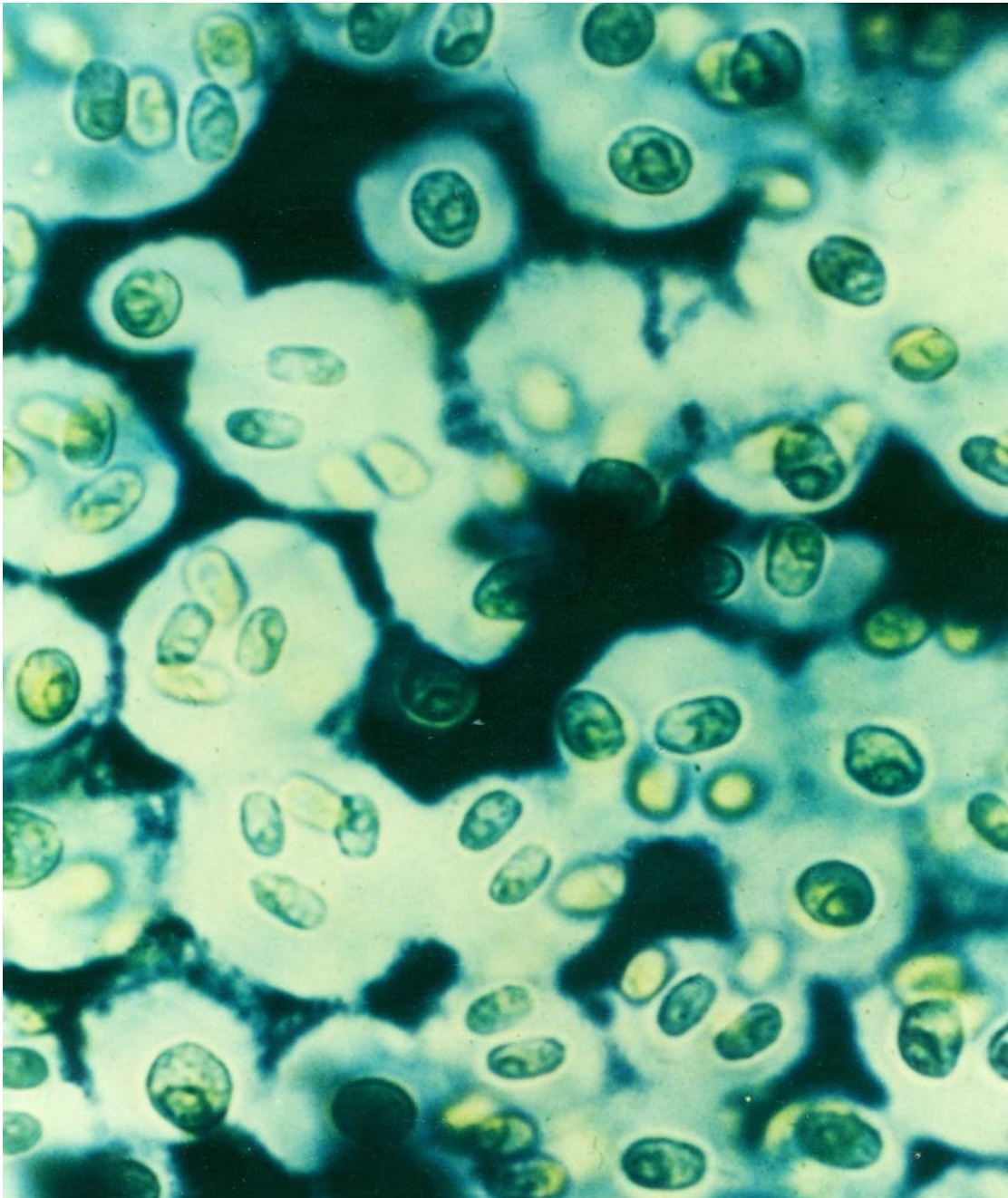
Soil Tech founder/agronomist, Dr. Jim Schaefer became fascinated by this concept after reading an article about it in a farm magazine. In 1982, Dr. Schaefer began discussions with professors at Iowa State University to try to determine the practical uses of microorganisms in agriculture. By 1983, Dr. Schaefer had formed Soil Technologies Corp. as a research and development company with the purpose of creating biological production systems for farmers.

During 1983, Dr. Fred Williams, Chairman of the Microbiology Dept. at Iowa State Univ., was contracted by Soil Tech and began exploring the agronomic utility of polysaccharide producing microbes. Dr. Williams first quantified the production of these polymers by chlorophyta organisms. To his surprise, he observed that these lowly soil microbes were able to produce up to 1000x to 2000x their cellular weight in polysaccharides. In practical terms, a few ounces of chlorophyta would 'manufacture' 300-400lbs. of polysaccharides. When grown on the soil surface, a crop of chlorophyta could quickly (30-60 days) produce enough polymers to transform the soil structure, similar to the manner in which a farmer might plow down a cover crop (alfalfa, rye, etc.) to renovate his soils. The

‘microbial crop’ provided a shortcut that was faster, easier and less expensive.
(See Illustration #1)

Illustration # 1

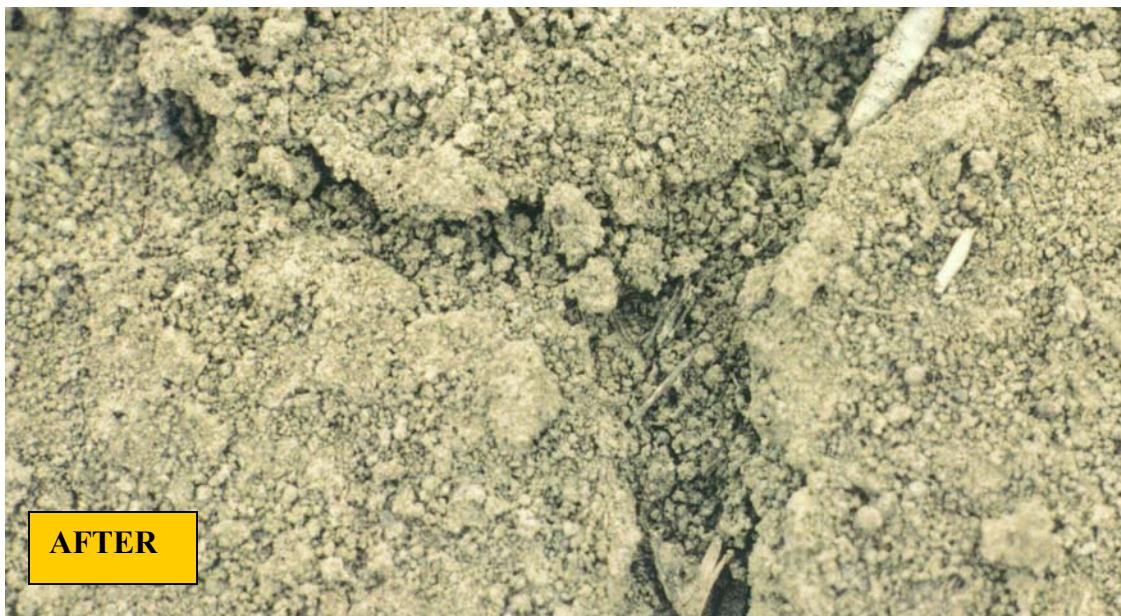
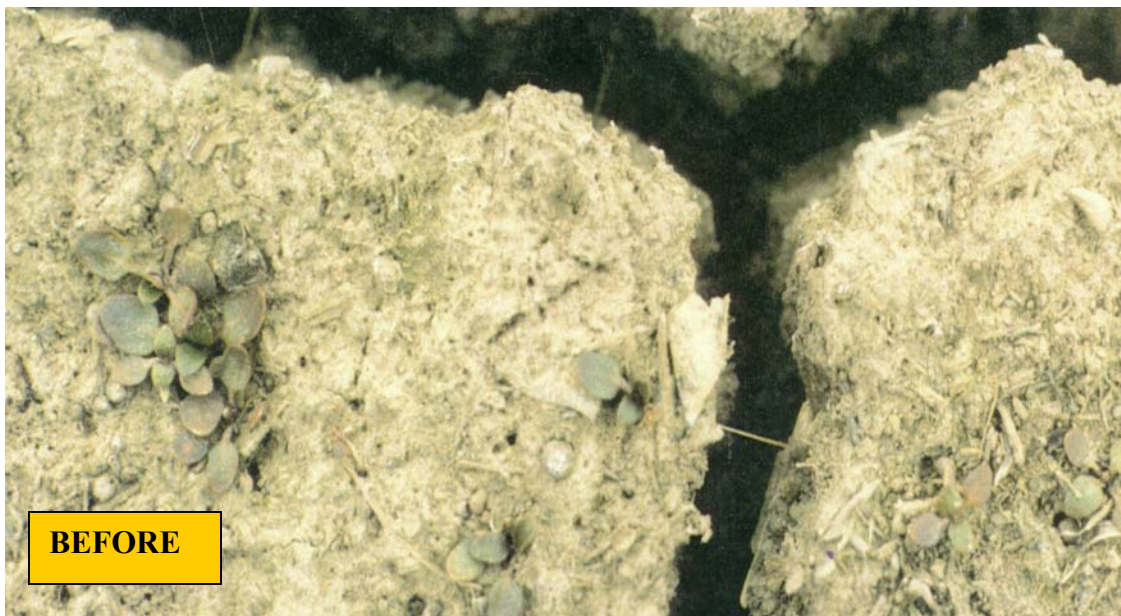
Chlorophyta cells surrounded by polysaccharide compounds



Among soil scientists, polysaccharides have long been known as ‘nature’s glue’, for their fundamental role in the formation of soil aggregates (crumbs). It is widely agreed that soil aggregation is beneficial to soil as a medium for the plant growth (See Illustration #1A).

Illustration # 1A

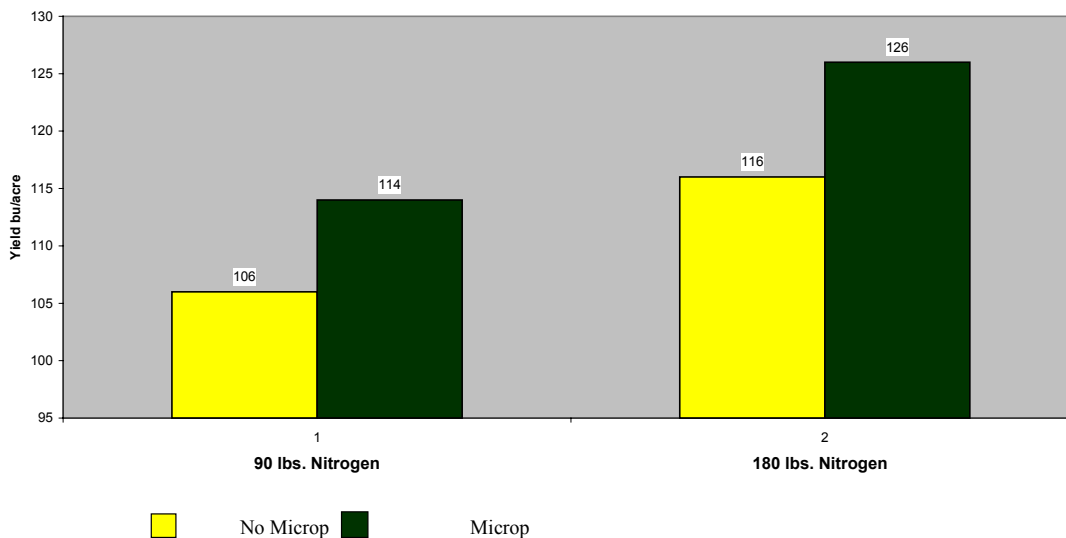
Compacted soil treated with Chlorophyta



By 1984, several more scientists were employed to show the practical benefits of treating soils with polysaccharide producing microbes. Dr. Rick Cruse, a soil scientist from Iowa State University, took a lead role in demonstrating the use of the ‘microbial cover crop’ in terms of reducing soil compaction and thereby increasing crop yields. In 1984, he published a paper showing increased crop yields and reduced fertilizer needs where the microbial system had been employed. (See Chart #1A) In 1985, Microp® (for agricultural crops.) and TurfTech (for turf) were introduced in the market by Soil Tech.

Chart #.1A

Corn Yields at Different Levels of Nitrogen

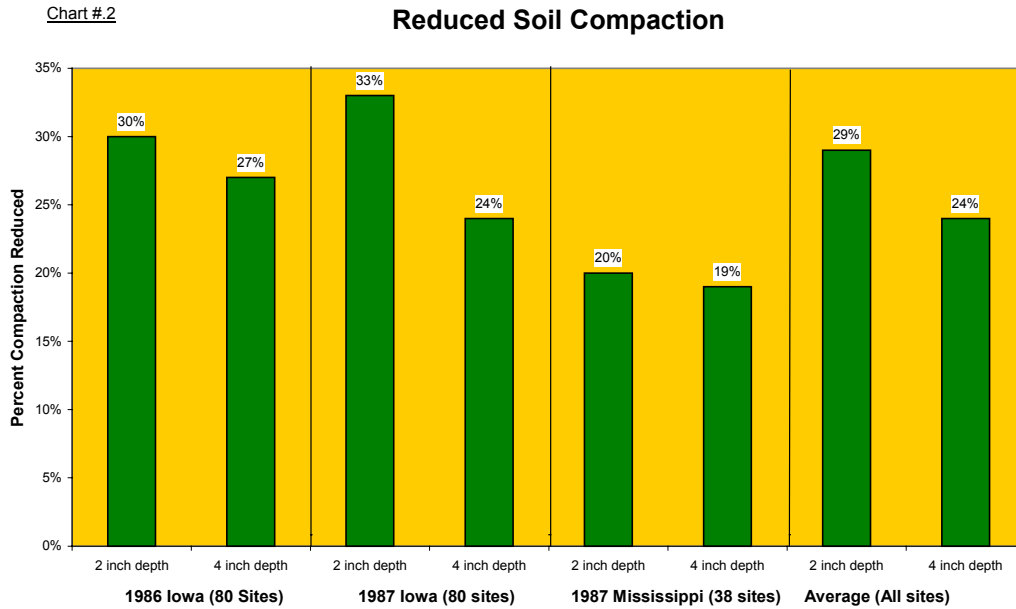


Results: Corn Yields showed an increase averaging 9 bu./acre following one treatment of MICROP. This effect was observed at each fertilizer level. A connection between Nitrogen utilization and MICROP treatment on corn yields can be seen when comparing yields with MICROP at 90 lbs. Of N/acre and control at 180 lbs. of N/acre.

Source: Rick Cruse, Ph.D., Iowa State University, Ames, Iowa.

During 1986-1987, a wide-scale research project was begun to show the influence of TurfTech™ seeding on soil compaction in S.E. Iowa and a Mid South Region. The results of this study were published in August, 1988 in the E.P.A. book titled “ I.P.M. for Turfgrass and Ornamentals,” edited by Anne R. Leslie. The study concluded that TurfTech treatments could reduce soil hardness (compaction) by an

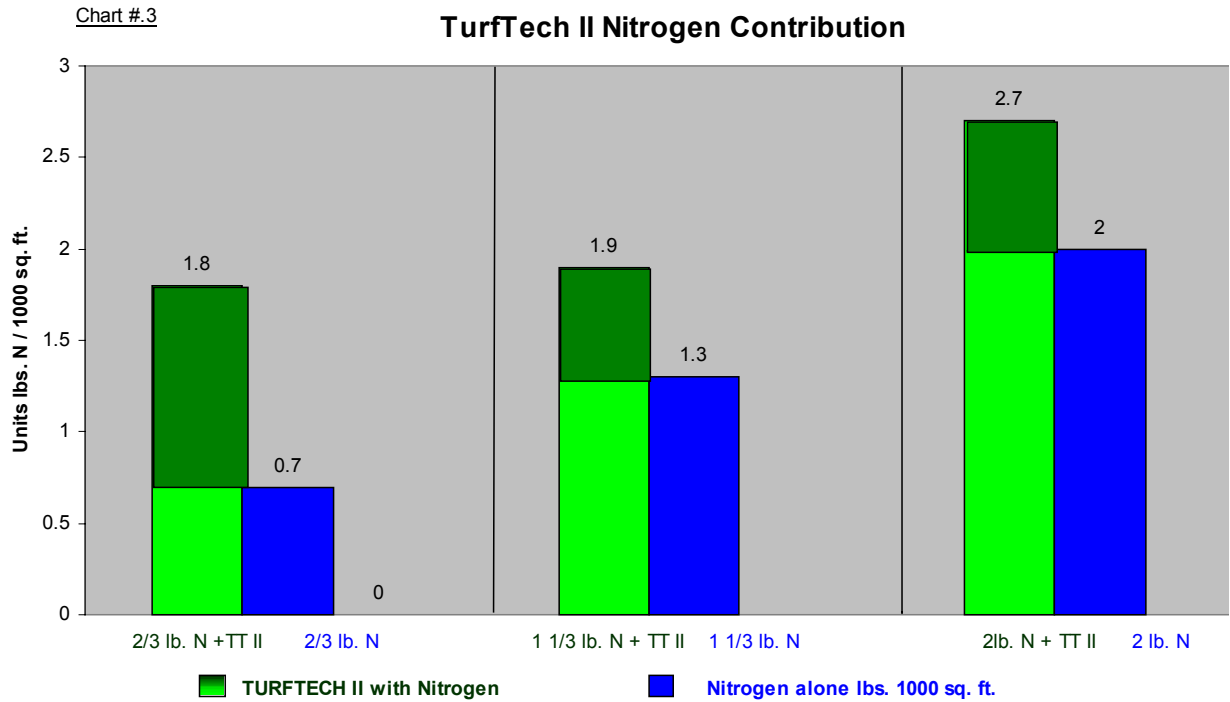
average of 29% at the 2” depth and 24% at the 4” depth in a period of 6-8 months after application. (See Chart #2).



Results: TurfTech plots averaged 29% less compaction at the two inch (2”) depth and 24% less compaction at the four inch (4”) depth than untreated control plots.
Source: EPA Publication, Intergrated Pest Management For Turfgrass and Ornamentals. August, 1989. Pages 161 - 165.

During 1987-88 a research project was begun at Soil Tech to develop a nitrogen-fixing soil inoculant that could be used as a bio-fertilizer. Dr. S.K. Goyal of the Indian Institute of Agriculture, a leading expert in the study of cyanophyta, collaborated with Soil Tech researchers to select specific strains of cyanobacteria that were then incorporated into the Soil Tech product formulations. TurfTech then became TurfTech II™. The selected cyanobacteria were free-living soil colonizers that produced a bio-fertilizer effect of nearly one pound (1 lb.) of nitrogen/1000 sq. ft./season. This was documented in trials at the Univ. of Arkansas in 1988 (See Chart #3). A range of N fertilizer rates were applied to plots, with and without TurfTech II, to determine the amount of N transferred from the cyanobacteria to the treated plants. In plots with lower rates of N

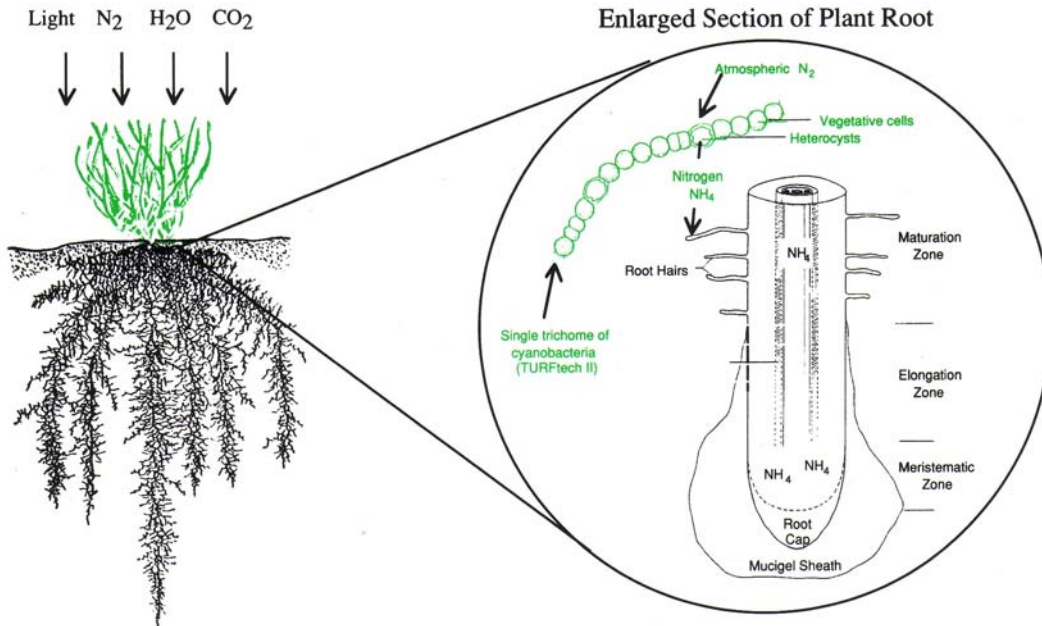
fertilizer, the cyanobacteria produced a relative higher response. This self-regulating feature of the cyanobacteria assured a steady, slow-release of N and posed no threat of phytotoxicity.



Results: TurfTech II treated plots showed significant gains in available nitrogen over time, compared to untreated control plots. A range of fertilizer rates was imposed on replicated treated and untreated plots to determine the amount of N transferred from TurfTech II to the plants. Nitrogen contributions were extrapolated from field analysis of plant growth.

Source: University of Arkansas, Stuttgart Experiment Station, 1988

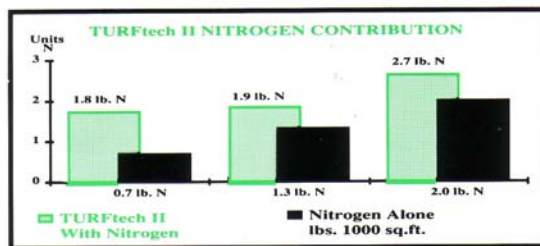
"GROW YOUR OWN NITROGEN" TURFTECH II™ – BIOFERTILIZER



Nitrogen, the magic stuff of plant life, is produced in ammonia form (NH_4) by cyanobacteria in TURFtech II. This ammonia is readily absorbed by the root hairs of the grass plant. TURFtech II's cyanobacteria grow near the soil surface.

TURFTECH II™ 100% SLOW-RELEASE ORGANIC FERTILITY PROGRAM

The heterocyst cell of the bacteria is the site for nitrogen reduction. It is here atmospheric nitrogen (N_2) is transformed into ammonia (NH_4). This useable form of nitrogen is released by the cell over time. TURFtech II can contribute up to 1 lb. of organic nitrogen per 1,000 sq. ft. over a 60 day period. Nature's slow-release process assures regular, daily absorption by the plant, for steady, even growth.



A range of N fertilizer rates was imposed on replicated, treated and untreated plots to determine the amount of N transferred from TURFtech II to the plant. N contribution was extrapolated from field analysis of plant growth.

TURFtech II's beneficial microorganisms also produce a variety of organic chemistries which are valuable for soil and plant improvement. Polysaccharides promote soil aggregation and reduce compaction. Organic acids break down mineral complexes in the soil to enhance nutrient availability. PGR's (plant growth regulators) improve seedling development and stimulate root growth. □

Old Strategy: Spread tons of urea over the golf course to supply nitrogen.
New Strategy: Spray a few ounces of TURFtech II and let the cyanobacteria do the work for you, fixing nitrogen and improving the soil.

Old Strategy: Weekly spoon-feeding was required to achieve a steady slow release of nitrogen to the plant.
New Strategy: TURFtech II converts atmospheric N_2 into ammonia NH_4 , all day, every day.

"Having a biologically active soil is like having a mini fertilizer manufacturing plant producing small amounts of 10-5-2 on a continuing basis. This system is worth perpetuating." Eliot C. Roberts of The Lawn Institute, "The Biology of Soils", Golf Course Management, April, 1989.

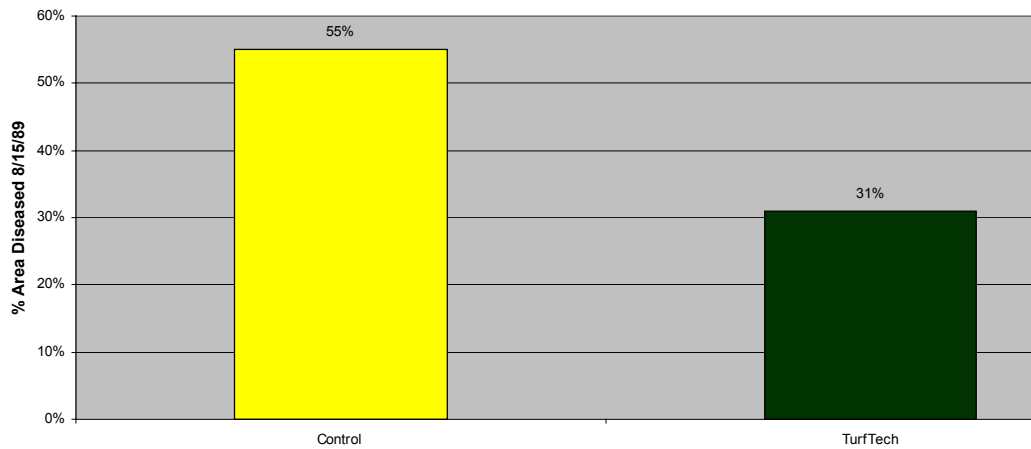
Following the successful introduction of TurfTech II in 1988, scientists at Michigan State Univ. began tests to determine the ability of organic fertilizers to

inhibit fungal pathogens of turf. During 1989, M.S.U. plant pathologists reported that TurfTech II had been effective in reducing Summer Patch and Necrotic Ring Spot by over 40% in treated plots. (See Charts #4A & #4B).

Chart #.4A

Preventative Management of Summer Patch

Grand Rapids Elks Golf Course Grand Rapids, Michigan



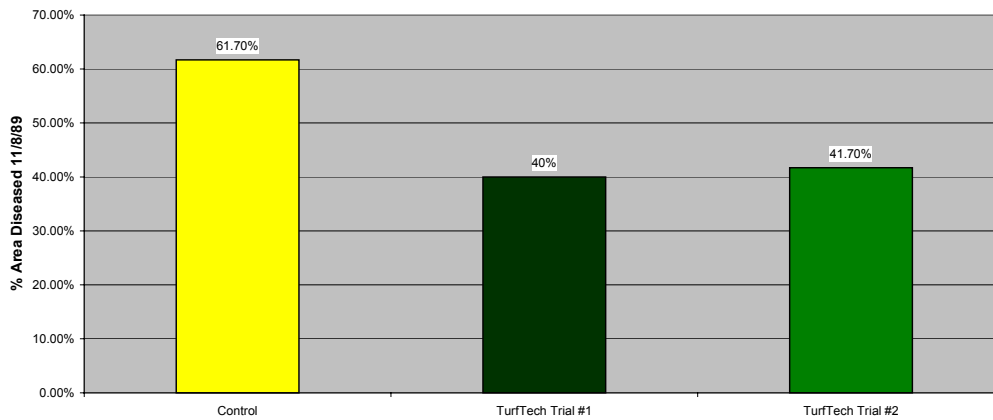
Results: TurfTech treated plots showed a significant reduction in the incidence of Summer Patch disease symptoms, compared to untreated control plots.

Source: Michigan State University, Department of Botany and Plant Pathology, 1989.

Chart #.4B

Preventative Management of Necrotic Ring Spot

Country Place Condominiums Northville, Michigan



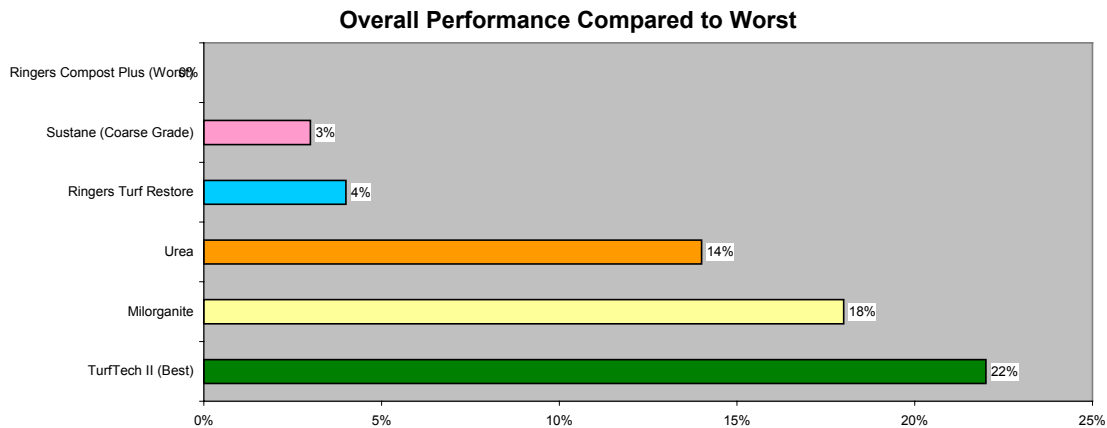
Results: TurfTech treated plots showed a significant reduction in the incidence of Summer Patch disease symptoms, compared to the untreated control plots.

Source: Michigan State University, Department of Botany and Plant Pathology, 1989.

In 1990, tests at Rutgers Univ. confirmed these results. An evaluation of organic nitrogen sources for control of Summer Patch showed that TurfTech II provided the best overall control of all 17 organic nitrogen products tested. The composite average of patch diameter, intensity, and turf quality showed TurfTech II performing consistently across all 3 categories. (See Chart #5).

Chart #.5

**Evaluation of Organic Nitrogen Sources for Control of Summer Patch
Rutgers University, New Brunswick, N.J., 1990**



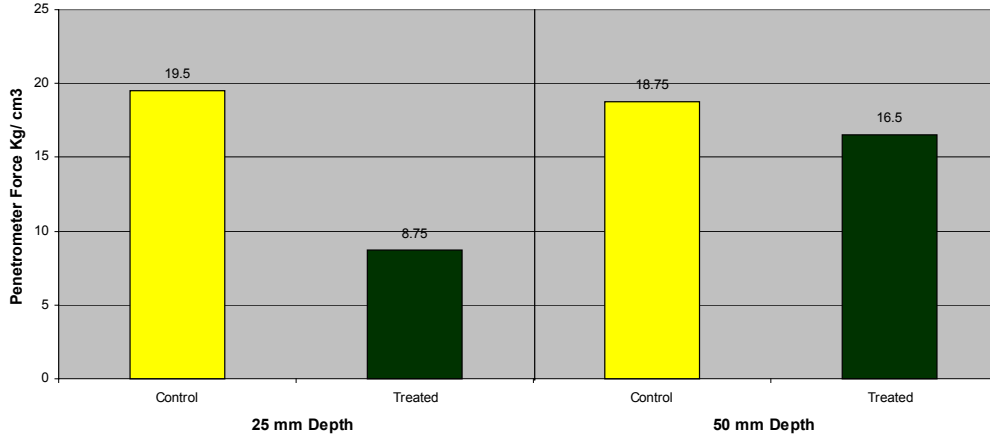
Results: Graphs show the performance of some popular products from best to the worst control. TurfTech II provided the best over-all Summer Patch control in a composite average of all measurements, that included patch diameter, patch intensity, and turf quality. Turf quality was acceptable following treatment with all of the organic sources.
Source: Thompson, D.C, B.B. Clarke, J.R. Heckman. 1990. Evaluation of Organic Nitrogen Sources for Control of Summer Patch caused by *Magnaporthe poae* in New Brunswick, NJ. during 1990. Department of Plant Pathology and Crop Science, Cook College, NJAES, Rutgers University, New Brunswick, NJ.

On the international front, TurfTech was being investigated in Japan during 1988-1990. The South Japan Green Institute published reports in which TurfTech reduced soil compaction by 12-55%, improved water infiltration by 44-52%, increased root growth by 22-41%, and increased soil nitrogen content by 33%. (See Charts #6-#9). All of the tests were done under field conditions on golf courses.

Chart #.6

Mizunami Kogen Country Club
Mizunami, Gifu Japan
-1990 TurfTech II Field Data-

Soil Compaction Reduction

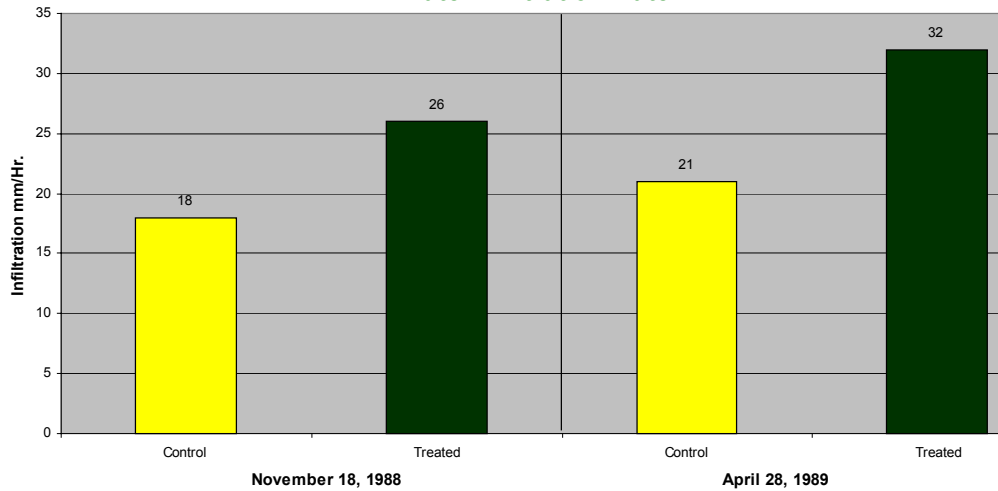


Results: This study analyzed the effects of TurfTech II applications on golf course soils. The plots compared soils treated with two applications Turftech II in the Spring of 1990, to untreated soils. The reduction in compaction levels is correlated to increased soil aggregation.
Source: South Japan Green Institute, Fukuoka, Japan. 1990. Evaluation of TurfTech II Effectiveness as a Soil Conditioner and a Biofertilizer.

Chart #.7

South Japan Green Institute
Fukuoka City, Japan
-1988 TurfTech Field Data-

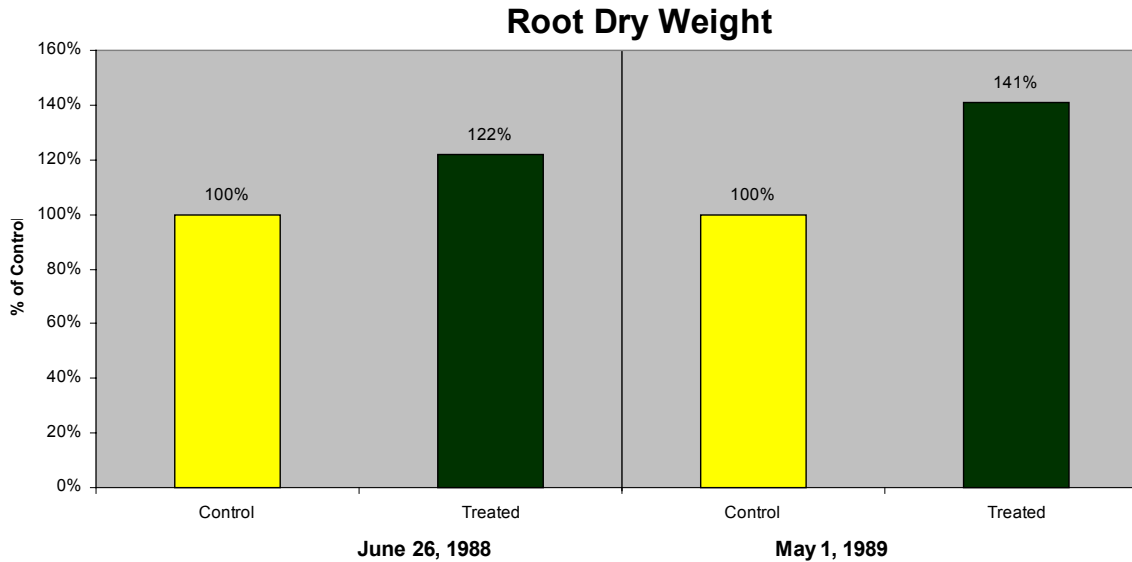
Water Infiltration Rate



Results: This study analyzed the effects of TurfTech application on soils and turf. Treated plots received two (2) applications of TurfTech the spring of 1988. An increase in the water infiltration rate is indicative of increased soil aggregation. Note that the improvements increased over time.
Source: South Japan Green Institute, Fukuoka, Japan. 1998. Evaluation of TurfTech Effectiveness in Improving Soil Physical property

Chart #.8

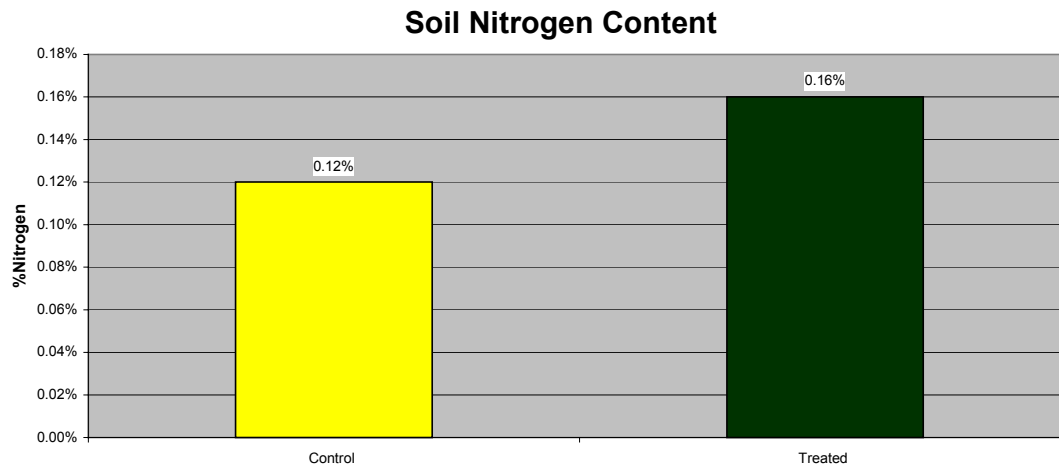
South Japan Green Institute
Fukuoka City, Japan
-1988 TurfTech Field Data-



Results: This study analyzed the effects of TurfTech application on turf grass rooting. Treated plots received two (2) applications of TurfTech in spring of 1988. An increase in the root dry weight is indicative of increased soil aggregation. Note that the root dry weight increased over time.
Source: South Green Institute, Fukuoka, Japan. 1998. Evaluation of TurfTech Effectiveness in Improving Soil Physical Properties.

Chart #.9

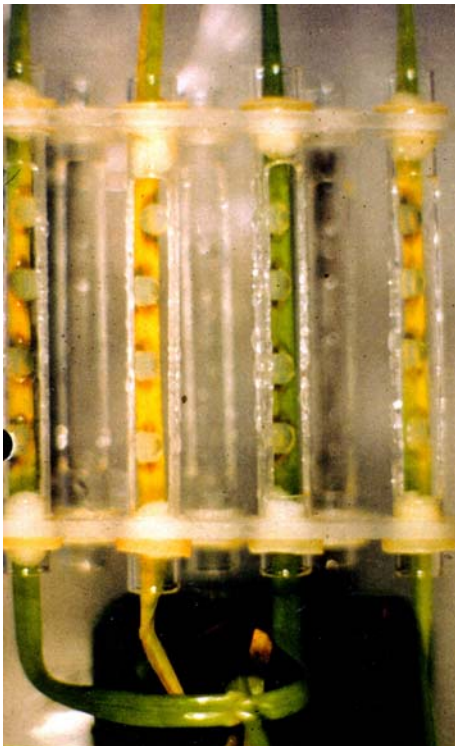
South Japan Green Institute
Fukuoka City, Japan
-1990 TurfTech II - Field Data



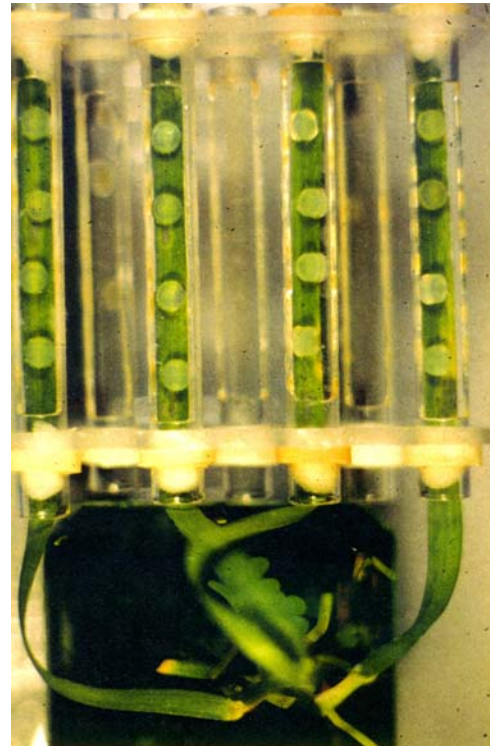
Results: This study analyzed the effects of TurfTech II applications on turf. The treated soils showed a 33% increase in soil nitrogen content over untreated soils. The increase in soil nitrogen content is correlated to the nitrogen-fixing properties of TurfTech II.
Source: South Japan Green Institute, Fukuoka, Japan. 1990. Evaluation of TurfTech II Effectiveness as a Soil Conditioner and a Biofertilizer.

By 1990, Soil Tech had launched a long-term R&D program to develop bio-fungicide products for turfgrass pathogens in co-operation with Dr. Nick Christians and Dr. Clint Hodges at Iowa State University. Soil Tech scientists began the screening process for bio-fungicide activity on several thousand bacterial strains. After narrowing the search to about 12 naturally occurring organisms, Dr.'s Hodges and Christians set out to determine the activity of these 'bio-fungicides' on two turf diseases: Dollar Spot (*Sclerotinia homeocarpa*) and Leaf Spot (*Bipolaris sorokiniana*). Several organisms showed good controls in the lab. (See Illustration #2).

Illustration #2 Evaluation of Bac-Pack Isolates as Potential Biological Control Agents for Foliar Pathogens of Turfgrasses



Dollar Spot (*Sclerotinia homeocarpa*) of Kentucky blue grass (*Poa pratensis*)



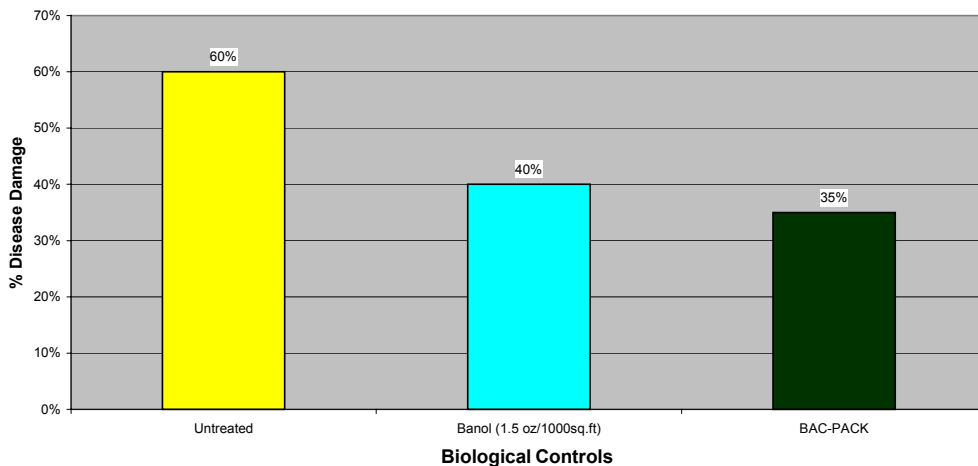
Bio-control by Bac-Pack on Dollar Spot (*Sclerotinia homeocarpa*) of Kentucky blue grass (*Poa pratensis*)

Investigators: Clinton F. Hodges and Nick E. Christians, Department of Horticulture, Iowa State university, Ames, Iowa, U.S.A, 1991

Over the next several years, and in cooperation with Scott Fertilizer Co.’s research scientists, field trials were conducted on the individual strains of bacteria. In 1994 it was concluded that in order to achieve a broad-spectrum effect on a wide range of pathogenic fungi, it would require a blend of multiple organisms. In 1996, Soil Tech introduced Bac-Pack, beneficial microbial blend to the market. After a successful product launch, in 1998 it was determined that Bac-Pack’s efficacy should be compared to several common chemical fungicides. Dr. Eric B. Nelson of Cornell University was chosen to conduct these trials. Experiments were conducted to evaluate a number of turfgrass diseases of creeping bentgrass/*Poa annua* putting greens at the Robert Trent Jones Golf Course at Cornell Univ. Bac-Pack treated plots were compared to conventional fungicide treatments. During July and August 1998 Bac-Pack treated plots showed significantly less disease symptoms than the chemically treated plots for *Pythium*, *Rhizoctonia*, and *Anthracnose*. (See Charts #11, 12, 13).

Chart #.11

**1998 Field Evaluation Of Microbial Inoculants at the R.T. Jones Golf Course at Cornell University
Chart A: Pythium 7/16/98**

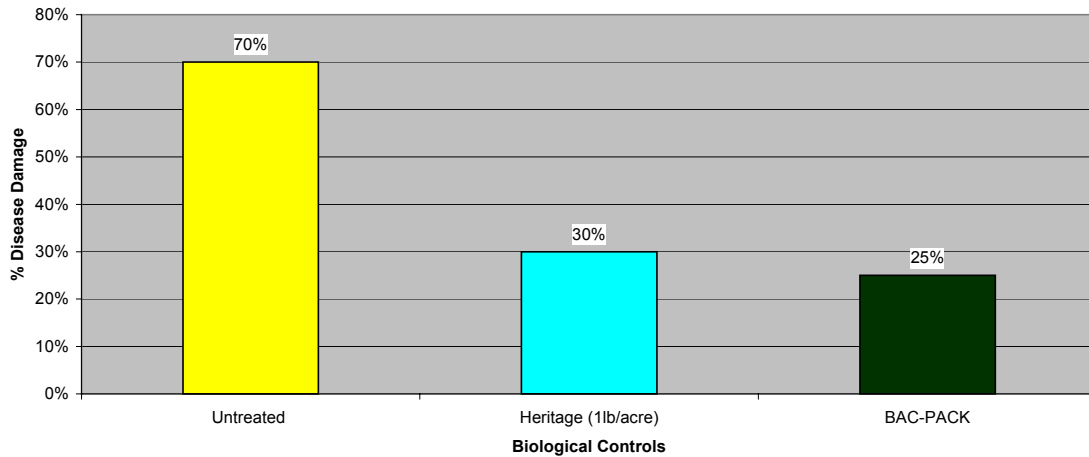


Results: In mid-July, following the first application of treatments, small reddish-brown patches appeared on plots. These symptoms were subsequently diagnosed as *Pythium* root rot. Bac-Pack treated plots showed reduced levels of disease compared with the untreated controls and conventional sprays.

Source: Nelson, Eric B. and Cheryl M. Craft, Associate Professor and Research Support Specialist II, respectively. 1998. Cornell University, Dept. of Plant Pathology, Ithaca, N.Y.

Chart #.12

**1998 Field Evaluation Of Microbial Inoculants at the R.T.Jones Golf Course at
Cornell University
Rhizoctonia (Brown Patch) 7/30/98**

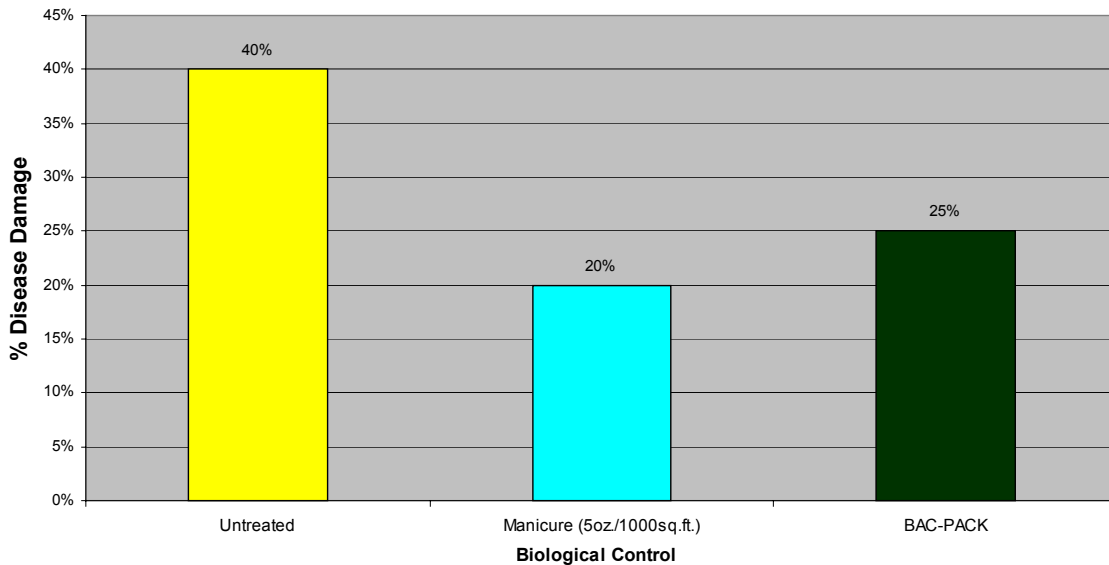


Results: Towards the end of July, Brown Patch symptoms were apparent. A number of significant treatment effects were observed at both the 7/30 and 8/6 rating dates. Bac-Pack showed a significant suppressive effect towards Brown Patch on the 7/30 rating date. By 8/6, Brown Patch symptoms were beginning to disappear (as indicated by ratings of untreated plots). At this rating date, the Bac-Pack treatment was less diseased than the untreated control plots and the conventional treatments.

Source: Nelson, Eric B. and Cheryl M. Craft, Associate Professor and Research Support Specialist II, respectively. 1998. Cornell University, Dept. of Plant Pathology, Ithaca, N.Y.

Chart #.13

**1998 Field Evaluation Of Microbial Inoculants at the R.J. Golf Course at
Cornell University
Anthracnose 8/11/98**

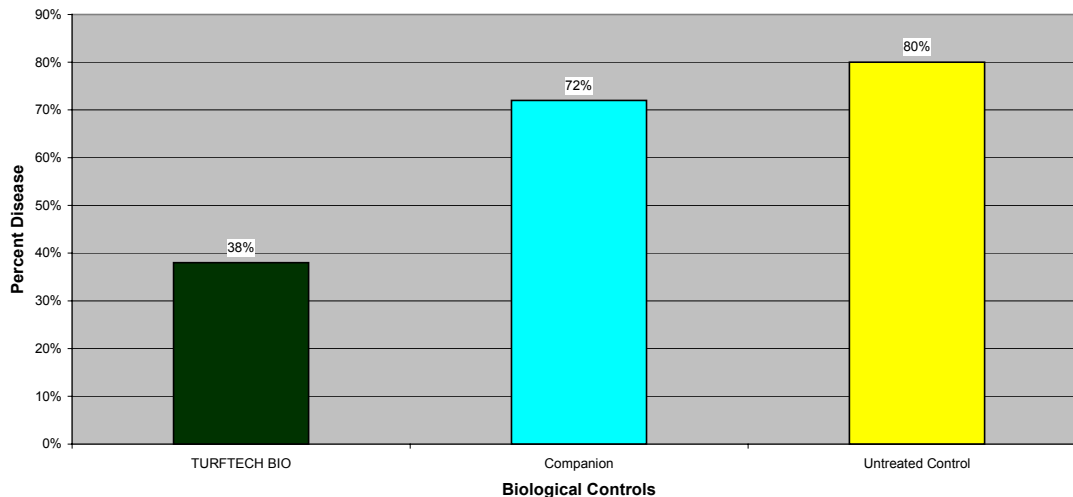


Results: Anthracnose became prevalent on experimental plots toward the middle of August. Plots treated with Bac-Pack showed nur reduced levels of disease compared with the untreated control plots.

Source: Nelson, Eric B. and Cheryl M. Craft, Associate Professor and Research Support Specialist II, respectively. 1998. Cornell Ur Dept. of Plant Pathology, Ithaca, N.Y.

In 1998, several of the beneficial organisms in Bac-Pack were incorporated into the TurfTech II formula to create a new product, TurfTech Bio®. In tests at Texas A&M University, TurfTech Bio was compared with other biologically based controls for *Rhizoctonia* Blight control on bentgrass putting greens. Although the majority of the biologicals provided little control against *Rhizoctonia* when compared to the untreated check, TurfTech Bio provided a 53% reduction of symptoms compared to the untreated plots. (See Chart #14).

Chart #.14 Rhizoctonia Blight Control on a Bentgrass Green Using Biological Based Controls



Results: There were no biologicals that gave significantly greater disease protection than Daconil 2787 fungicide. Although the majority of biologicals provided little protection against *Rhizoctonia* Blight when compared to the untreated check, TurfTech Bio was one of the treatments that was encouraging and showed a 53% reduction of *Rhizoctonia* Blight compared to the untreated control plots.

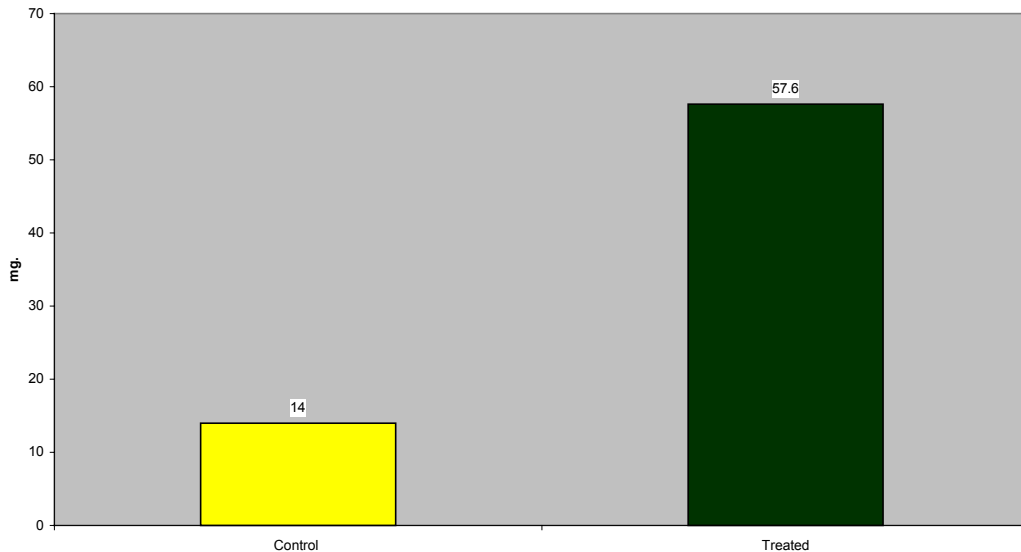
Source: P.F. Colbough and S.P. Metz, Texas A&M University Research Center, Dallas, Texas. 1998. Turfgrass Pathology Research Summary.

During the later product development history of the TurfTech products, it had become increasingly apparent to the Soil Technologies technical staff that the pressure on golf course managers to provide faster green speeds and lower mowing heights was continuing and increasing the stress on United States Golf Association (U.S.G.A.) greens. Whereas the TurfTech products were effective for managing a variety of conditions on native soil areas on golf courses (fairways, tees, and older soil-based greens), the management of U.S.G.A. spec greens with the TurfTech products was insufficient to

completely ameliorate the conditions that were prevalent in these areas. A decision was made to initiate a new product specifically for the conditions unique to the U.S.G.A. greens. The beneficial organisms in the TurfTech products were formulated with numerous bio-stimulant compounds to form a new product, Micro-Gro Plus. This product consists of seaweed extracts (SWE), humic substances, micronutrients, enzymes, volcanic rock dusts, and the beneficial organisms described earlier. The seaweed extracts (SWE) have been demonstrated in 1990 by Dr. Richard Schmidt of Virginia Tech to provide significantly improved turfgrass shoot and root weight. (See Chart #15). In an article published in Grounds Management, June 1990, Dr. Schmidt concludes “Treatments allow turfgrasses to tolerate low soil moisture by helping plants develop larger root systems and by altering plant physiology.”

Chart #. 15A

Shoot Dry Weight

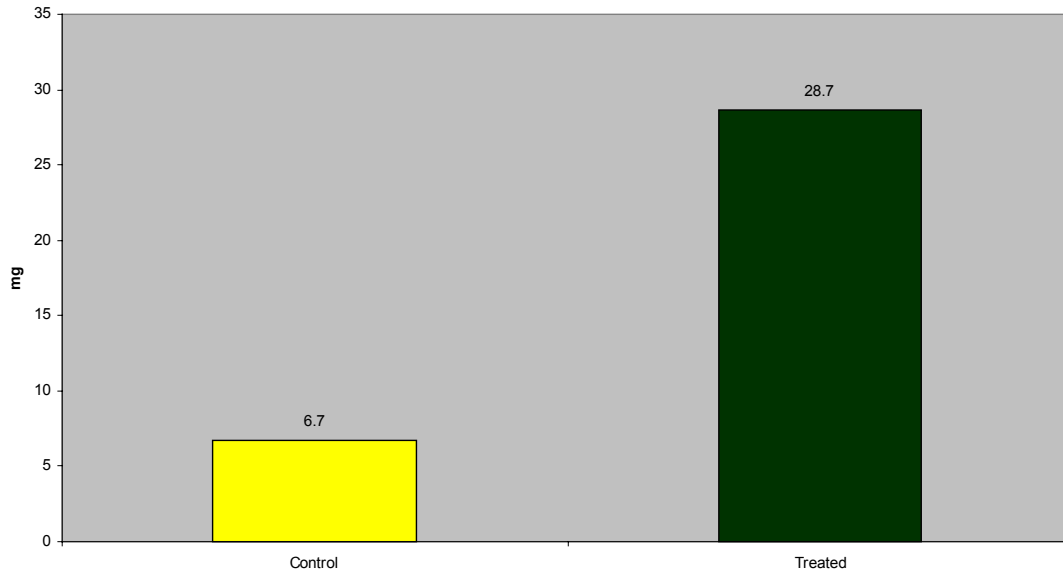


Results: Kentucky bluegrass seedlings treated with Seaweed extracts (SWE) showed a significant increase in shoot (dry wt.) when compared to untreated controls

Source: Goatley, J.M, R.E. Schmidt. 1990. Seedling Kentucky Bluegrass Growth Responses to Chelated Iron and Biostimulator Materials. "Agronomy Journal." 82(5):901-905

Chart #. 15B

Root Dry Weight



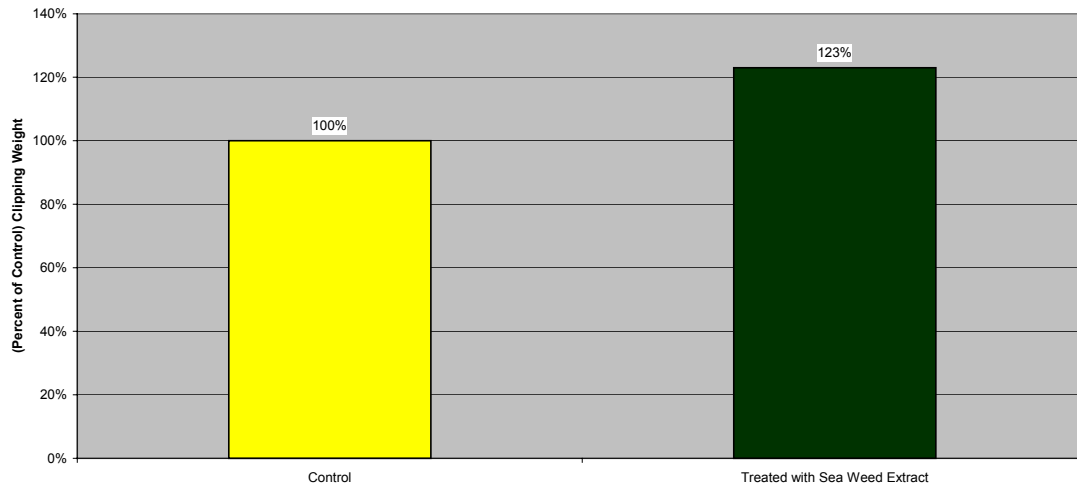
Results: Kentucky bluegrass seedlings treated with Seaweed extracts (SWE) showed a significant increase in rooting (dry wt.) when compared to untreated controls.

Source: Goatley, J.M, R.E. Schmidt. 1990. Seedling Kentucky Bluegrass Growth Responses to Chelated Iron and Biostimulator Ma "Agronomy Journal." 82(5):901-905

In further studies reported in 1992, Dr. Schmidt showed that SWE helped turfgrasses overcome saline soil growing conditions. "The results clearly show that SWE helps turf maintain a better leaf water status and increases root growth." Under saline-water irrigation SWE treated turf had 23% more foliage than untreated turf. (See Chart #16).

Chart #.16

Foliage Growth Under High Salinity Irrigation Water (2000 ppm)



Results: A mature stand of Kentucky bluegrass was treated with a high salinity hazard (2000ppm) irrigation water. The saline irrigation water was applied 3 times/week for 7 weeks. The plots treated with Seaweed extract (SWE) had 23% more foliage than the untreated turf.

Source: Schmidt, R.E., Grounds Maintenance, July, 1992, pgs 38-57. Dept. of Crop Sciences, Virginia Polytechnical Institute and State University.

By combining a variety of beneficial organisms with biostimulant materials such as SWE, Micro-Gro Plus provides a variety of benefits to turfgrasses, best described as a bio-fertilizer effect. The practical results to turfgrass managers include lower fertilizer requirements, less soil compaction, and improved plant health, especially on the intensive management of turfgrasses on U.S.G.A greens.

These product technologies, developed by Soil Tech scientists over the past 20 years and utilized on thousands of golf course and sports field applications, provide an effective method for managing a variety of agronomic factors affecting turfs, while using sustainable technologies. The wide range of research findings and the consistently positive results has paved the way for turfgrass managers and horticulturalists to embrace these products with confidence.