CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

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The Challenge Of Poor Irrigation Water

The recurrent droughts experienced through the US each year have given the turf industry pause. Watershed commissions that cross state lines, water management districts that determine water needs, and municipal water suppliers continue to question the use of potable water for recreational (read nonessential) use.

The Northeast Climate Center reported that the month of April in the Northeast United States was the driest in recorded history. The Southeast United States is in the throes of the most significant drought in the last 100 years. The Florida golf turf industry may soon be facing phased-in restrictions that will allow watering of fairways once per week, and greens and tees twice per week.

The energy debate that is currently raging across the United States—and focused in California—pales in comparison to the volatility and politics of water. "Water rights stir deep emotions in the Western states," says Bill Bradley, former Senator from New Jersey and member of the Senate Energy and Natural Resource Committee, in his 1996 memoir *Time Present, Time Past* (Knopf Publishing, NY). "Disputes over water in Western history have affected sovereignty and influenced borders," Bradley alludes, "where many say whiskey is for drinking, water is for fighting."

With less than 1% of the world's water available for human consumption and 80% of the fresh water consumed for agriculture, concern is growing over water used for maintaining greenspace, such as golf courses. Jim Watson, Ph.D., in the opening chapter of the 1994 text *Wastewater Reuse for Golf Course Irrigation* (Lewis Publishers, MI), proposes six areas the will increase water availability. Along with conservation and development of plants that use less water, Watson suggests that the use of wastewater and desalinization of seawater offer two important options. As salt water intrusion into Long Island wells increases, desalinization may soon be required.

Wastewater

With population growth and the demand for potable water expected to increase, the turfgrass industry can no longer take a passive

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This Times

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Clippings

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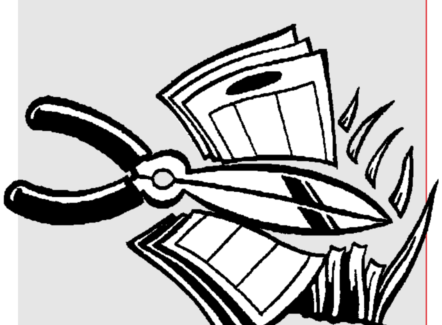

Villani Fund Established

The passing of Mike Villani has resonated around the world in the scientific community, as well as locally, as we grapple with the loss of our friend. The loss of a man as selfless and giving as Mike is difficult to honor in a way that would be worthy. This is why prior to Mike's death he assisted with setting up a Memorial Fund. The Mike Villani Graduate Student Research Fund will be awarded to a deserving graduate student in entomology at the Geneva Station.

Donations can be made to The Mike Villani Graduate Student Research Fund in Entomology. Checks should be made payable to Cornell University and mailed to the Mike Villani Fund, Cornell University, Development Office, 272 Roberts Hall, Ithaca, NY 14853.

CUTT plans a special memorial issue in Mike's honor for the Fall issue. If you have any stories or photos of your association with Mike Villani that you'd like to contribute, contact Frank Rossi by phone, (607) 255-1629, or email, fsr3@cornell.edu.

Lawn.cornell.edu highlighted in ON Magazine

Under the heading "The Taming of the Green", our own Dr. Frank Rossi was interviewed by ON Magazine, which bills itself as "your where-to-go, how-to-do-it guide to being connected," for the July 2001 issue. Author Phil Roosevelt wrote:

"The most beautiful grass that Frank Rossi ever saw was nearly 10 feet high. It was swaying gently in the wind in an old Wisconsin prairie, filling Rossi with 'this enormous feeling of peace.' Rossi, a professor of turfgrass at Cornell University in Ithaca, NY, knows that most folks don't want a prairie for a lawn. But he still recommends keeping the green stuff on the long side. 'Mow high, mow often,' he instructs at his elegantly simple lawn care website, www.lawn.cornell.edu.

"The idea is that longer grass grows longer roots—and longer roots make a lawn less vulnerable to drought, insects and weeds. Set your mower to leave the grass at least 3 inches tall, he says, but never let it grow so high that you have to cut it by more than a third (that damages the grass blades)."

HORTICULTURE Elemental/Nutrient Analytical LABORATORY

The Horticulture Elemental/Nutrient Analytical Laboratory is one of a small number of university laboratories nationwide dedicated to assisting growers and homeowners in evaluating the nutritional and environmental status of their plants, water and soil.

The lab has been performing plant nutrient analyses for growers and researchers since the 1950s. Cornell faculty work closely with lab personnel to provide fertilizer recommendations and consultations on growers' specific problems. Soil or plant samples may also be submitted for total carbon/nitrogen ratios.

In the last decade, lab services have expanded to include environmental testing of water, plants, amended soil, and sewage sludge. This provides homeowners, turf managers and municipalities with levels of potentially toxic heavy metals so that they can evaluate the safety of their environment. State-of-the-art plasma emission technology is used to provide simultaneous elemental analysis of 30 elements.

The Horticulture Elemental/Nutrient Analytical Laboratory is committed to quality data, and the operation is tested quarterly through the North American Proficiency Testing Service. Please contact the lab for more information on sample preparation, available services and prices. The Horticulture Elemental/Nutrient Analytical Laboratory, 20 Plant Science, Cornell University, Ithaca, NY 14853-5908; (607) 255-1785; www.hort.cornell.edu/department/facilities/icp/index.html.

Iron Influences Bentgrass and Annual Bluegrass Differently

Annual bluegrass is found in disturbed areas around the world in virtually every climate and elevation. High traffic and significant disturbance that occurs on turf areas creates an ideal environment for invasion. While most golf turf areas in northern climates are considered "two grass" systems (bent and poa), there is always interest in understanding any differences that could be exploited to reduce or mask annual bluegrass populations.

Researchers at Penn State University investigated the influence of iron on an annual biotype and a perennial biotype of annual bluegrass, as well as Penncross creeping bentgrass. The objective of the study was determine if the biotypes and bentgrass differ in their growth or color responses to iron. Iron increased color ratings of all grasses, however, the perennial biotype exhibited the highest color ratings at similar iron levels. In fact, the annual biotype responded similarly to Penncross with iron applications. Interestingly, creeping bentgrass produced the greatest shoot and root growth response to iron and growth on both biotypes of annual bluegrass was reduced at increasing iron rates. Significant differences in growth were not correlated with differences observed in tissue iron content.

Results from this study support the sufficiency range for iron in tissue to be between 35 to 100 ppm. However, the high variability relative to corresponding growth indicates that tissue iron content is not a reliable diagnostic feature. Still, interesting growth differences demonstrate potential management options. It is important to note that other researchers have not been able to demonstrate field level responses that result in a meaningful shift in population to favor the bentgrass.

From: Xu, Xia and C.F. Mancino. 2001. Annual bluegrass and creeping bentgrass response to varying levels of iron. HortScience 36:371-373.

Bentgrasses Differ in Salt Tolerance

Increasing populations continue to place pressure on the use of potable water sources for turf and landscape. Also, many turfgrass areas are forced to use poor quality water as a result of reliance on runoff fed ponds and streams that drain from impervious surfaces. Consequently, turfgrasses will need to be selected for their performance under saline conditions.

Ken Marcum at the University of Arizona has been a leading researcher in the area of turfgrass salinity tolerance. Recently, he conducted a study to evaluate 35 bentgrass cultivars for salinity tolerance. Thirty three creeping bentgrasses, one colonial and one velvet were grown in the greenhouse and exposed to various levels of saline water. Various growth measurements were evaluated such as amount of green leaf, shoot and root growth. As exposure time to high salt levels extended out to 10 weeks there were obvious cultivar differences.

Salinity tolerance range indicated that Seaside and Seaside II, as well as Grand Prix and Mariner were considered salt tolerant. L-93, G-2, and 18th green were moderately tolerant. SR1119, Regent, Putter, Penncross, and G-6 were salt sensitive. These results demonstrate that not only is there potential for breeding enhanced salt tolerance, but if water quality is an issue at your facility, you can begin selecting now for a cultivar that will perform under the salt stress conditions.

From: Marcum, K.B. 2001. Salinity tolerance of 35 bentgrass cultivars. HortScience 36:374-376.

Scanning the Journals

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Poor Irrigation Water

continued from page 1

Nationally about 13% of all courses use effluent. Where irrigation water costs can range from $100,000 to $1,000,000, effluent is a viable option.

Dan indicated that salt levels increased 5 to 10 fold during the summer months. He then asked how many superintendents regularly monitor their irrigation water quality. Less than 10 hands were raised in a room of 500 attendees!

In a presentation at the 2001 USGA Florida Regional Conference, Bob Carrow stated that "the three most important aspects of managing high salt content irrigation water are leaching, leaching, leaching."

approach to water use issues. The Western US receives only one third of the nation's rainfall, yet uses 80-85 percent of the nation's fresh water.

A 1999 survey conducted by the National Golf Foundation reported that 34% of golf courses in the Southwest US use effluent water (recycled, non-potable, wastewater, reclaimed). Nationally about 13% of all courses use effluent. Where irrigation water costs can range from $100,000 to $1,000,000, effluent is a viable option. Still, should every course use effluent? Is all effluent created equal? Does effluent create other challenges?

Effluent wastewater can be delivered following primary, secondary or tertiary treatment at a wastewater treatment facility. Primary treatment mechanically removes the majority of the solid waste with screens, grinders and settling tanks. While primary treatment involves mechanical removal of solids, secondary treatment engages biological processes to remove the majority of the remaining solids. Secondary treatment may also involve chlorinating prior to discharge. Water for turf and landscape uses must have at least experienced secondary treatment.

Several processes may follow secondary treatment, including using chemicals to flocculate remaining solids followed by more sediment removal, and various methods of filtration. A reverse osmosis process or chlorinating that can occur prior to release produces highly purified water. In the end, the water will likely contain a variety of nutrients (from the waste), metals (from the flocculation) and salts (from the purification) that will require careful management to minimize their impact on turf quality.

Interestingly, golf courses often involved with real estate development are constructing their own wastewater or desalinization treatment facilities. Several Audubon International Signature Properties are leading the way with small facilities that utilize ultra filtration and biological reactors to treat wastewater before reusing it back on the course. Jupiter Island Country Club in Florida recently installed its own reverse osmosis facility to desalinize salty ground water. Estimates are that the $500,000 price tag can be recovered in a few years based on the increasing cost and restrictions placed on irrigation water is south Florida.

Be Aware

Dan Quast, the former golf course superintendent at Medinah Country Club outside Chicago, IL, discussed his preparation and challenges from the 1999 PGA Championship at the New England Turfgrass Conference. The summer of 1999 will be remembered for its drought; Dan will remember it because of his high salt content irrigation water. Dan indicated that salt levels increased 5 to 10 fold during the summer months. He then asked how many superintendents regularly monitor their irrigation water quality. Less than 10 hands were raised in a room of 500 attendees!

Golf course superintendents who manage with effluent water cannot afford such ignorance. Effluent water quality can be variable and will always have a variety of "contaminants" that will require specific management practices.

Professors Bob Carrow and Ronny Duncan from the University of Georgia authored *Salt Affected Turfgrass Sites* (Lewis Publishing, MI) in an effort to bring together the best thinking on managing turfgrass with poor quality water. The title of the Carrow and Duncan book clearly identifies the major challenge with effluent irrigation water—high salt content—but it is not the only issue.

The March/April issue of the USGA Green Section Record included an article by Mike Huck, a USGA agronomist in the Southwest Region with Carrow and Duncan, on effluent water. The article outlines the major agronomic and environmental issues and suggests that the first step to using effluent water is to establish a regular monitoring program. In fact, even if your effluent provider offers periodic lab results on the water, Huck et al indicate that this will often not be sufficient for assessing irrigation water quality. A reputable agricultural soil and water lab is preferred. (See the article on page 2 about Cornell's Horticulture Elemental/Nutrient Analytical Laboratory.)

Salty Turf

In a presentation at the 2001 USGA Florida Regional Conference, Bob Carrow stated that "the three most important aspects of managing high salt content irrigation water are leaching, leaching, leaching." This is not simply a matter of copious amounts of water that keep salts moving downward; the superintendent must know the type of salt that must be leached, rainfall amounts, turf species tolerance range, and time of year.

Sodium salt can have a direct influence on plant growth in a manner similar to how dog urine burns leaf tissue (although dog urine is a different salt). However, while the direct burn from high salt content irrigation water is rare, high sodium content soils often produce plants that have restricted rooting and develop drought stress symptoms. Depending on the water source and rainfall pattern, the long-term effects of sodium on soils is well documented. As sodium content increases in the soil, the vital process of aggregation is disrupted.

Sodium molecules absorb large amounts of water and swell. The swelling prohibits finer silt and clay particles from making larger aggregates that offer a variety of pore spaces for water and nutrients. In other words, as described by Nick Christians in his 1998 book, *Fundamentals of Turfgrass Management* (Ann Arbor Press, MI), soils with high sodium content have the appearance and behavior of fine talcum powder. This slows the infiltration of water and renders the soil unsuitable for plant growth.

As suggested above, moving the sodium downward via leaching is the key. However, the leaching water should include a soluble calcium (Ca) source. The Ca literally pushes the sodium off the soil particles and leaves it vulnerable to leaching. Of course, the Ca content takes on more importance if the leaching water is already high in sodium.

Salt Management

There are a variety of other water quality issues that are addressed in the USGA Wastewater text, the new Duncan and Carrow text, and several articles in the Green Section Record in 2000-2001. These issues include heavy metal toxicity, other nutrients, total suspended solids, and low pH. All of these factors will require specific management practices in an effort to minimize the impact on turf quality.

The first step, as previously stated, is a regular water quality monitoring program. The next aspect of leaching is critical for long term turf performance. Additionally, core aeration creates channels for water to infiltrate when leaching. Also, less destructive techniques such as high pressure water injection, slicing, spiking, etc. can be implemented. Finally, one must recognize the species tolerance of poor quality water and realize that a biological system cannot just shift to poor quality irrigation water use without a noticeable reduction in quality. Specifically, cool season grasses are significantly less tolerant of high salt content and will decline rapidly, especially in warm summer months.

Regulatory as well as "hidden" costs can consume any savings realized from utilizing less expensive wastewater. Significant costs can be incurred for contamination protection devices and employee training as well as to meet specifications for wastewater storage. Other management costs could include water amendments that will need to be injected into the irrigation system as well as the deterioration of equipment regularly exposed to high salt content water. There can be revenue impacts such as having to close a course during the day to irrigate overseeded turf.

A 2003 Anniversary

The 1993 Golf Course Wastewater Symposium was an important contributor to raising awareness nationally on what was up until then viewed as a regional concern. Twenty two states had golf courses using wastewater irrigation, with over 70% of them coming from the Southwest and Florida. What will those numbers look like in 2003, the 10 year anniversary of the Symposium? How about general poor water quality experienced by people such as Dan Quast in IL?

Most superintendents, especially in areas with adequate rainfall, take their high quality irrigation water for granted. If the population continues to grow, the leadership effort by the turf industry in using effluent could be viewed as facilitating "smart growth." In other words, communities will need golf courses as outlets for society's waste, whether it is water or compost.

Frank S. Rossi

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Silvery Thread Moss Research at Cornell University

Program Spotlight

Seven hundred golf course superintendents were surveyed, with a 17% response rate. Low mowing, nutrient deficiency, lack of metal-based fungicides, and excessive surface moisture were consistently associated with high moss populations.

The ability to maintain a dry putting green surface would reduce the invasion of moss, but not likely control existing populations.

Increased demand for golf in the United States has lead to more heavily trafficked putting surfaces. Poor design, excessive maintenance and high performance expectations result in weak turf. Weak turf is characterized by low surface density likely to be infested by weeds. Recently, an "epidemic" invasion of the moss species *Bryum argenteum*, has been identified that reduces functional and aesthetic quality below an acceptable level. The TriState Turfgrass Research Foundation and the Metropolitan Golf Course Superintendent Association provided the major funding for a project to develop a more thorough understanding of the moss problem on putting greens. Specifically, our objectives were to identify ecological factors associated with moss invasion and persistence, develop postemergence control, and establish a sustainable moss exclusion program.

David Dudones was accepted for graduate study at Cornell University in January 1999 and worked with Dr. Frank Rossi on the moss project. An eight page survey was developed to identify the extent of the moss problem and specific ecological factors associated with moss distribution. Seven hundred golf course superintendents were surveyed, with a 17% response rate. Fifty percent of the respondents had objectionable moss populations. We were unable to identify a clear ecological niche based on the low survey response rate. However, low mowing, nutrient deficiency, lack of metal-based fungicides, and excessive surface moisture were consistently associated with high moss populations.

A field study was initiated in 1999 to ascertain the influence of environmental conditions, topdressing, spray volume, and formulation of copper hydroxide with and without mancozeb (a zinc manganese based fungicide) on moss efficacy. The study was conducted on golf courses in NY, NJ, and CT. Copper hydroxide, an organic fungicide and source of Cu nutrition, decreased moss populations by as much as 40% depending on environmental conditions and spray volume. Fall applications provided the best control. An additional field study was conducted in 2000 to evaluate the use of desiccants such as peroxide and fatty acid based products. A potassium based fatty acid reduced moss populations over 65%. Growth chamber studies were conducted in 2000-01 to evaluate potential moss exclusion programs. Biweekly low rate applications of copper hydroxide or fatty acid materials were applied to juvenile moss plants. Results indicated that 1000 ppm Cu applied as copper hydroxide and a potassium based fatty acid provided 85 to 95% moss control. Further research is needed to evaluate soil and tissue copper accumulation, as well as phytotoxicity of fatty acid based compounds.

2000-2001 Progress Report

One of the critical aspects of this project was to develop a more thorough understanding of the biological and ecological aspects of moss invasion. A considerable effort was made to review previous studies and confer with experts in the field of bryology, notably Professor Jon Shaw of Duke University. The information gathering phase of the project identified several key points that lead us to conclude:

1. The ability to maintain a dry putting green surface would reduce the invasion of moss, but not likely control existing populations. In fact, microscopic perched water tables that result from soil layers or organic matter accumulation would be sufficient for moss to invade.
2. Increased mowing heights will reduce the invasion of moss primarily by maintaining high turf density and minimizing voids. However, increased mowing heights will only mask existing populations.
3. Increased nitrogen fertility will reduce moss invasion by maintaining high surface density. Research from Ohio State University demonstrated how 10 lbs. of nitrogen per 1000 sq. ft. controlled existing moss populations. We believe this may be related to a nutrient complex that involves a significant pH reduction at the surface and the uptake of metal ions.
4. Moss distribution, specifically *Bryum argenteum*, is significantly limited in the pres-

ence of metal ions (see Figure 1). In fact, a small study at Oregon State University demonstrated the potential for Cu and Zn to be effective in reducing moss populations

5. Moss growth is less active under environmental conditions similar to the fall season in northern climates.
6. *Bryum argenteum* reproduces almost exclusively from the vegetative phase under managed putting green conditions. Spores do not represent a major source of distribution on greens as a result of the close mowing.

2000-01 Studies

Abbreviated Methods

Field studies that attempted to exploit the susceptibility of moss to low levels of metal ions were initiated in 1999-2000 at three locations (Westchester CC, Galloway National, and Fairview CC). Initial soil tests were taken to establish baseline soil nutrient levels and initial moss population counts to evaluate control methods.

CuOH with and without mancozeb (Zn and Mn base) was applied in a CO_2 backpack sprayer calibrated to deliver 2 or 4 gallons of water per 1000 sq. ft. The pH of the spray solution water was 6.5. Half of the applications were made after an abrasive topdressing procedure. Application regimes occurred in fall only (4 apps), fall and spring (8 apps), or spring only (4 apps).

Controlled environment studies were initiated in the winter of 2000 and repeated in the spring of 2001 to investigate potential exclusion programs. Applications of a K-based soap or 250 ppm, 500 ppm, or 1000 ppm Cu supplied as CuOH were applied every three weeks to substrate that harbors moss. Applications were made with a CO_2 backpack sprayer calibrated to deliver 2 gallons of water per 1000 sq. ft. Population counts were made following three applications.

Abbreviated Results

1. No statistical differences were detected between chemical treatments suggesting that Cu levels were the limiting factor.
2. Overview of all treatments suggested main effects of timing and spray volume to be significant (see Figure 2).
3. Fall applications were more effective than Spring (see Figure 3).

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Figure 1

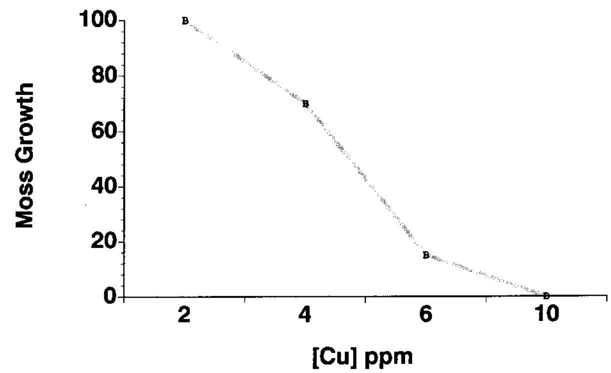


Figure 2

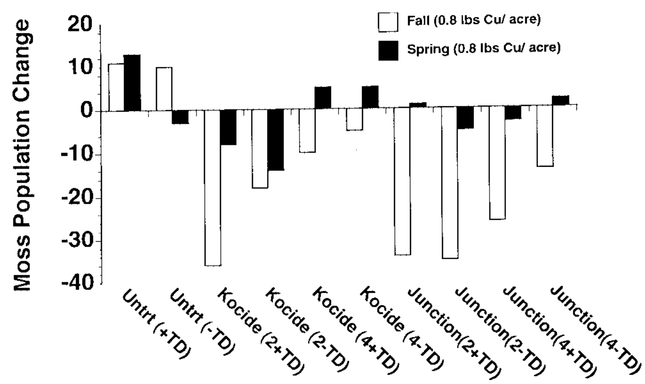
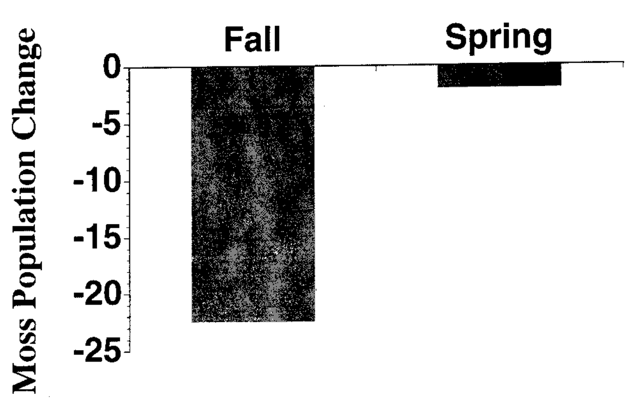


Figure 3



Moss growth is less active under environmental conditions similar to the fall season in northern climates.

Nutritional research suggests that Cu levels in the plant can vary from 25 ppm to as high 600 ppm, depending on species.

On soils with pH in the 5.5 to 6.0 range, very little soil accumulation was noted. Higher pH soils might accumulate more; however, the Cu will not be available.

Silvery Moss

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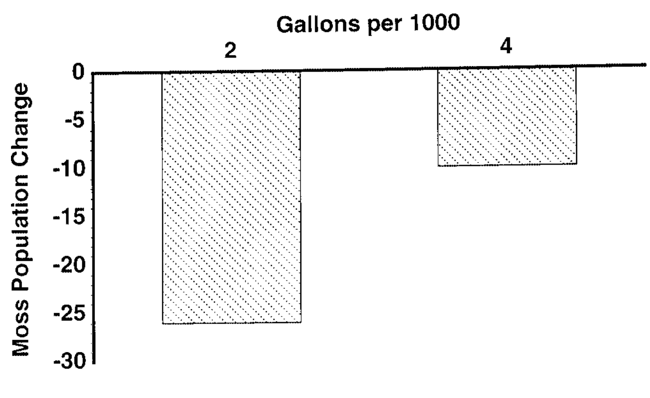
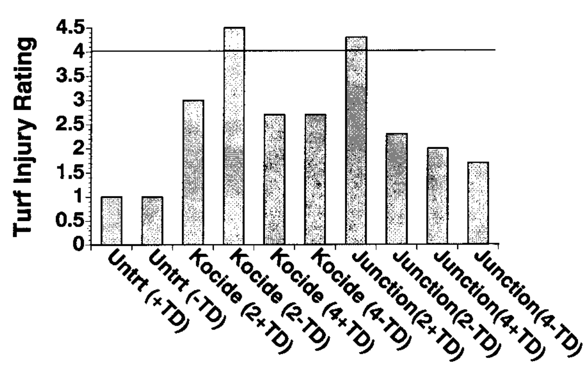
4. The 2-gallon per 1000 sq. ft. spray volume was more effective than 4-gallon (see Figure 4).

Figure 4



5. Significant injury to annual bluegrass was noted on Westchester CC plots after two applications (see Figure 5). However, this injury was short lived and was not detected on bentgrass.

Figure 5



6. Follow-up leaf and root tissues samples indicated significant increase in Cu levels (see Figure 6). Nutritional research suggests that Cu levels in the plant can vary from 25 ppm to as high 600 ppm, depending on species.
7. Soil Cu levels were highly variable and revealed weaknesses in soil testing procedures (see Figure 7). Still, on soils with pH in the 5.5 to 6.0 range, very little soil accumulation was noted. Higher pH soils might accumulate more; however, the Cu will not be available.
8. Follow-up evaluation of K- and Cu-based soap applied in Fall 2000 demonstrated substantial moss population reductions (see Figure 8).
9. Controlled environment studies begin to suggest potential for multiple low rate applications of CuOH at 1000 ppm or K-based soap product (see Figure 9).

Major Accomplishments to Date

1. Improved understanding of moss biology and ecology and the role of cultural practices in both establishment and mature phase.
2. Development of NOFA approved organic moss control.
3. Identification of optimum timing and spray volume for moss control programs.
4. Identification of potential desiccant product for moss control.
5. Potential for low rate exclusion programs to reduce moss invasion.
6. Dave Dudones' MS degree in July 2001.

Additional Studies

1. Improved understanding of the role of soil and tank water pH on control, persistence, uptake, and injury.
2. Develop "safener" technology to reduce injury that results from nutrient deficiencies.
3. Field test exclusion program.
4. Further research with K-soap to secure label in US.
5. Improve understanding of genetic diversity of putting green populations.
6. Develop cultural program to support improved chemical control and exclusion.

David Dudones and Frank S. Rossi

Figure 6

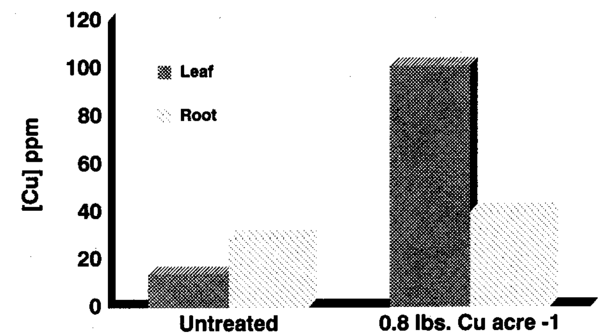


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Figure 7

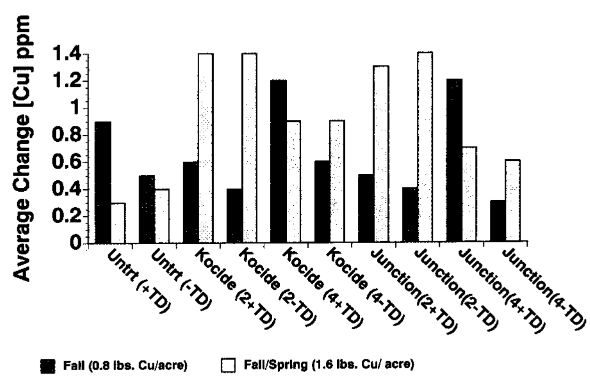

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Figure 8

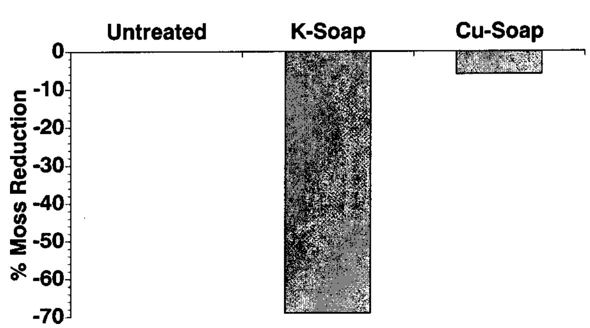
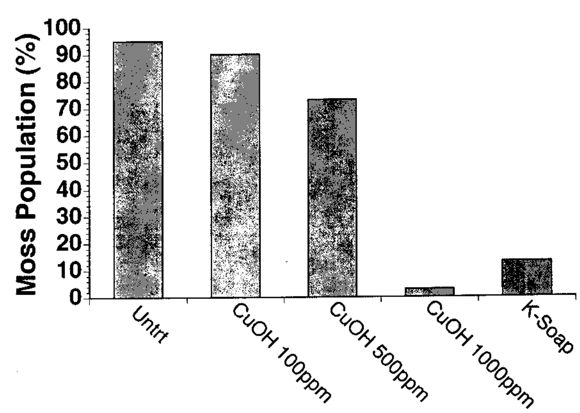


Figure 9



Evaluation of Putting Green Nematode Populations

Program Spotlight

The goals of this project were to 1) determine the identity and distribution of genera of plant parasitic nematodes currently found on a golf course putting green located in New York State, and 2) track the level and distribution of plant parasitic nematode populations through the growing season.

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This research project involved a survey of the distribution of nematode genera and population levels on the #2 putting green located at the Country Club of Ithaca. This green was selected because of its chronically reduced vigor and the previous diagnosis of nematode problems.

The most recent past survey of nematode occurrence was conducted in 1991 by Peter Mullin of the Department of Plant Pathology at Cornell University. Mullin examined 18 samples from various New York State golf courses and found numerous genera of plant parasitic nematodes.

Prior to that survey, a study was conducted in July-September 1976 on greens in southeastern New York (Murdoch et al. 1978). This study used a random sampling approach which unfortunately doesn't indicate the distribution patterns across a green. Due to the lack of information available on cool season phytonematodes, our survey has provided valuable information to turfgrass industry members and university researchers. Our survey focused on the distribution patterns and population levels across a putting green to learn how varied the population can be and in turn determine the accuracy of our current sampling procedures.

Procedures

The #2 putting green located at the Country Club of Ithaca was the site used to conduct the study. The putting green is approximately 15 x 22.5 m in size. 120 (1.5 x 1.5 m) blocks were established across the green. Within each 1.5 x 1.5 m sample block, 10 small cores (2.5 width x 15 cm deep) were collected in a systematic pattern to obtain at least 50 grams of soil per sample site. The 10 cores were mixed together, placed in a plastic bag, and labeled. Samples were transported to the diagnostic clinic and stored in a refrigerator until extractions, identification and nematode counts were made.

Samples were collected at three different sampling times. We predicted that soil temperatures may influence the population changes and that the optimum soil temperatures for the approximately 12 genera of plant parasitic nematodes that are found on cool season turfgrasses may vary depending on the genus of nematode. A record of soil temperatures and cultural practices conducted during the growing season were recorded but we encountered difficulty with our recording device and analysis of this information may take some time.

Nematode extractions were conducted using the sugar flotation extraction method. The sugar floatation method was chosen for the quick isolation of the nematodes. Fifty grams of soil were placed in a beaker with enough water to mix it thoroughly. The mixture was then poured through a 100- and a 400-mesh sieve to first collect any debris and then to catch the nematodes. The 400-mesh sieve was then rinsed into a vial that was centrifuged for approximately 5 minutes. The surfactant was decanted and a sugar solution added to the vial. The nematodes were located in the pellet formed by the centrifugation of the soil mixture. Therefore, the pellet was broken up by tapping the vial on a counter and placed back in the centrifuge for 45 seconds. The nematodes are not as dense as the sugar solution and are contained in it. The solution was poured off through a 400-mesh sieve. The sieve was rinsed to remove the sugar from the nematode environment and then rinsed into a vial for evaluation at a later time. All plant parasitic nematodes were identified to genus and population levels were recorded.

Data Collection

The collection of the soil samples was conducted on April 19, June 19, and September 10, 2000. Extractions of the nematodes were conducted as quickly as possible after the collection dates. Six genera of plant parasitic nematodes were detected in these samples, *Hoplolaimus* sp., *Tylenchorhynchus* sp., *Meloidogyne* sp., *Criconemella* sp., *Pratylenchus* sp., and *Helicotylenchus* sp. Additionally, the free living nematodes were counted for informational purposes of later population comparisons.

The population numbers recorded were placed into color-coded maps for an easier visual assessment of the findings (see Figures 1-3). Three shades are used to represent low (1-49 nematodes/50 grams of soil for plant parasites and 1-249 nematodes/50 grams of soil for free living), moderate (50-99 nematodes/50 grams of soil and 250-499 nematodes/50 grams of soil for free living), and high (100+ nematodes/50 grams of soil and 500+ nematodes/50 grams of soil for free living) levels of infection. The determination of the levels used in our ranges was based on the first sampling. The ranges have no association with any population thresholds currently used in determining possible damage points.

Results

The overall population levels detected were lower than expected. The April collection date produced samples with relatively low population levels for all the plant parasitic and free-living nematodes observed. Low levels were expected at this time due to the cold temperature and continued dormancy of the turfgrass. The spring and summer were extremely wet which should have created ideal conditions for population expansion of the various nematodes.

In June we expected to see a significant rise in the nematode population numbers observed but that was not the case. Soil and air temperature was lower than normal for this time period and we suspect that may have been a factor. *Hoplolaimus* sp. increased slightly at the June collection then reduced slightly in September. Very few of these nematodes were detected to our surprise. This large nematode has been found in cool season turfgrasses and we expected higher numbers than we found. Of the 120 plots for each collection date we found only 96 total *Hoplolaimus* sp. in April, 126 in June, and 96 in September. The distribution pattern was quite interesting. Low levels of this nematode were detected at scattered sites across the green. An occurrence of this nematode was found at the top of the green with another occurrence found 10-15 feet away. This distribution pattern continued across the green and not only occurred in the April collection but continued through the June and September collections.

Tylenchorhynchus sp. appears to be the dominant plant parasitic nematode detected on this green. Although higher levels of one other genera of plant parasitic nematode, *Criconemella*, was found, the population threshold for damage caused by *Tylenchorhynchus* is lower and the nematodes are reported as being more damaging to the plant material. *Tylenchorhynchus* were detected at low levels throughout the green and the distribution of this nematode was very uniform across the green. The total populations were highest in the April collection. Population levels decreased in June with a moderate rebound in September.

Meloidogyne sp. were detected during the initial collection in April at numerous block locations within the green. Interestingly, none were detected in the June sampling. Then again in September the nematodes were found at a low level. This may be explained by the life cycle of this nematode. The J2s are the infectious, juvenile stage of the nematode. They are the life cycle stage we observed in the April sampling. This makes sense when we consider this early part of the growing season is most likely the time for infection by this nematode. By June the J2s had either died off or infected the plant tissue and were located within the root tissue not swimming around in the soil where we were collecting our nematodes for analysis. Therefore, none were found. By September these nematodes may have been reproducing again and a few juveniles were again present in the soil. Another interesting observation of this nematode was that they were found mainly in the lower section of the green. Whether this was due to the environmental conditions, soil temperatures, soil texture, water levels, etc., or to it being the location of the first inoculation of the green is unknown.

Criconemella sp. were detected at all collection dates. The total numbers began at 5,170 nematodes found in 120 samples on this green. The level decreased as seen in other genera during June and then returned to a higher level of 7,958 in September. The high numbers of this nematode would not be of concern to most nematologists. Previous studies have reported this nematode at very high levels without caus-

continued on page 12

Our survey focused on the distribution patterns and population levels across a putting green to learn how varied the population can be and in turn determine the accuracy of our current sampling procedures.

The overall population levels detected were lower than expected. Low levels were expected in April due to the cold temperature and continued dormancy of the turfgrass. The spring and summer were extremely wet which should have created ideal conditions for population expansion of the various nematodes.

Tylenchorhynchus *sp. appears to be the dominant plant parasitic nematode detected on this green. Total populations were highest in the April collection. Population levels decreased in June with a moderate rebound in September.*

Nematode Populations

continued from page 11

This research project has provided us with some very valuable data to analyze. The different genera found help in determining the possible threats of damage and, when comparing this to other research projects, the distribution of these nematodes across our state and the country.

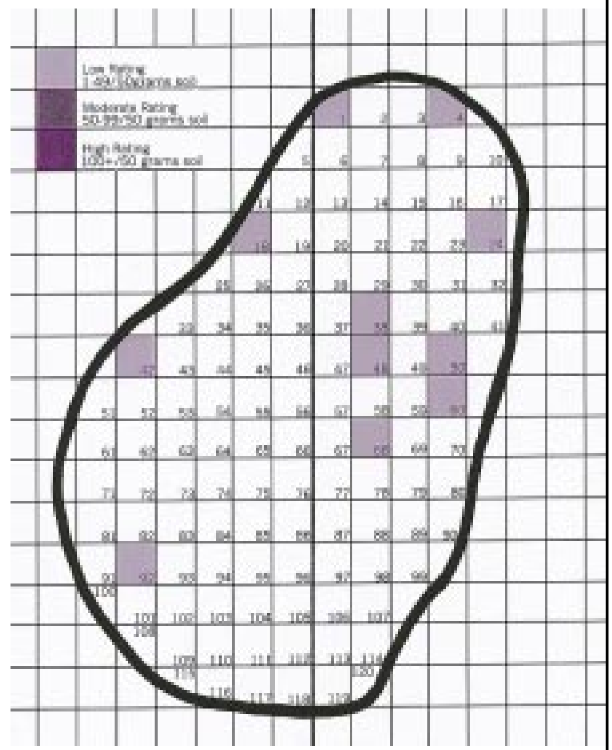
Therefore, we conclude that Tylenchorhyncus *sp. is the nematode of interest in our studies and further research should be conducted to learn about the conditions that promote infection and damage.*

ing any symptoms of damage. This is the reason we believe the nematode to study in future analyses is *Tylenchorhynchus* sp. Like *Tylenchorhynchus* sp., the distribution pattern of *Criconemella* sp. was very uniform and spread across the green during all the sampling periods.

The levels and occurrence rate of *Pratylenchus* sp. and *Helicotylenchus* sp. were extremely low and are not considered an important factor in the nematode evaluation but the findings are included in this report.

The recording device used for the collected of the soil temperature and moisture levels was a WatchDog datalogger. The datalogger had the capability of recording the soil moisture at one site and the soil temperature at two different sites located approximately 25 feet apart on the green. The readings were collected and saved in a spreadsheet. We encountered difficulty during the summer months when we found the datalogger no longer operated correctly after just a few days of proper functioning. We needed to replace the batteries of the unit often and believe the problems arose due to very high humidity in the containers used to protect the unit from water and soil exposure.

Figure 1



Hoplolaimus *sp. incidence rates 4/19/00*

It was hopeful that a professional survey of the green could enlighten us on any possible association between topography and nematode population levels. Unfortunately, the green could not be surveyed at this time. The facility was hoping to have this done at their expense but could not fit it into their schedule this summer.

Discussion

This research project has provided us with some very valuable data to analyze. The different genera found help in determining the possible threats of damage and, when comparing this to other research projects, the distribution of these nematodes across our state and the country. The nematodes found are consistent with the nematodes present in past research projects.

Our collections did not produce high levels of nematode populations that would trigger a call for some type of management action being conducted on this green. The green has a number of factors that are contributing to the decline of the turf which is usually most apparent during the hot, dry summer months. The green is shaded during part of the day, which can reduced photosynthesis and allow pathogens to establish if drying time of the turf is prolonged. Additionally, the green was built in the 1950s and the subsoil is made up of a very tough clay composition. The presence of the plant parasitic nematodes is just another factor that contributes to the decline of the turf at this site.

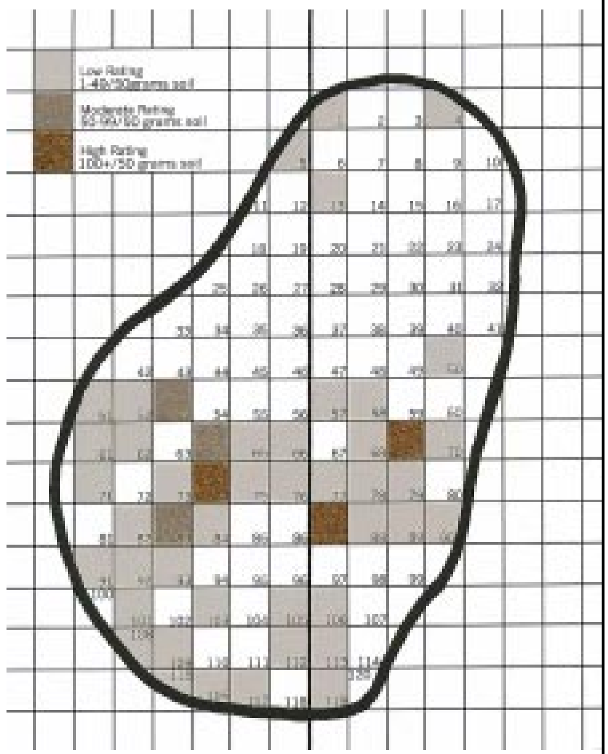
This study has contributed to the assumption that *Tylenchorhynchus* sp. is the nematode of concern in the northeast on cool season turfgrasses. Other nematodes are present and at levels that may prove damaging but *Tylenchorhynchus* sp. are more abundant and the spatial distribution pattern on this green has shown that they are found uniformly. Therefore, we conclude that this nematode is the nematode of interest in our studies and further research should be conducted to learn about the conditions that promote infection and damage.

The spatial distribution of the various genera of nematodes was very interesting. This information should be followed up with continued research of other sites to determine if the nematodes consistently tend to congregate in areas that they prefer on the green site. Our research showed that *Criconemella* sp. and *Tylenchorhynchus* sp. were all over the green while *Meloidogyne* sp. and *Hoplolaimus* sp. prefer lower and high locations respectively. Studying another green at a location fairly close to this green may provide us with answers to these questions.

The results of this research project show that the time of sampling and location of a single sample can heavily influence the outcome of a nematode analysis. Our data shows that an early April sample collection may be the most revealing when looking for diversity of the nematode genera and nematode population levels. Also, the location of the sample collection can be very important. If a sample was only taken from the upper center section of this green (around blocks 14-16), we may not have known of the presence of *Meloidogyne* sp. and *Hoplolaimus* sp. nematodes and depending of the sampling date, the presence of *Tylenchorhynchus* sp. and *Criconemella* sp. All the information collected during this project will prove quite valuable in determining better sampling procedures and will aid in the development of more research studies to help us understand these organism better than we do now.

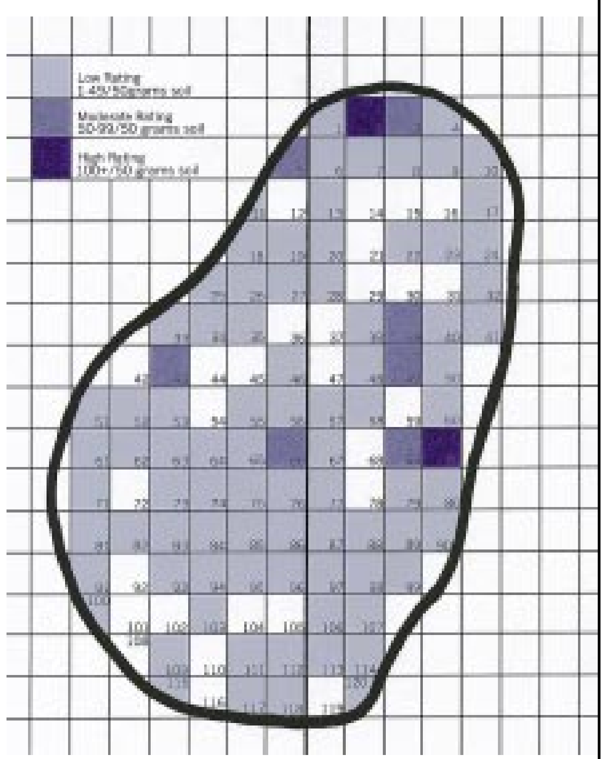
Karen Snover

Figure 2



Meloidogyne *sp. incidence rates 4/19/00*

Figure 3



Tylenchorhynchus *sp. incidence rates 4/19/00*

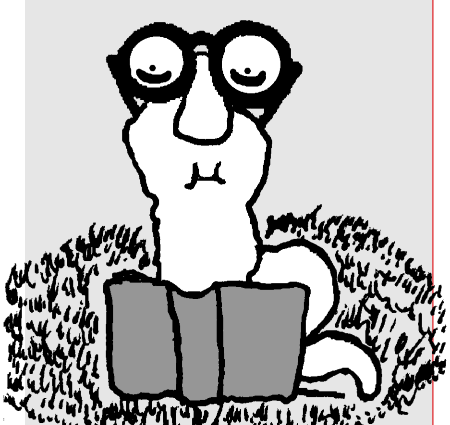
The results of this research project show that the time of sampling and location of a single sample can heavily influence the outcome of a nematode analysis.

Creeping Through the Summer Grass

The Lawn Reader

The author has devoted the last 20 years of his career to the golf superintendents in the Mid-Atlantic region who struggle with managing putting greens during the summer months.

He states in the opening section of his book, "it became abundantly clear that many summertime problems with golf turf were often stress rather than disease related."



Creeping Bentgrass Management: Summer Stresses, Weeds and other Maladies
Peter Dernoeden, Ph.D
Ann Arbor Press, Chelsea, MI
ISBN 1-57504-143-X

Father's Day weekend in Oklahoma was hot. The fans were enjoying watching the greatest golfers in the world do some incredible things with a golf ball. Each golfer hopes to have his hot putting stroke at the right time. Yet, the hottest thing will be the bentgrass greens growing in the smoldering heat.

Only a decade ago the thought of a championship tournament on high-performance bentgrass putting greens in the transition zone was an enormous risk. Sophisticated cooling systems would have to be in place to minimize the heat stress and improve air movement. Penncross, the industry standard, simply was not up to the task. How are the new grasses able to provide these conditions under heat? Can every grass do this?

Peter Dernoeden, Professor of Natural Resources at the University of Maryland, College Park, authored the 2000 book "Creeping Bentgrass Management: Summer Stresses, Weeds and Selected Maladies," from Ann Arbor Press. Pete has devoted the last 20 years of his career to the golf superintendents in the Mid-Atlantic region who struggle with managing putting greens during the summer months.

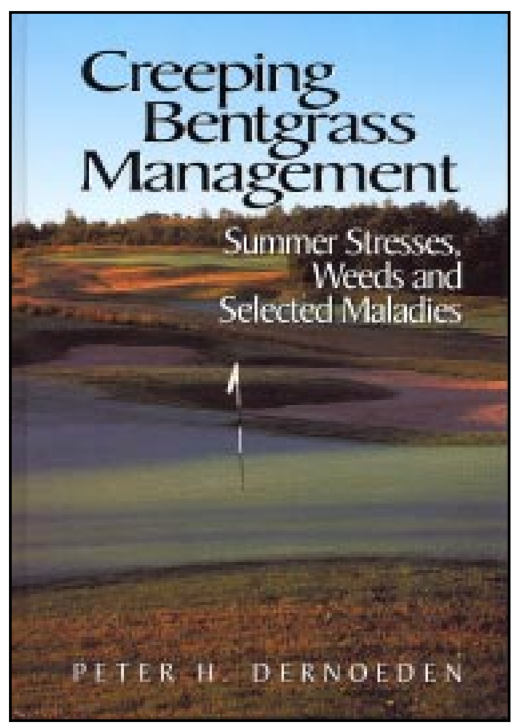
Training in turfgrass diseases and agronomy provided Pete with an important perspective on the complex problems that cause putting green failure. Pete states in the opening section of his book, "it became abundantly clear that many summertime problems with golf turf were often stress rather than disease related."

This is one of the most practical reference texts for golf turf managers to date. Born our of Pete's GCSAA seminar, this is an extremely practical and easy to read review of an important stress area. The biggest problem with the book is the title. While many issues in the book are specific for bentgrass, most of the maladies discussed are pertinent for annual bluegrass as well. Therefore, while bentgrass is the focus, anyone who manages turf in summer stress conditions including sports turf managers would benefit form Pete's wealth of experience.

My favorite section addresses summer bentgrass decline that has plagued the golf turf industry for the last decade, as more bentgrass is grown in marginal environments. The backbone of these management programs has been regular fungicide use to control turf diseases. Dernoeden alludes to this concept describing the superintendents as "perplexed and invariably disappointed when a chemical treatment for the decline cannot be recommended". Yet, conservatively Dernoeden estimates that 30% of the bentgrass samples submitted to the diagnostic lab are negative for any primary disease.

Half of the text is devoted to annual bluegrass control with herbicides and plant growth regulators. This section can serve as a good basis for information; however, cultivar and management regimes will require local information from other golf turf specialists. In the end though this book is filled with Pete's experiences and scientific support for his recommendations. If the summer we are beginning to have keeps up you need this book!

Frank S. Rossi



Got Pest Problems? You Need This Book!

Insects, diseases, weeds, and other problems can wreak havoc on a lush, healthy stand of turfgrass. Identifying the cause of a turfgrass problem can be an exercise in frustration for homeowners, golf course superintendents, and park and sports field managers who take great pride in their lawns, greens, parks, and fields. A new 214 page pocket guide, *Turfgrass Problems: Picture Clues and Management Options*, can help turf managers and lawn care aficionados identify problems and implement appropriate management strategies to achieve and maintain healthy plants.

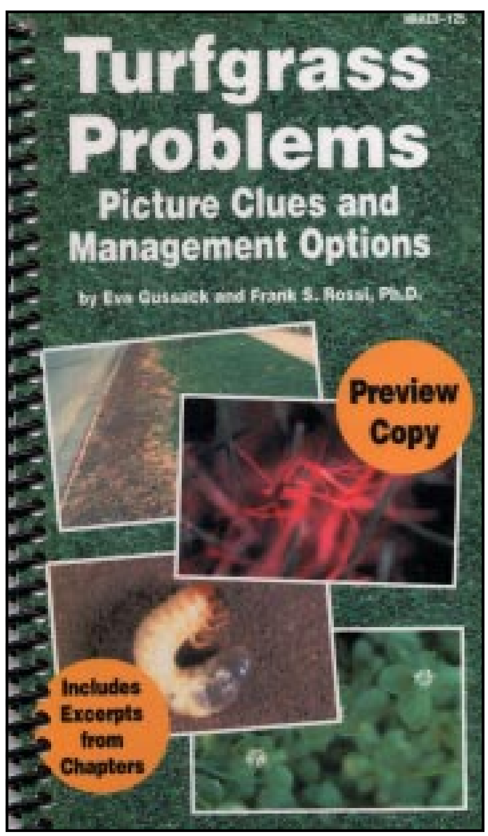
Turfgrass Problems: Picture Clues and Management Options features over 130 color photos of problems that affect cool-season turfgrasses (including creeping and colonial bentgrasses, Kentucky and annual bluegrasses, fine-leaf and tall fescues, and perennial ryegrasses). The compact, spiral-bound guide is an invaluable reference for anyone with a serious interest in turfgrass health—including homeowners, IPM specialists, lawn care professionals, golf course superintendents, agronomists, park managers, extension educators, and students.

The guide covers four types of problems: abiotic problems, diseases, insects, and weeds. (Abiotic problems are caused by "nonliving" factors, such as weather, poor soil structure, or improper nutrient levels.) Each problem discussion includes photos, a complete description of the problem's appearance and the conditions under which it tends to occur, and nonchemical management strategies. Color-coded tabs on each page help readers flip to a particular chapter quickly. If the problem cannot be identified from the photos and descriptions, a chapter on scouting and sampling procedures will help readers take further action.

A unique feature of the guide is the timelines chapter, which includes three symptom timelines that tell when a certain disease, insect, or weed is likely to emerge. The timelines are based on average climate conditions in the northern United States, but detailed instructions are included for refining the timelines for a specific locale using growing degree days. A glossary, conversion factors, and references are included as well.

Turfgrass Problems: Picture Clues and Management Options was written by Eva Gussack, Extension Associate, and Frank S. Rossi, Assistant Professor of Turfgrass Science and Extension Turfgrass Specialist, both of the Department of Horticulture at Cornell University. It was published by the Natural Resource, Agriculture, and Engineering Service (NRAES). The guide was inspired by the now out-of-print *Picture Clues to Turfgrass Problems*, which was published by Cornell Cooperative Extension in 1982 and written by A. Martin Petrovic, Maria T. Cinque, Richard W. Smiley, and Haruo Tashiro.

Turfgrass Problems: Picture Clues and Management Options is available to NYSTA members through NYSTA for $18, a 30% savings off the retail price. To order, contact NYSTA at (800) 873-8873. Non-NYSTA members may order the book through NRAES, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. For more information, contact NRAES at (607) 255-7654, by fax at (607) 254-8770, or e-mail NRAES@CORNELL.EDU or visit the web site at WWW.NRAES.ORG.



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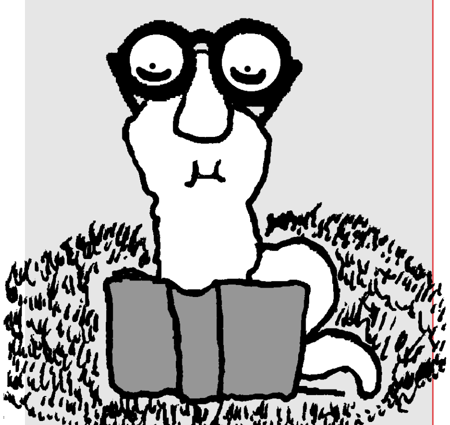
The Homeowner's Lawn Care and Water Quality Almanac

The Lawn Reader

Organized as a month-by-month checklist, the Lawn Care Almanac includes color illustrations, charts and recommendations to help you decide what is best for you, your lawn and your environment.

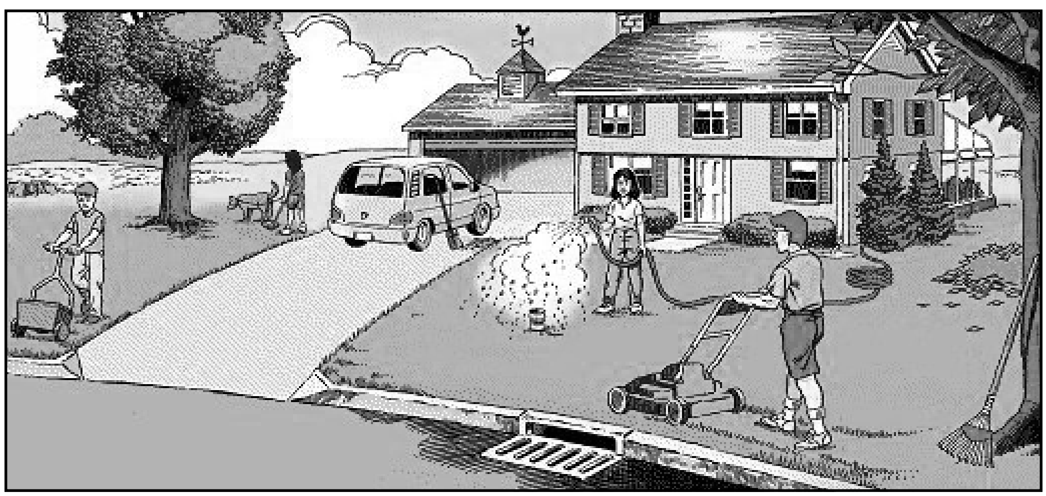


This new book written by Eva Gussack, Extension Associate, and Frank S. Rossi, Assistant Professor of Turfgrass Science and Extension Turfgrass Specialist, both of the Department of Horticulture at Cornell University, tells how to grow and maintain a dense, healthy lawn without polluting watersheds with pesticides, metals, nutrients, and petroleum.

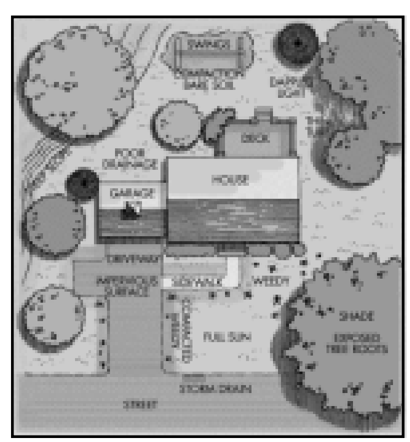
Organized as a month-by-month checklist, it includes color illustrations, charts and recommendations to help you decide what is best for you, your lawn and your environment. For example, in March you'll conduct a landscape water quality assessment and in April you'll address pesky weeds. The May chapter provides picture clues to the most common lawn diseases.

This almanac includes useful contacts and features a problem-solving index. Easy to use and filled with unique tips and helpful ideas, the year ends in December with a list of creative gift suggestions you can buy for your lawn. After that, flip over the pages and your twelve-step guide to a healthy lawn and healthy environment is ready to use year after year.

The Homeowner's Lawn Care and Water Quality Almanac is a 28-page spiral bound booklet that costs $11.95. Quantities of 10-49 copies earn a 20% discount; quantities of 50 or more qualify for a 25% discount. New York residents must add 8% sales tax and all books are subject to a handling charge of $1.00. The almanac can be ordered from Cornell Cooperative Extension, Resource Center, 7 Cornell Business and Technology Park, Ithaca, NY 14850. VISA and MasterCard are accepted. For further information call (607) 255-2085, fax (607) 255-9946, email resctr@cornell.edu, or visit the web site www.cce.cornell.edu/publications.



Illustrations by Jim Houghton.



Field Day Expands!

The 2001 Cornell Turfgrass Field Day will become the 2001 Cornell Turfgrass and Landscape Management Field Day. On Tuesday August 21, 2001, green industry professionals will gather at Cornell's Turf and Landscape Research Center in Ithaca, NY for the expanded program. They will view the latest in golf, sports and lawn turf research, and this year landscape horticulture research with woody plants and herbaceous perennials will be on display.

We expect this to be a full day of education and fun as we continue the traditions of the Field Day trade show, awarding of gifts, and the research tour. This year there will be a putting green challenge, tours of Tree City USA (Ithaca, NY), and a tour of the extensive Cornell Plantations.

Registration information will be sent in June (or send in the form below), so keep an eye out for this exciting opportunity to the finest turfgrass and landscape research in the Northeast. If you register before August 10, the fee is $50; registration on-site the day of the event is $60.

For more information, phone Joann Gruttadaurio at (607) 255-1792 or email jg17@cornell.edu.

For the Turf Professional

- Microbial and Organic Product Evaluations
- Turfgrass Nematode Research Update
- Low- and Non-Chemical Management of Golf Greens
- Turfgrass Evaluation for High Use Sports Turf
- Moss Control in Putting Greens
- Turfgrass renovation Using Basamid
- Compost Amendments for Sports Turf
- Mowing Height Effects on Turf Disease

Of Ornamental Interest

- At the Research Center:
    - Evaluation of Seed and Clonal Perennials
    - Weed Suppressive Ground Covers with Aesthetic Appeal
    - Weed Suppressive Fescues for Use in Turf
    - Herbicides for Weed Management in Turf and Ornamentals
    - Competition Studies with Mugwort
- On Campus in the Cornell Plantations:
    - Biological Control of Viburnum Leaf Beetle
    - Resistance of Viburnums to Viburnum Leaf Beetle
    - Arthropod Pests on Tour
- In Downtown Ithaca:
    - Tough Trees for Tough Sites
    - Structural Soil and Root Growth Under Pavement
    - Organic Amendments for Improving Compacted Soils
    - Maples for Urban Sites

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Yes! Sign me up for the 2001 Cornell Turf and Landscape Management Field Day

❑ $50 Advance registration fee enclosed

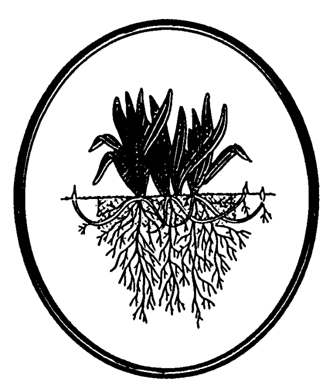
Name:

Address

City: State: Zip:

Phone:

Email:



The Human Dimension

Many turf managers are in George's shoes. They have crucial decisions to make to conquer the current crisis, successfully complete this season and/or resolve longer term personal or business issues.

Five characteristics of resilient people:

1. *Positive*
2. *Focused*
3. *Flexible*
4. *Organized*
5. *Proactive*

When the Going Gets Tough, the Tough Get Going

We have often heard the cliché: "When the going gets tough, the tough get going." We do not question whether turf managers are tough. We know they are. We do not question whether they are ready to get going. We know they are. The question is: What should a golf course superintendent or other manager of a turf business do to "get going" and where should he or she be "going?"

Let's start by looking at a business we can all relate to. This is a small business, like most golf courses and turf businesses, with a small number of employees where the manager provides labor, management and in some cases ownership. They have a similar dilemma about how to "get going" and where to "go."

The example is Myrtle's Diner. The diner has been serving meals for over 40 years. Myrtle and Frank started the diner in 1957. Their son George now has primary responsibility but rarely a day goes by without a visit by Myrtle. The diner has successfully supported Myrtle and Frank and now George and his family.

Recently, however, business has been declining. With the strong local economy have come difficulties in hiring competent cooks and wait staff. As a consequence, food quality and service have declined. A recent case of food poisoning added to the difficulties faced by Myrtle's Diner. A large restaurant from a popular national chain opened nearby a little over a year ago. Myrtle's Diner is under great economic pressure and George is feeling severe stress.

George is "tough" and ready to "get going." Consider two alternative strategies for George:

A. George could be "tough" by working long, hard hours. He could reduce labor costs and improve food quality by doing more of the cooking and waiting on tables himself. Perhaps he could get his family to work more as well.

B. George could be "tough" by focusing his energy on improving Myrtle's Diner and by carefully considering the future of the business. He could begin by working with the current staff to rekindle their excitement for this business and satisfying the diner's customers. He would focus on training, increasing employee satisfaction and recruiting. George would also begin a careful analysis of Myrtle's Diner's future to determine needed changes including dramatic changes like closing the diner.

Now put yourself in George's shoes. What would you do? The first choice might well have short-term benefits but would not likely resolve the underlying business problems. The second choice, while counter to most of our instincts to plunge in and "work" harder, has a greater chance of success. The second alternative would enable George to address the critical but extremely difficult issues facing Myrtle's Diner.

Many turf managers are in George's shoes. They have crucial decisions to make to conquer the current crisis, successfully complete this season and/or resolve longer term personal or business issues. It is easy and appealing to follow George's first alternative. Even knowing that the second approach is correct, it is often not followed because of uncertainty as to what to do. How to implement George's alternative B is the topic of this article.

In times of change, managers and others must develop increased resilience. Resilience is "the ability to *bounce* back from the consequences of change." Change experts including Daryl Conner, author of *Managing at the Speed of Change*, have identified five characteristics of resilient people:

1. Positive
2. Focused
3. Flexible
4. Organized
5. Proactive

Although each characteristic has unique qualities, none is mutually exclusive. Aspects of all five characteristics are needed for business success in the future.

The Resilient Turf Manager is Positive

In a recent episode of the new TV series *CSI*, the crime scene investigators were solving a bombing at an office building. The culprit turned out to be the high school son of a fired employee. The son was so incensed by repeatedly hearing his father's bitter complaints about being fired unfairly that the son determined that it was his duty to "get even" with his father's former employer.

Although fictional, this story illustrates how dramatically both our words and attitudes impact ourselves and those around us. The father in the story had no idea how his words and attitude were impacting his son; in this situation with devastating results.

If an individual is not positive about what he or she is doing—whether a golf course superintendent or a university professor—it is time to seriously consider a change in attitude or job or both. In fact, personal development experts are unanimous in the recommendation that each of us must consider making whatever changes are needed —including changing jobs—to develop a positive attitude about what we are doing. Each of us must seriously examine our attitudes for the sake of ourselves and for the emotional health of those around us.

One help in staying positive is to concentrate on things that we can influence rather than things over which we have no influence. In the diagram below, the circle of concern includes everything in the white and dark circles. The dark inner circle contains only those items that concern us *and* which we can influence. Staying inside our circle of influence will lead to a more positive attitude.

Weather, for example, is in our circle of concern but is *not* in our circle of influence. Dwelling on the weather only creates frustration because it is not in our circle of influence. In times of inclement weather, it is almost impossible to focus on the weather and stay positive. We can, however, move to our circle of influence by concentrating on making plans to be prepared when the inclement weather has moved on.

The Resilient Turf Manager is Focused

The quote, "Without a vision, the people perish," originates in Proverbs and is used by motivational speakers and management consultants to illustrate the importance of vision to individuals, businesses and organizations. Most of the readers of this article are a part of a business with a mission that involves turf.

What is your personal and course or business vision? Golfer or homeowner enjoyment? Community beauty or well being? Personal growth and development? Providing an environment for golfer growth?

We believe you know your personal and organizational vision. By more clearly articulating your vision you are in a position to clarify

continued on page 20

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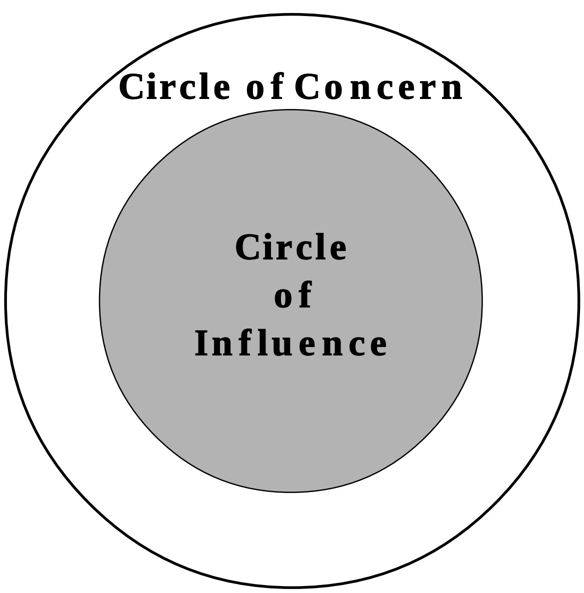

Developed by Sharon M. Danes, College of Human Ecology, University of Minnesota.

Tough Going

continued from page 19

We all can become more resilient in regard to change if we know and focus upon what is really important—our personal vision, the vision of our family, and the vision of our course or business.

If you are working too many hours and are becoming "burned out," try to:

- *Lighten up*
- *Be more positive*
- *Seek support from others*

or even alter your mission. You may find, as have many turf managers before you, that there is more than one alternative that can fulfill the vision for you and your course or business.

One danger of not being focused on your real vision and mission is that you can get stuck and resist change when that change would improve your situation without deviating from your vision. You must continuously ask how important it is to your vision to do things a certain way, to use a particular technology, to work on a particular course or place of business.

We all can become more resilient in regard to change if we know and focus upon what is really important—our personal vision, the vision of our family, and the vision of our course or business.

The Resilient Turf Manager is Flexible

Dr. Peter Senge, a well-know professor at MIT, asks his students to view change as a biologist. This seems like an interesting analogy for those of us interested in turf, but what does he mean? Think of turf or another plant that is not growing well, perhaps it is wilted or diseased. What do you do? Do you tell it to grow? Of course not; you figure out what is wrong and take corrective action.

When we find ourselves or others not changing, what do we usually do? We often tell ourselves or others to change. That would be equivalent to telling the ailing plant to grow!

Dr. Senge suggests that we should approach change similarly to how we approached the ailing plant. Focus on why we or others are not changing and then remove the constraints to change and provide needed support to enable the change.

What are some of those constraints? It may relate to our attitudes. We may be negative and need to become more positive. It may be that we are stuck in the outer portion of our circle of concern and need to move into our circle of influence. It may be that we need more information and need to take the time to collect, analyze and use that information.

The second part of Dr. Senge's suggestion is to provide support for those who need to change. For others that means encouragement and assistance. What, however, does that mean when we personally need support to change. We suggest that it means reaching out to your family, friends and colleagues and ask for their support in your efforts to change.

A Concluding Comment

You are likely reading this article in the dog days of summer. You have been working too many hours and are becoming "burned out." What should you take away from this article?

1. Lighten up. Think about those thinks that are frustrating you that are *not* in your circle of influence. What can you do to move to your circle of influence? When you find yourself being angry, anxious, or frustrated, ask yourself: "What is it about this situation that I have control over?" That moves you back into your circle of influence.
2. Be more positive. Think about the many great things that have happened already this summer. Start first with how you talk about things. Reframe them in positive words. A more positive attitude and behavior gradually comes with positive words.
3. Seek support from others. Think about issues you have that are troubling you or you are avoiding. Stop avoiding them and ask for help in finding solutions.

Robert A. Milligan, Sharon M. Danes

References

Conner, Daryl. 1992. *Managing at the Speed of Change: How Resilient Managers Succeed and Prosper Where Others Fail*. Villard Books, New York.

Danes Sharon M. 1999. *Loss, Opportunity, and Resilience*. University of Minnesota Extension Publication (FO-7421-S). St. Paul, MN. http://www.extension.umn.edu/distribution/familydevelopment/DE7421.html

Senge, Peter, Art Kleiner, Charlotte Roberts, Richard Ross, George Roth and Bryan Smith. 1999. *The Dance of Change: The Challenges to Sustaining Momentum in Learning Organizations*. Doubleday/Currency, New York.

Creeping Bentgrass

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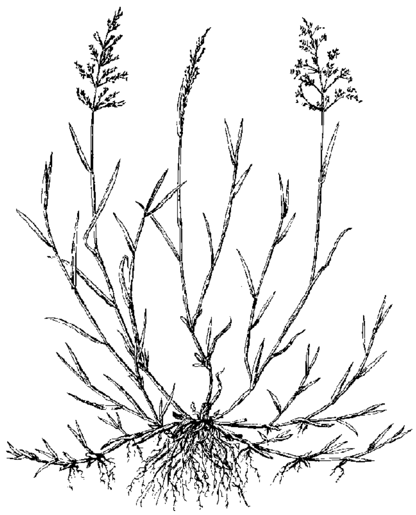
minutes on two consecutive days to avoid persistent contamination problems. After solidifying, plates were inoculated with a 24 hour culture of *P. aphanidermatum* and placed in a 27° C incubator.

To produce zoospores from *P. aphanidermatum* cultures, 18 mm diameter mycelial disks were excised from a 3-day old culture and placed in sterile plastic 60 x 15 mm petri dish (one disk/dish). Disks were flooded with 10 ml distilled deionized water and incubated at 24° C. After one hour, the water was removed and replaced with 10 ml fresh water, and returned to the 24° C incubator. Disks were then examined microscopically for zoospore activity every couple of hours. If sporangia and/or oogonia were not present, disks were then placed at 4° C for one hour, then returned to the 24° C incubator. On the other hand, if zoospores were present, they were enumerated by counting 200 µl aliquots with a haemacytometer and the number of zoospores/ml calculated. Zoospore suspensions were then diluted up to 1000X and used in seedling bioassays.



Seedling bioassays were conducted in 12-well tissue culture plates. Each plate was set up to include one or two sets of 4 non-inoculated wells and one or two sets of 4 inoculated wells to which either no bacteria were added or to which each of the bacterial treatments were added. In pathogenicity experiments where mycelial inoculum was used, one set of four wells each were inoculated with a 2 mm diameter disk removed from a 24 hour V8 culture of the appropriate *P. aphanidermatum* isolate. To each of four wells, 23 mg of seed of the particular bentgrass cultivar was added. Tissue culture plates were placed in clear plastic boxes to reduce evaporation and incubated in a 28° C incubator (14 hour day, 10 hour night). Seed germination was assessed daily, beginning three days after inoculation (time at which shoots were first visible) by estimating the percentage of seeds in the well that had germinated relative to the non-inoculated control.

For studies with zoospore inoculum, 450 µl of water was added to each set of 4 replicate wells. To inoculate wells with zoospores, 50 µl of the appropriate zoospore dilution was added to each set of 4 replicate wells providing a range of zoospore densities in a total well volume of 500 µl. After the addition of zoospores, 23 mg of seed of the appropriate bentgrass cultivar was added to each well. Tissue culture plates were then placed in clear plastic boxes to reduce evaporation and incubated in a 28° C incubator (14 hour day, 10 hour night). Seed germination was assessed daily, beginning three days after inoculation, by estimating the percentage of seeds in the well that had germinated relative to the non-inoculated control.

Results

Tolerance of Bentgrass Cultivars to Pythium aphanidermatum

Mycelial Inoculum. Bentgrass cultivars varied in their response to the two different *Pythium aphanidermatum* isolates used in this study (see Figure 1). Pa58 was again more virulent than isolate PRR-147 against all cultivars tested. Those cultivars most tolerant of isolate Pa58 were Penn G-6, Seaside II, Providence, L-93, Southshore, and SR7100. Those cultivars most sensitive were Penncross, Regent, Sefton, and Tiger. Those cultivars most tolerant of PRR-147 were Penn G-6, Seaside II, Sefton, Providence, Southshore, Trust, and L-93. Those cultivars most sensitive to mycelial inoculum of PRR-147 were Lopez, SR7100, Putter, Cato, 18th Green, Backspin, Penncross, and Tiger.

Zoospore Inoculum. As with mycelial inoculum, bentgrass cultivars also varied in their response to zoospore inoculum of each of the *Pythium aphanidermatum* isolates. In general, PRR-147 was less virulent than Pa58 at zoospore dosages that ranged from 250 to

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Seed germination was assessed daily, beginning three days after inoculation, by estimating the percentage of seeds in the well that had germinated relative to the non-inoculated control.

Those cultivars most tolerant of isolate Pa58 were Penn G-6, Seaside II, Providence, L-93, Southshore, and SR7100. Those cultivars most sensitive were Penncross, Regent, Sefton, and Tiger.

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We reasoned that lower disease pressure alone would be a dominant host plant factor favoring the activity of introduced bacterial inoculants. Our results indicate that this reasoning appears to be invalid.

100,000 zoospores/well. Among the more sensitive cultivars to isolated PRR-147 were Lopez, LCB-703, Penncross, Procup, Putter, Regent, Trust, Seaside II, Sefton, Southshore, SR1020, SR1119, and Tiger. Most cultivars were highly sensitive to isolate Pa58. Those cultivars that were the least sensitive were Exeter, L-93, Penn G-6, Providence, SR7100, and Viper. In general, zoospore concentrations as little as 250/well were sufficient to result in 100% seedling mortality 7 days after inoculation. Since isolate Pa58 was uniformly more virulent, our subsequent bacterial inoculations were all conducted using this isolate.

Efficacy of Bacterial Inoculants on Different Bentgrass Cultivars

Based on reactions of the different bentgrass cultivars to infection by the two different *Pythium aphanidermatum* isolates, we predicted that inoculants would be more effective on cultivars such as Exeter, L-93, Penn G-6, Providence, or SR7100 that were less susceptible to *P. aphanidermatum* isolate Pa58 than the other more susceptible cultivars such as Lopez, LCB-703, Penncross, Procup, Putter, Regent, Trust, Seaside II, Sefton, Southshore, SR1020, SR1119, and Tiger. We reasoned that lower disease pressure alone would be a dominant host plant factor favoring the activity of introduced bacterial inoculants. Our results indicate that this reasoning appears to be invalid. For example, even though *E. cloacae* was more effective on Penn G-6, Providence, and SR7100 than on cultivars such as Lopez, LCB-703, Penncross, and SR1020 and thus fitting our predicted model, it was also more effective on cultivars such as Southshore, Regent, Putter, and Tiger than on cultivars such as Exeter or L-93. This latter scenario did not fit our predicted model.

Injury from a Pythium root infection. (Photo from Creeping Bentgrass Management by Peter Dernoeden.)

Each of the bacterial strains evaluated in this study behave differently from each other on the different cultivars. Of all the cultivars tested, *E. cloacae* was effective in suppressing Pythium damping-off on all cultivars except Cobra, LCB-103, 18th Green, Cato, SR1020, and Penncross. *P. fluorescens*, on the other hand, behaved quite differently from *E. cloacae*. For example, *P. fluorescens* produced compounds that were phytotoxic to seeds of many of the bentgrass cultivars tested. Of the cultivars tested that were not sensitive to the *P. fluorescens* phytotoxins, *P. fluorescens* was highly effective only on L-93, LCB-703, Lopez, Exeter, Crenshaw, Cobra, LCB-103, 18th Green, and Cato. *P. fluorescens* was less effective on Backspin.

Conclusions

Our results clearly indicate that the performance of introduced microbial inoculants for the biological control of *Pythium aphanidermatum*-incited damping-off of bentgrasses is strongly influenced by the cultivar. Biocontrol efficacy on some cultivars exceeds that observed on other cultivars. With some cultivars, no biocontrol activity was supported.

Our results further indicate that the reaction of inoculants to the various cultivars vary with inoculant. *Enterobacter cloacae* strain EcCT-501 behaved differently from *Pseudomonas fluorescens* strain Pf-5 on most cultivars. We originally hypothesized that efficacy of inoculants would be enhanced on those cultivars that are least susceptible to *Pythium aphanidermatum*. However, this was not the case and there was no apparent relationship between susceptibility and biocontrol performance. We were able to demonstrate that the different bentgrass cultivars differed in their sensitivity to different isolates of *Pythium aphanidermatum*. It is likely that introduced inoculants would also be affected by the isolates of the pathogen tested.

The reasons for the phytotoxicity of *P. fluorescens* to some cultivars of bentgrass are unknown but are likely related to the produc-

Figure 1. Virulence of Mycelial Inoculum of Pa58 and PRR-147 on Creeping Bentgrass Cultivars

	Seed Germination (% of Control)[a]			Seed Germination (% of Control)[a]	
Cultivar	Pa58	PRR-147	Cultivar	Pa58	PRR-147
Penn G-6	42.5	50.0	Penn A-1	1.0	15.0
Seaside 2	12.5	40.0	18th Green	1.0	10.0
Providence	10.1	30.0	SR 1119	0.8	20.0
L-93	8.8	27.5	Princeville	0.8	20.0
Southshore	7.8	30.0	Crenshaw	0.8	17.5
SR 7100	7.8	10.0	SR 7200	0.5	15.0
Penn G-1	6.5	20.0	Cobra	0.3	12.5
Exeter	6.5	17.5	LCB-103	0.3	12.5
Viper	5.5	20.0	LCB-703	0.3	12.5
Putter	5.3	10.0	SR 1020	0.3	12.5
Trust	3.3	30.0	Backspin	0.3	10.0
Pro Cup	2.8	12.5	Lopez	0.3	7.5
Cato	1.8	10.0	Sefton	0.0	40.0
Mariner	1.5	17.5	Regent	0.0	15.0
National	1.5	15.0	Tiger	0.0	10.0
Penn A-2	1.5	12.5	Penncross	0.0	10.0
Penn A-4	1.0	20.0			

[a] Seed germination assessed 7 days after sowing and inoculation

tion of antibiotics such as pyoluteorin and 2,4-diacetylphloroglucinol. These antibiotics are known to be produced by strain Pf-5 and they are known to be phytotoxic in sufficient concentrations. It is likely that seedling turfgrasses are much more susceptible than mature turf to these antibiotics so that reactions on mature turfgrasses are likely to be somewhat different.

Additional Research Required

Much additional research is required and it will be important to have answers to many other questions regarding the performance of introduced inoculants on different bentgrass cultivars. For example, important research priorities will be to understand 1) how different grass species (not just cultivars) affect performance, 2) how cultivars react in different soil types, 3) how inoculants react to different cultivars infected by different strains of Pythium and different genera of pathogens, 4) how reactions of seedling turf compare with those of mature turf, 5) how different microbial inoculants behave on the different cultivars, and 6) how these reactions hold up under field conditions. These studies will comprise the focus of this work in coming years.

Contributions to the Current Knowledge Base

The utilization of different cultivars of bentgrasses to improve disease control has been largely ignored over the years. There are now over 40 different bentgrass varieties that can be used in golf course turf. With disease control being the major challenge of golf turf managers, it is surprising that these cultivars have not been exploited more fully. Our findings that cultivars vary in their susceptibility to *Pythium aphanidermatum* is significant in and of itself, since it may be possible to utilize more disease resistant cultivars for integration with other disease control practices. However, even more significant is the finding that inoculants behave differently on different cultivars. This may provide a new means of understanding why inoculants might fail in the field and also to allow us to design appropriate inoculant-cultivar combinations for enhanced biological disease control. We feel that these new findings are just beginning to reveal some of the factors that will ultimately allow us to successfully implement microbial inoculants into turfgrass systems for effective and consistent disease control.

Eric B. Nelson and Frank S. Rossi

The results clearly indicate that the performance of introduced microbial inoculants for the biological control of Pythium aphanidermatum*-incited damping-off of bentgrasses is strongly influenced by the cultivar.*

This may provide a new means of understanding why inoculants might fail in the field and also to allow us to design appropriate inoculant-cultivar combinations for enhanced biological disease control.

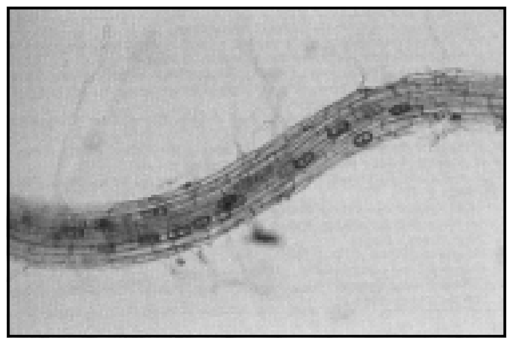
CUTT

A Healthy Ecosystem

In a recent study, our goal was to determine whether biological control activity of introduced inoculants was affected by the creeping bentgrass cultivar to which they were applied.

Creeping Bentgrass Cultivar Influences Biocontrol

Inconsistent performance of biological control strategies for turfgrass disease control has limited the adoption of this technology into IPM programs. A major contributing factor to this variable performance in agricultural systems is the cultivar to which biological control organisms are applied. In a recent study, our goal was to determine whether biological control activity of introduced inoculants was affected by the creeping bentgrass cultivar to which they were applied. We reasoned that biological control performance should be enhanced on cultivars that are less susceptible to the disease in question as opposed to highly susceptible cultivars. The short-term applied goal of this research was to develop the understanding of how we might maximize the performance of microbial inoculants in turfgrass systems.



A normal appearing bentgrass root embedded with numerous Pythium *oospores. (Photo from* Creeping Bentgrass Management *by Peter Dernoeden.)*

The objectives of our research were to 1) determine the differential susceptibility of bentgrass cultivars to *Pythium aphanidermatum* and 2) determine the efficacy of known microbial inoculants in controlling Pythium damping-off on different bentgrass cultivars. The results of this study will ultimately be critical in making sound IPM recommendations for creeping bentgrass cultivars that will be most compatible with biological control strategies.

Methodologies

Bacterial inoculants used in this study (*Pseudomonas fluorescens* strain Pf-5 and *Enterobacter cloacae* strain EcCT-501) were chosen because of their known activities against Pythium diseases of turfgrasses and their consistent efficacy in controlling Pythium disease on a wide variety of plant species. For use in assays, bacteria were grown in 40 ml trypticase soy broth (TSB) shaken on a rotary shaker at 120 rpm for 16 hours at 27° C. Cells were rinsed in phosphate buffer and resuspended at the original concentration.

The *P. aphanidermatum* isolates used in this study (Pa-58 and PRR-147) were routinely grown in darkness on V8 agar at 27° C. The V8 medium was composed of the following: V8 juice, 100 ml, H_2O, 400 ml, $CaCO_3$, 1.5 g, Bacto Agar, 8.5 g. The medium was autoclaved for 25

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