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Biotechnology, Fact and Fiction: What Does the Future Hold?

By Dr. G. A. de Zoeten

"Any day now. . . ." is the expectation that many have for the application of biotechnololgy in production plant agriculture. Uninhibited extrapolation from exciting laboratory results form the basis for these expectations.

There are several categories of exciting technological advances with their attendant promise of application in plant agriculture.

•Recombinant DNA techniques, by which agriculturally useful plant or microbial genes are identified, isolated and moved into the chromosomes of target plants provide a methodology with a bright future.

A cautionary note may be called for. At this time our molecular biologists are just learning to transfer single gene traits in to mostly experimental model plant systems such as tobacco. However, many of the agriculturally desirable characters, such as nitrogen fixation are controlled by many host as well as bacterial genes.

•Currently tissue culture methodologies are used in the experimental exploitation of somatic embryogenesis (artificial seed), somaclonal variation (variation occurring in plant cells due to genetic pressure in tissue culture), and somatic hybridization (protoplast fusion) of species that cannot be crossed sexually. Although promising laboratory results have been obtained it is hard to predict when benefits of these new technologies will reach the turf grass grower. This assessment is mainly based on the fact that grasses and in general monocotyledonous plants have been extremely difficult to regenerate from single cells currently a prerequisite for biotechnological advances in plant agriculture.

The claimed advantage of the application of recombinant DNA and tissue culture techniques is time savings over traditional plant breeding. At this stage of development of the methodologies it is questionable that the application of these technologies to plant agriculture can bypass the conventional plant breeding approaches completely and produce an acceptable variety of any crop.

•Diagnostic application of recombinant DNA techniques and serological techniques based on monoclonal antibody methodology hold the only promise of immediate useful application in agriculture.

It is the profit margin and the value of a commodity that determine the financial space in which both the biotechnology firm and the agricultural producer can maneuver. Thus, high value crops and high cost items in the production of medium to low value crops will be targets for biotechnology. Turf grass disease diagnosis because of the high replacement costs of turf grass stands have been targeted by some companies for development of diagnostic kits. The Pro Turf detection kits for golf course turf managers developed by Agri-Diagnostics Associates are being marketed by O. M. Scott and Sons, Inc. and seem among the first products of biotechnology that found their way to practical plant agriculture.

Since services to agricultural producers traditionally available free of charge from extension and other federally supported programs are being cut drastically, commercialization of the "do it yourself diagnostic kits" for agriculture may be helped greatly.

Although the promises of biotechnology in agriculture are great and the possibilities for their realization within 10-20 years are real (facts), the expectation of "any day now. . . ." is mainly fiction.

Editor's Note: Dr. Gus de Zoeten has been a Plant Pathology professor at the University of Wisconsin since 1967. A native of Holland, Dr. de Zoeten earned his Ph.D. degree in plant pathology at the University of California — Davis in 1965. His research in the department includes viral multiplication and translocation, and the mechanism of cross protection.

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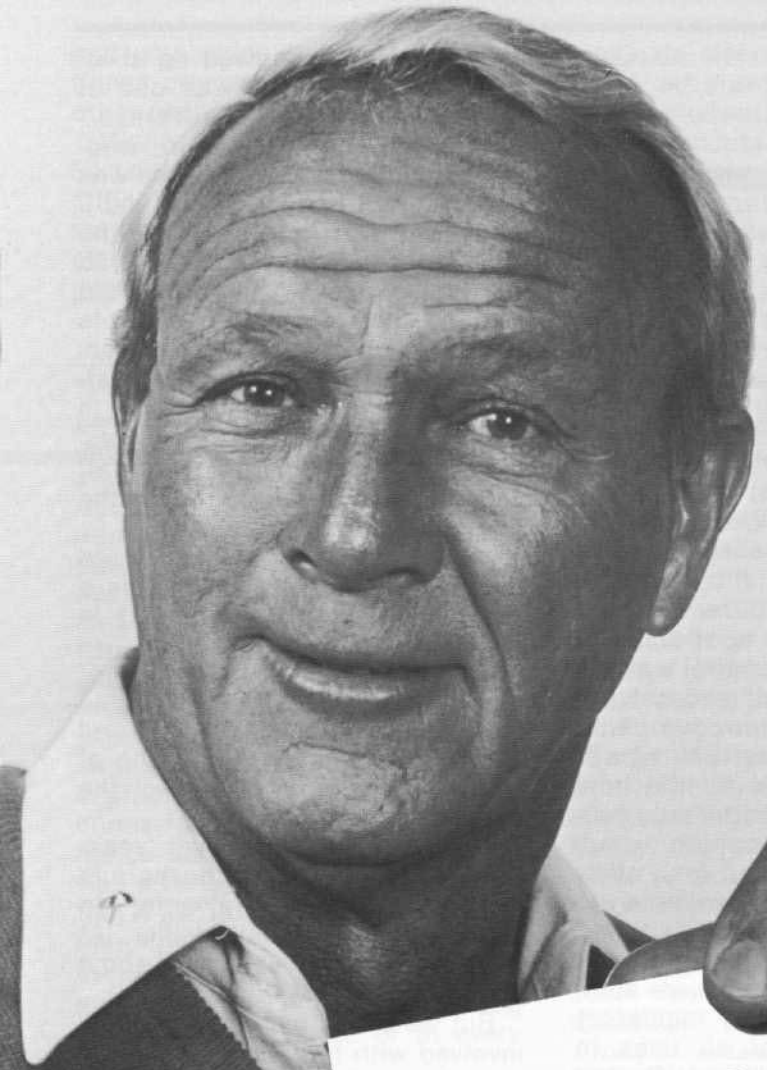

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Repell	5.7
Citation II	5.7
Manhattan II	5.7
Premier	5.6
All Star	5.6
Blazer	5.6
Ranger	5.6
Birdie II	5.6
Fiesta	5.5
Yorktown II	5.5
Pennant	5.5
Derby	5.4
Cowboy	5.4
Dasher	5.3
Diplomat	5.3
Ovation	5.3
Pennfine	5.3
Regal	5.2
Delray	5.2
Barry	5.2
Omega	5.2
Elka	5.2
Manhattan	5.1
Citation	3.6
Linn	

Test locations: Kingston, RI; Ithaca & Riverhead, NY; North Brunswick & Adelphia, NJ; Beltsville & Fairland, MD; Blacksburg & Springfield, VA; Lexington, KY; Mississippi State, MS; Ames, IA; St. Paul, MN; Lincoln, NB; Stillwater, OK; Fort Collins, CO; Everett & Puyallup, WA; Hubbard, OR; San Jose & Riverside, CA.

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Wisconsin Golf Courses Serve as University Experiment Stations

By Dr. Gayle L. Worf

The occasion of this newsletter gives me reason to reflect upon our involvement over the years with the golf course superintendents, and our mutual efforts to serve the state and its people with the production and maintenance of high performance amenity turf. Our high numbers of golf courses and players in the state on a per capita basis speaks of the demands for it.

But we don't have a turf research facility that supports it in the manner typical of most other land grant universities. That was—and still is—the circumstance when we began our relationships over a quarter of a century ago. Had it not been for the character and persistence of a rather large number of superintendents who recognized the situation, we may have had to be content with "borrowed" information from other states that may-or may not-have met Wisconsin's needs.

But some superintendents insisted: "Why don't you use our courses for your research trials?" So we started to do so. And this article is a recollection of some of those experiences, as well as an effort to identify some of the progress that has come through those cooperative efforts.

We started out innocently enough, as I recall. We went out to take a look at a disease response taking place in Dr. Jim Love and Roger Larson's fertilizer trials at Maple Bluff. Dollar spot was the disease, and good control was being obtained with the (excessively) highest rates of nitrogen. That started the question about fungicide efficacies. At that time we had Actidione, thiram, mercuries, cadmium, captan, mancozeb, PCNB and a few other lesser compounds available to control turf diseases. Each had their problems and limitations, and two of the main actors were soon destined to be lost by regulatory action for some or all uses in Wisconsin. Daconil and Dyrene were just coming on the market, and superintendents were asking questions about them. So we set up our first replicated trials there in 1965, together with Love and Larson. It was a factorial, involving 0, 3 and 9(!) pounds of N/1000 ft2 as 33-0-0 and 10-6-4. We tested Daconil, Dyrene and Dithane M-45 (Fore) with 6 applications from June 7 to July 27. With all that effort, no disease showed up at all that summer! But it was one of those years for "fall disease." Symptoms developed in mid-September. Very little disease was present in plots receiving 3 and 9 pounds of N. It was severe in the low N plots—evidence of the need for high N by Poa annua. And Daconil and Dyrene treatments had only about half as much infection as non-treated and Fore-treatments—evidence that there is some carryover benefit from summer treatments into the fall season, but not enough to do the job without supplementation.

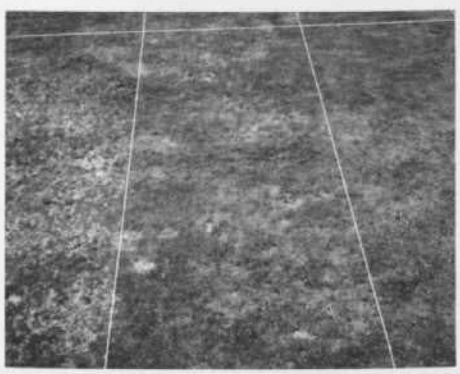
(The absence of expected disease during the season was a pattern often to be repeated in subsequent years, we were to learn later. Reliable prediction of disease outbreaks, which could result in more timely selection and use of chemicals remains one of the most important needs of the golf course industry today.)

That was followed two years later with a Helminthosporium control trial at Nakoma, in cooperation with Pete Miller. At that time we were also trying some remedies for "Fusarium blight."

But we didn't become seriously involved with fungicide evaluation work on golf courses until 1970. That was a bad time for golf courses and the pesticide industry. Three children of a New Mexico family became blinded and paralyzed after eating pork from a hog their father butchered that had been (illegally) fed grain treated with a methyl-mercury fungicide. This occurred soon after some other mercury-related calamaties in Pakistan, Japan and Sweden,

Cooperative trials on the golf courses often involve applications with this unit, which has been designed to deliver chemicals uniformly and precisely for comparative evaluations. The next two photographs offer examples.

Fungicides are sometimes found to control one disease but not another in the same trials. Dollar spot is evident in the left section, anthracnose in the center, while both are controlled in the section to the right.



The experimental chemical Bay Meb 6447 (later named Bayleton) was the first chemical we observed to have dramatic effects upon the control of summer Poa decline.

and was coinciding with international concerns about DDT and other pesticides.

Work was needed right away to: (1) confirm where mercuries were critically essential to golf course maintenance, and (2) establish alternative treatments where possible.

We felt a panic especially for snow mold control in the state. Trials at Ozaukee, Maple Bluff and Lake Forest golf courses were established. Fortunately for this situation—we picked a bad snow mold year! The trials vividly demonstrated the devastating potential of snow mold. (To this day we admire the understanding and patience of the Maple Bluff membership, but we will never again display the bravery, naivety, and/or audacity to try such large experiments on greens!) We also showed that Dyrene was **not** an acceptable substitute for the mercuries, as was being claimed in states east of us; that chloroneb was a very excellent product—but that it will fail as a replacement for mercury on many courses under severe pressure; and that "snow mold" is simply not the same thing on every golf course or in every year!

Soon afterward, cadmium and chromium-containing fungicides were nearing a ban (which ultimately occurred in Wisconsin). These three compounds were literally the backbone of disease control on golf courses, and their departure signalled a need for a revolutionary change in pesticide choices. Fortunately, we were entering into a new era of fungicide discovery that could be taken advantage of to develop useful alternatives for the traditional products that had been produced before the modern toxicological and environmental restrictions were in place. People following my generation find it difficult to imagine a world without television or satellites. Younger superintendents may likewise be unappreciative of the fact that the benzimidazoles (Tersan 1991, Fungo 50, etc.), dicarboximides (Chipco 26019, Vorlan), ergosterol biosynthesis inhibitors (Bayleton and Rubigan), and systemic or residual Pythium-controlling products (Subdue, Banol and Aliette) are all products that have been developed and registered for turf in the last dozen years. Of importance to this story is that research conducted on golf course (and other) turf sites in Wisconsin contributed significantly to their ultimate registration and availability.

We've gone back through our records to offer the following summary of "cooperative research stations" (golf courses only) where such research has been conducted:

Year	Location and Research
1965	Maple Bluff Dollar spot
1966	Nakoma Helminthosporium
1970	Lake Forest Snow mold
	Maple Bluff Snow mold
	Ozaukee Snow mold
1971	Maple Bluff Snow mold
	Lake Forest Snow mold
	Wausau Snow mold
1972	Bass Lake Snow mold
	Maple Bluff Snow mold
	Telemark Snow mold
1973	Bass Lake Snow mold
	Maple Bluff Snow mold
	Peninsular State Park Snow mold
	Plum Lake Snow mold
	Telemark Snow mold
1974	Bass Lake Snow mold
	Maple Bluff Snow mold
	Nakoma Snow mold
	Telemark Snow mold
1975	Bass Lake Snow mold
	Blackhawk Helminthosporium
	Maple Bluff Snow mold
	Nakoma Snow mold
1976	Telemark Snow mold
	Wausau Snow mold
1977	Maple Bluff Snow mold
	Telemark Snow mold
1978	Maple Bluff Snow mold; Dollar spot
	Odana Helminthosporium
	Telemark Snow mold
1979	Blackhawk Poa decline
	Buttes des Mortes Snow mold
	Maple Bluff Poa decline, Pythium, Snow mold
	North Hills Pythium
	Odana Helminthosporium
	Ozaukee Dollar spot
	Tuscumbia Dollar spot
1980	Blackhawk Poa decline
	Maple Bluff Poa decline
	Nakoma Dollar spot
1981	Blackhawk Poa decline and Dollar spot
	Lake Geneva Dollar spot
	Maple Bluff Poa decline
	Mascoutin Necrotic ring spot
	Nakoma Dollar spot; Anthracnose
	Oconomowoc Dollar spot
	Tuscumbia Dollar spot; Poa decline
1982	Blackhawk Poa decline; Dollar spot
	Brynwood Pythium
	Chaska Snow mold; Necrotic ring spot
	Maple Bluff Poa decline
	Nakoma Dollar spot; Anthracnose
	North Hills Pythium
	Riverside Poa decline
	Timber Ridge Red thread
	Westmoor Fairy ring
1983	Devil's Head Pythium
	Maple Bluff Pythium
	Nakoma Dollar spot; Anthracnose
	North Hills Pythium
	Tuckaway Dollar spot; Anthracnose
	Wausau Snow mold
	Westmoor Snow mold
1984	Nakoma Dollar spot; Anthracnose
	Oconomowoc Dollar spot; Poa decline; Growth regulator effects
	Wausau Snow mold
	Westmoor Snow mold
1985	Blackhawk Fairy ring
	Camelot Dollar spot; Variety plot
	Nakoma Dollar spot; Anthracnose; Poa Patch disease
	Oconomowoc Dollar spot; Poa deline; Growth regulator effects
	Stevens Point Nematode; Snow mold

Not included are the many that have contributed other forms of insight into turf health, including some demonstration treatments, samples and observations. And we

(Continued on page 38)

With his back to the camera, Randy Smith (Nakoma) is discussing the results of his plots with two chemical representatives from Kansas City. They ultimately decided to label products in accordance with Wisconsin experiences.

The plots have served extension functions, too. Ray Knapp and Glenn Dahl, former student assistant, were awaiting fellow golf course superintendents to view Ray's plots when this photograph was taken at Tuckaway.

DISEASE RESISTANCE

By Dr. Albert H. Ellingboe

Diseases of plants are controlled by a combination of host plant resistance, use of pesticides, and cultural and other management practices. For some diseases there is an adequate level of host plant resistance so that the use of pesticides is unnecessary and, even if the cultural practices favor the pathogen, adequate control is still achieved. An example is the high level of resistance to rust in some cultivars of bluegrass. Other cultivars have an intermediate level of resistance that is adequate for control of rust in most, but not necessarily all, crop management schemes. Other cultivars may have such a low level of resistance that adequate disease control is achieved only under specific management practices or the use of pesticides.

The ability to breed for resistance to diseases is dependent on finding a source of resistance. That usually involves screening a large collection of individuals of that species for resistance, either by creating epidemics through inoculations or by planting in an area where the disease is known to be severe. Individuals that are classified as resistant, or having some potentially useful level of resistance are then crossed to the commercially acceptable cultivars, and selection in subsequent generations are for resistance and the other desirable agronomic traits.

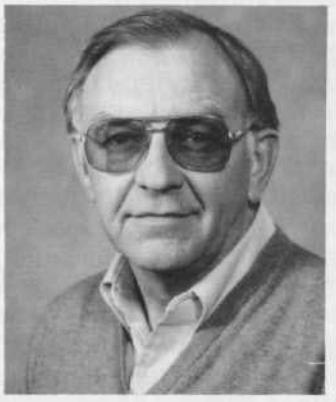
The availability of resistance in a plant species is dependent on the particular disease. For some diseases it is possible that 25 percent or more of the members of a worldwide collection of a species may be resistant to the pathogen. If such is the case, breeding for resistance is relatively easy. If, on the other hand, only a few members of the germplasm collection are resistant, then the development of agronomically acceptable and disease resistant cultivars may be more difficult.

The level of resistance available may also differ. For example, it is relatively common to find a high level of resistance to leaf pathogens but only low levels of resistance to root pathogens. The systems to screen for resistance to leaf pathogens are usually quite easy. The systems to screen for resistance to root pathogens are usually quite difficult, and less reliable. These differences help to explain why there has been extensive breeding for resistance to leaf pathogens and relatively little effort to breed for resistance to root pathogens. The difference also helps to explain why most basic research on the mechanisms of resistance have been with leaf pathogens. When there are high levels of resistance to a pathogen and it is easy to distinguish between resistant and susceptible plants, it is relatively easy to study the patterns of inheritance of resistance. Hence, most basic studies on the genetics of interactions between plants and pathogens have been done with leaf pathogens.

The development of disease resistant cultivars does not necessarily give long term disease control. That is because the pathogen may change from being avirulent to virulent on that cultivar. The frequency of the genetic changes in pathogens is dependent on the pathogens and the host genes that originally gave the plant its resistance. Therefore, breeders must continue to develop new cultivars that are resistant to a pathogen based on different genes. When one cultivar becomes susceptible, it can be replaced by cultivars that are essentially identical except for the genes that give it disease resistance.

Any one plant species, such as bluegrass, is affected by many different diseases. An objective for breeding is to develop cultivars with resistance to as many pathogens as possible and still retain the desirable agronomic traits. That means that techniques must be developed to screen for resistance to each of the important pathogens, and then the genes that give resistance to each pathogen must be combined into a single cultivar. Because of the difficulties of combining all the genes for disease resistance as well as the genes that affect growth habit, drought tolerance, etc., and the fact that the pathogens are constantly changing, new cultivars are released for usage that may have resistance to some but not all diseases. Some diseases are controlled by host resistance, some by the use of pesticides, and some by management strategies.

Breeding for disease resistance is considered a safe, effective means to control diseases. The availability of resistance in the plant species, the level of resistance, the ease with which that resistance can be transferred, and the stability of that resistance all affect the success of a program to breed disease resistant cultivars.



Editor's Note: Professor Al Ellingboe is a relatively new member of the Department of Plant Pathology at the University of Wisconsin — Madison, joining the staff in 1983. His previous experience includes twenty years as a plant pathologist on the faculty at Michigan State University (1960 — 1980) and three years of work with the International Plant Research Institute (1980 — 1983).

Born and raised on a Minnesota dairy farm, Dr. Ellingboe received all of his formal plant pathology education at the University of Minnesota — B.S., 1953; M.S., 1955; and Ph.D., 1957. His specialty in the Department is the study of diseases of field crops with emphasis on the genetics of host-parasite interactions and the cloning of genes controlling disease resistance.

(Continued from page 35)

suspect that we've missed some important cooperators along the way. But from the above one can begin to appreciate that the state's golf courses do, indeed, serve an integral role in the business of figuring out what's needed for turf disease identification and control.

We shouldn't lose sight of the fact that these sites not only have provided a research site, they've also played an important extension role, too. Most of these have been observed by other superintendents in informal or formal settings. The information is a basis for much of the disease control recommendations. And Camelot and Oconomowoc have served as the hosts for the Turfgrass Field Days for the past two summers.

We hope the proposed turf research station becomes a reality someday. It would save a lot of travel time; we could conduct different types of research than we can now—and it should be safer than dodging golf balls, too! But I suspect that some work would still remain on these very special kinds of "University Research Stations.

It's an impressive list of cooperators. We appreciate it!

Biological Control of Soilborne Plant Disease

By Dr. Jennifer L. Parke

In the plant pathologist's black bag are several strategies for controlling plant disease. These include traditional methods of chemical control (fungicides, fumigants), the use of disease-resistant plant varieties, sanitation to limit disease spread, and modification of cultural practices to create an environment less conducive to disease. Although each strategy is useful, there are occasions when none of these methods is effective or economically feasible in solving disease problems. For instance, fungicides are expensive, often require multiple applications, present some degree of environmental hazard, and with repeated use can result in development of pathogen populations which are resistant to the fungicide. It is in these situations that an alternative control strategy such as biological control should be considered.

Biological control uses living organisms, or metabolites produced by living organisms, to combat plant pathogenic fungi, bacteria, viruses, or nematodes. This process occurs naturally in many soils; just as plant species compete with one another for light, nutrients, and water, so do microorganisms compete for nutrients, oxygen, and microsites. Microorganisms have evolved complex "weaponry" for this competition, including antibiotics and special chelating molecules that bind certain soil nutrients very tightly to prevent their utilization by other microorganisms. In fact, the field of medicine has exploited this intense natural competition among soil microorganisms in the use of antibiotics to fight human pathogens; streptomycin, produced by the soil microorganism **Streptomyces**, is one example. Microorganisms can also act as predators or parasites, digesting or invading propagules of plant pathogens, decreasing their viability and their potential to cause disease.

The competition between soil microorganisms is most intense in the area immediately surrounding plant roots called the rhizosphere ("rhizo" = root), because it is here that most of the sugars and organic acids they use for food are leaked from roots to the soil. Each microorganism is vigorously competing for this limited source of nutrients to the extent that plant roots are densely covered by fungi and bacteria, many of which are actually beneficial to plant growth. Because of this intense competition it is unusual that a single pathogenic organism can gain a strong enough "foothold" to cause disease; it is rare to see root disease epidemics in soils which support a large and diverse rhizosphere population of microorganisms. However, in soils in which microbial populations are low, either because the soil is sandy, low in organic matter, or treated with a biocide, this depleted rhizosphere population is less able to prevent an aggressive pathogen from dominating the root zone.

Biological control makes use of microbial antagonism, either by restoring a large and diverse rhizosphere population by cultural means, or by finding and adding back one or more strains of microorganisms which antagonize a particular pathogen. In some cases, antagonistic bacteria have been mass-produced, then added as a seed coating, much as the nitrogen-fixing bacterium **Rhizobium** is added to alfalfa, pea, and bean seed to improve plant growth. Other modes of application include adding microorganisms to soil as a drench, as a dry powder, or as pellets. Biological control agents reproduce in the rhizosphere, and give protection against plant pathogens approaching the root. Biological control has been suc-

cessful in controlling a variety of root diseases including **Sclerotinia** root rot of lettuce, **Phytophthora** root rot of avocadoes, crown gall of woody plant species and many others. One of the best examples is the biological control of the take-all disease of wheat caused by the fungus **Gauemannomyces graminis** var. **tritici**, for which antagonistic bacteria are applied to wheat seed at the time of planting to reduce disease. Since wheat and turf grasses are closely related and share numerous diseases in common (**Pythium, Rhizoctonia, Fusarium**), one would expect biological control of wheat diseases to have successful application to many turf diseases. Because this is a new and rapidly developing field of research, biological control agents should become available commercially within the next five years.

One classic approach in biological control of soilborne plant pathogens is to identify, characterize, and utilize disease suppressive soils. Suppressive soils can arise in an area where disease was once prevalent but where it has subsided with continued monoculture of the crop. The suppressiveness is generally associated with the build-up of a microbial population which is antagonistic to plant pathogens. If a suppressive soil is steamed to eliminate its living microorganisms, the soil loses its ability to deter plant pathogens. Once a suppressive soil is found it can be used as a source for microbial antagonists which can be tested individually for their effectiveness in reducing the growth, survival, or disease-causing ability of the pathogen in lab, greenhouse, and field trials.

The field of genetic engineering has increased the potential for achieving biological control. Within the next several years it should be possible to genetically modify microorganisms to increase their effectiveness as biological control agents; an organism could thus be modified to incorporate the attributes of a good root colonist and rhizosphere competitor along with having the capability to grow rapidly, tolerate environmental extremes and produce antibiotics to limit specific soilborne plant pathogens. Even though the technology for this is currently available, we need to learn much more about which organisms to modify, and in what way.

Biological control of turf diseases is just beginning to be explored. In many ways turf is ideally suited for biological control; because turf is a perennial, a desirable rhizosphere microflora, once established, could be maintained indefinitely and may not require repeated applications of biological control agents. The high intensity horticulture used for turf production and maintenance makes the application of biological control agents eminently feasible. The use of biological control organisms would probably be a safer alternative than application of toxic chemicals, a consideration very important because of the public's exposure to turf in their home gardens, parks, schools, and golf courses. Most important, perhaps, is the opportunity to maximize the effectiveness of biological control in turf by carefully controlling the environment in which these organisms are expected to perform; more than for any food crop, it is possible to adjust soil conditions in turf by altering the frequency and duration of irrigation, applying soil fertilizers, maintaining soil pH, spot-treating confined areas, and so on. In view of the increasing importance of biological control as a strategy for decreasing disease in agriculture as a whole, additional research is certainly warranted to examine the potential benefits of this strategy as it applies to turf.

Editor's Note: Born in Washington state and raised in California, Dr. Jennifer Parke moved to Madison in July of 1984 to assume a position as Assistant Professor of Plant Pathology at the University of Wisconsin. She received a B.A. degree from California — Santa Cruz in 1975 and a Ph.D. degree from Oregon State University in 1982. After completing her studies in Corvallis and prior to coming to Wisconsin, she received a Fulbright postdoctoral fellowship to work at the CSIRO Division of Soils in Adelaide, South Australia.

She specializes in the ecology and biocontrol of soilborne plant pathogens.

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