GCSAA Research Synopsis

Completed Projects Published 2007-2014

A summary of applied agronomic, environmental and regulatory research to provide golf facilities and golf course superintendents with the latest information to produce high-quality playing conditions in a manner that is compatible with the environment.

Funded by the Environmental Institute for Golf, the philanthropic organization of the GCSAA.

MISSION STATEMENT

GCSAA is dedicated to serving its members, advancing their profession and enhancing the enjoyment, growth and vitality of the game of golf.

The Environmental Institute for Golf fosters sustainability through research, awareness, education, programs and scholarships for the benefit of golf course management professionals, golf facilities and the game.

GCSAA Research Synopsis

Completed Projects Published Between 2007 and 2014

Supported by The Environmental Institute for Golf, the goal of the GCSAA research program is to fund research that is important to superintendents. Because growing conditions and the problems faced by superintendents vary greatly across the country, the research projects cover a wide range of topics.

The research highlighted in the GCSAA Research Synopsis represents projects that were completed between 2007 and 2014, and have been published in *Golf Course Management* (*GCM*) magazine. Completed projects will be added each year once they have been published.

For a more in-depth description of each project in this synopsis, GCSAA members can electronically access past issues of *GCM* that are available through TGIF at Michigan State University. To access past issues of *GCM*, please enter the members only section of the GCSAA website and click on the archive link directly under the image of *GCM*.

If you have questions regarding a specific research project, please contact the scientist who conducted the project at the email address listed or GCSAA's Director of Environmental Programs, Mark Johnson, at mjohnson@gcsaa.org.

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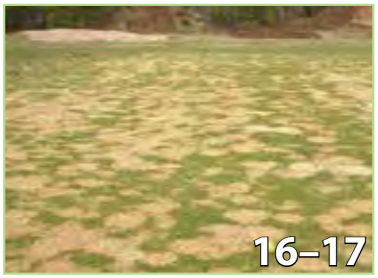
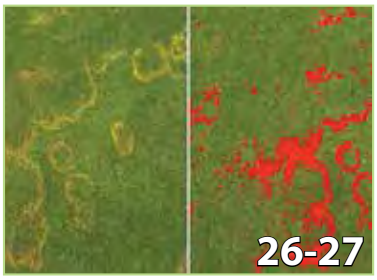
Disease Management





Photos by M. Fidanza

New Insight on Fairy Ring

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Objective

Characterize soil chemical and physical properties associated with turfgrass suffering from Type I fairy ring.

Summary

Fairy ring has become a persistent problem and an unsightly nuisance on golf course turfgrass. Type I fairy ring symptoms include wilted, necrotic or dead turfgrass appearing in rings or arcs. Fairy ring control measures are inconsistent.

Soil cores were extracted from Type I fairy ring sites on three golf courses in Pennsylvania. Soil cores were taken from adjacent healthy turfgrass for comparison. The soil was analyzed for several chemical and physical properties.

Results

- Where fairy ring occurred, soil pH was slightly higher; concentrations of ammonium, potassium, sulfur and soluble salts were statistically higher; volumetric water content was significantly lower in soil; and water-droplet-penetration test times were significantly longer.
- The fungi that cause fairy ring directly or indirectly contribute to the development of water-repellent soil and the depletion of soil moisture, resulting ultimately in turfgrass death.

Funded by

Pennsylvania Turfgrass Council

Philadelphia GCSA

Central Pennsylvania GCSAA

EIFG Environmental Institute for Golf

Published in GCM, March 2007, pages 107-110.

Photos by M. Fidanza

Treating Fairy Ring with Fungicides, New Soil Surfactant

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Objective

Determine the performance of four fungicides applied with and without a surfactant for control of fairy ring symptoms.

Summary

Fairy ring has become a persistent problem and an unsightly nuisance on golf course turfgrass. Type I fairy ring symptoms include wilted, necrotic or dead turfgrass appearing in rings or arcs. Fairy ring control measures are inconsistent.

Field trials were conducted on turfgrass stands with Type I and II fairy ring symptoms in California, Pennsylvania, and South Carolina. The turfgrass was treated with four fungicides applied with and without a surfactant.

Results

- At all three locations, the tank-mix of the fungicide and the surfactant consistently reduced fairy ring symptoms.
- Applying any of the tested fungicides in 4 gallons of water carrier rather than 2 gallons reduced fairy ring symptoms. However, applying a tank-mix of any of the tested fungicides plus the surfactant in either 2 or 4 gallons of water carrier produced a similar reduction in fairy ring symptoms.

Funded by

Pennsylvania Turfgrass Council

Philadelphia GCSA

Central Pennsylvania GCSAA

EIFG Environmental Institute for Golf

Published in GCM, May 2007, pages 121-125.

Photos by G. Jung

Distribution of *Typhula* Species and Varieties in Wisconsin, Utah, Michigan and Minnesota

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Objective

Identify the specific species and variety of *Typhula* snow mold causing fungi found on golf courses in the northern U.S.

Summary

Typhula snow mold disease is caused by three separate species and three varieties of one of the species and are responsible for the most important winter diseases of turfgrasses in cool climates of the Northern Hemisphere. Since some fungicides may only control a specific species or variety of *Typhula*, it is important to know the distribution of each species and variety to develop effective management strategies for *Typhula*.

Species-specific DNA markers were used to identify *Typhula* species collected on golf courses in Wisconsin, Utah, Michigan, and Minnesota.

Results

- Samples of three *Typhula* species and three *T. ishikariensis* varieties were collected from 135 golf courses in Wisconsin, Utah, Michigan and Minnesota.
- Sites were identified where each *Typhula* species or variety occurred frequently within the study area, and climatic conditions and biotic factors (species competition and interaction) were correlated with that distribution data.
- The three *Typhula* species were found to occupy distinct ecological niches, but the three *T. ishikariensis* varieties are not adapted to different environments.
- A better understanding of how *Typhula* species and varieties are influenced by their environment can help researchers develop more effective strategies of snow mold control.

Funded by

Wisconsin GCSA

Intermountain Chapter GCSAA

Northern Great Lakes Chapter GCSAA

EIFG Environmental Institute for Golf

Published in GCM, January 2008, pages 170-175.

Photos by G. Jung

A Fresh Look at Fungicides for Snow Mold Control

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Objective

Determine the efficacy of various fungicides to control several species and varieties of snow mold.

Summary

Snow molds, which can be a devastating disease in the northern U. S. and Canada, are caused by several species of fungi and, in some cases, by different varieties of the same fungal species. Superintendents apply fungicides for snow mold control but often see inconsistent results.

Research was conducted at two golf courses in Wisconsin. One course has an average 80-day snow cover of 5 inches and the other has an average 110-day snow cover of 5 inches. Six different fungi were artificially inoculated into the plots. Fungicides were applied later before the first snow cover.

Results

- Snow mold disease severity increased as the number of days of snow cover increased.
- Fungicide efficacy decreased as the snow-cover days increased.
- Several fungicides provided consistent control of the six snow mold species.
- The first step in developing a snow mold fungicide program is to choose the appropriate fungicides based on the species of snow mold fungi on the golf course.

Funded by

Wisconsin GCSA

EIFG Environmental Institute for Golf

Published in GCM, July 2007, pages 91-94.

Photos by G. Jung

Minimum Fungicides Rates for Species-Specific Snow Mold Control

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Objective

Determine the minimum application rate of individual fungicides required to yield acceptable disease control of each snow mold species.

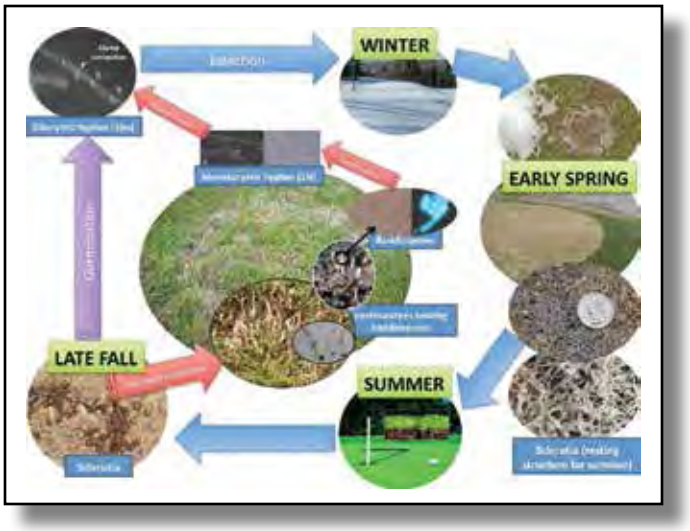
Summary

Snow mold, caused by several fungal species, is the most important winter disease of cool-season grasses in northern regions where continuous snow cover persists for several months. Selecting the most effective fungicide(s) and application rate(s) for control is not an easy task.

Trials were conducted at two Wisconsin golf courses that experience different lengths of snow cover. Plots at both locations were inoculated with 12 different isolates of six snow mold species or subspecies and later five fungicides were applied to determine snow mold control.

Results

- Disease severity was significantly influenced by snow mold species, fungicide rate and snow cover at the site.
- Different snow mold species showed significantly different levels of sensitivity to each of the five fungicides tested in the study.
- Where disease pressure is high, applying a tank-mix of fungicides is recommended; split applications are also more effective than single applications.



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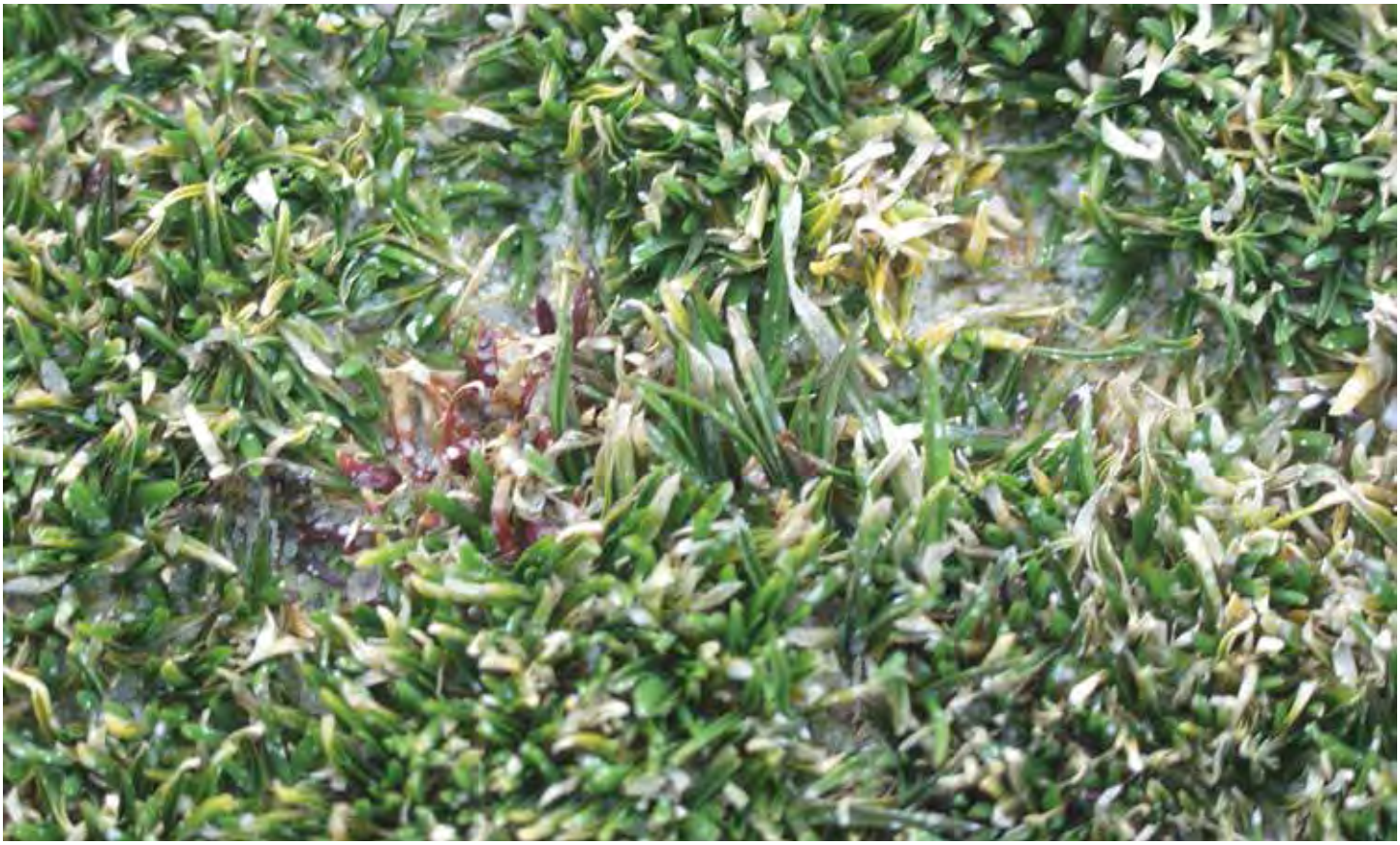

Photos by W. Uddin

Vertical Mowing and Mowing Height Affect Anthracnose Basal Rot

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Objective

Determine the effect of vertical mowing and mowing height on the severity of anthracnose basal rot on a putting green comprised of annual bluegrass and creeping bentgrass.

Summary

Basal rot anthracnose is a destructive disease of annual bluegrass and creeping bentgrass and the incidence and severity has increased in recent years. The reasons for the increased problem on greens are not clear.

All combinations of verticutting (three depths, once a week for four weeks) and mowing (three heights) were imposed on an annual bluegrass/creeping bentgrass putting green. The green was inoculated with anthracnose prior to imposition of verticutting and mowing treatments.

Results

- Low mowing heights and increased depth of vertical mowing increased basal rot anthracnose development in annual bluegrass in a mixed annual bluegrass and creeping bentgrass green.
- Mowing and verticutting caused significant mechanical injury and thus increased disease severity.
- Increasing turfgrass mowing height and reducing vertical mowing depths may reduce severity of basal rot anthracnose.

Funded by

Pennsylvania GCSA

Pennsylvania Turfgrass Council

EIFG Environmental Institute for Golf

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Photos by W. Uddin

Nitrogen Fertility and Anthracnose Basal Rot in Putting Greens

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Objective

Determine the effects of rate and source of nitrogen application on the severity of anthracnose basal rot on a putting green comprised of annual bluegrass and creeping bentgrass.

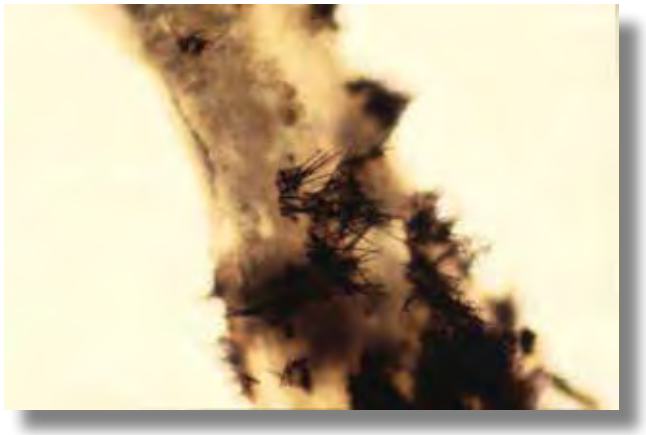
Summary

Basal rot anthracnose is a destructive disease of annual bluegrass and creeping bentgrass and the incidence and severity has increased in recent years. The reasons for the increased problem on greens are not clear.

Three nitrogen sources were applied at three rates every 14 days from April to July to an annual bluegrass/creeping bentgrass putting green. The green was inoculated with anthracnose prior to imposition of nitrogen treatments.

Results

- A higher rate of nitrogen fertilization significantly reduced anthracnose development in annual bluegrass in a mixed annual bluegrass and creeping bentgrass green.
- Controlled-release nitrogen provided greater suppression of the disease than the quick-release nitrogen.
- Maintaining an adequate level of nitrogen in plants throughout the season is an important component of integrated anthracnose management strategy.



Funded by

Pennsylvania GCSA

Pennsylvania Turfgrass Council

EIFG Environmental Institute for Golf

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Photos by J. Inguagiato

Mowing and Rolling Strategies to Manage Anthracnose on Annual Bluegrass Greens

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Objective

Evaluate mowing height, mowing frequency, lightweight rolling and the potential interaction effects on anthracnose severity and green speed of annual bluegrass putting greens.

Summary

Anthracnose has become a common disease on annual bluegrass greens, and to a lesser extent, creeping bentgrass greens. Anthracnose is more severe on stressed turfgrass and cultural practices employed to increase green speed are thought to enhance the disease by increasing stress on the turfgrass plants.

Three mowing heights (0.110, 0.125, 0.141 inch) two mowing frequencies (once or twice daily), and lightweight rolling (rolling every other day or no rolling) in all combinations were imposed on an annual bluegrass putting green maintained using industry standard practices. Anthracnose severity and putting green speed were evaluated at regular intervals throughout the growing season.

Results

- Increasing mowing height by as little as 0.015 inch can reduce anthracnose severity.
- Increasing mowing frequency to twice per day did not increase anthracnose severity.
- Rolling provided a subtle reaction in disease severity under moderate disease pressure and also increased green speed.
- Playability can be maintained by increasing mowing frequency and/or rolling without increasing anthracnose severity.
- A comprehensive management program integrating these practices with moderate nitrogen fertility may reduce the quantity and/or increase the application interval of fungicides required to provide acceptable disease control.

Funded by

New Jersey Chapter GCSAA

Tri-State Turf Research Foundation

USGA

EIFG Environmental Institute for Golf

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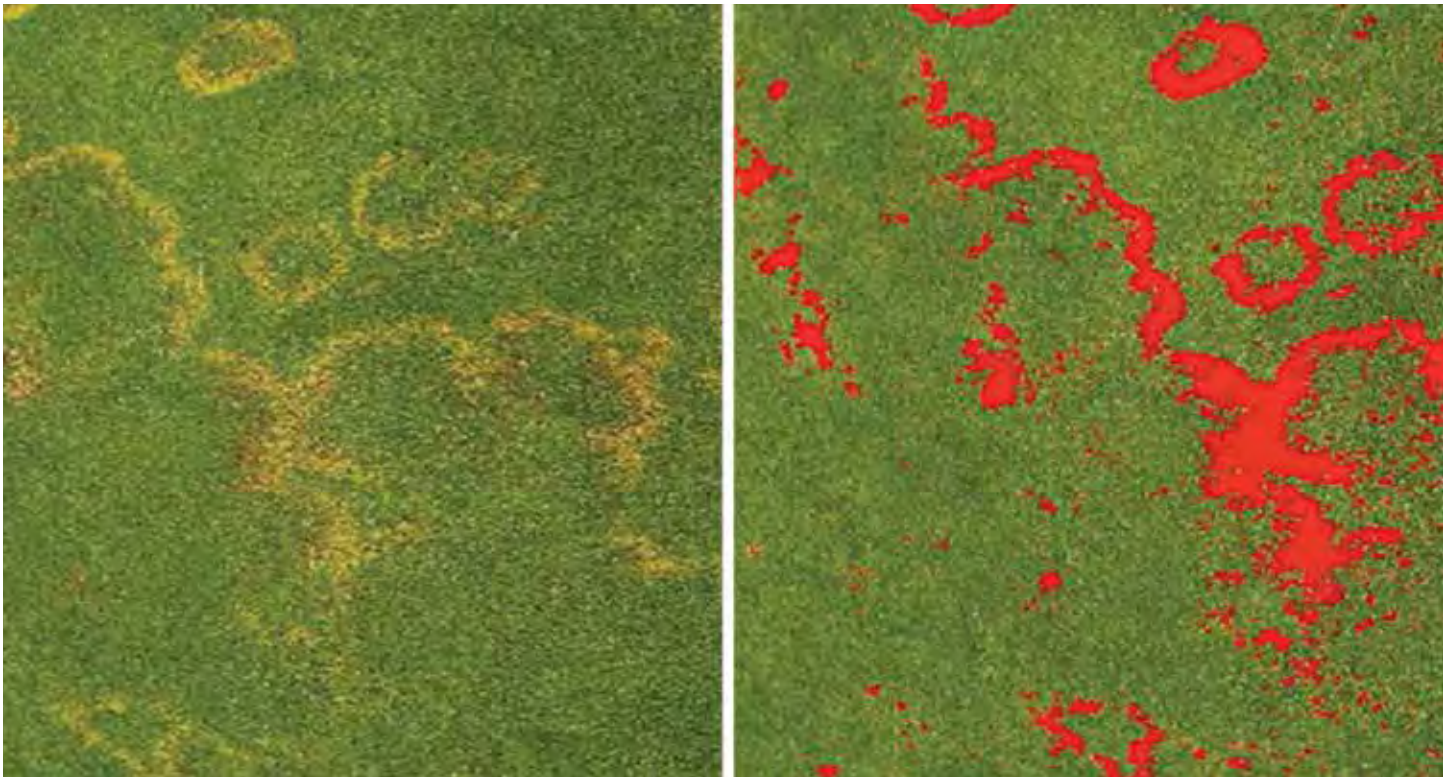

Photos by L. Stowell

Effects of Nitrogen and Primo Maxx on Brown Ring Patch Development

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and Larry Stowell, Ph.D.,
PACE Turf

Objective

Determine the effects of nitrogen rate and source, and Primo Maxx on brown ring patch severity on annual bluegrass greens.

Summary

Brown ring patch (also known as Waitea patch) is an emerging disease in the U.S., affecting annual and roughstalk bluegrass. Best management practices are still being developed for management of the disease.

Nitrogen was applied at two rates using calcium nitrate, ammonium sulfate, or urea with and without Primo Maxx to annual bluegrass greens. Brown ring patch severity was determined using digital image analysis.

Results

- In these studies, increased nitrogen fertility reduced the severity of brown ring patch.
- No differences in disease severity ratings were detected among treatments using the 1-pound rate of ammonium sulfate, calcium nitrate or urea.
- Primo Maxx used alone appeared to slightly increase disease severity in some cases; this effect was not observed in plots treated with nitrogen and Primo Maxx.
- Applications of Primo Maxx with nitrogen resulted in the best turf color and in disease suppression equivalent to nitrogen used alone.
- Even the 0.5-pound rate of calcium nitrate (with or without Primo Maxx) greatly increased the effect of a fungicide applied at the low label rate.

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San Diego Chapter GCSAA
EIFG Environmental Institute for Golf

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Photos by L. Stowell

Chemical Control of Brown Ring Patch

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Objective

Provide superintendents with information on the best fungicide options for controlling brown ring patch.

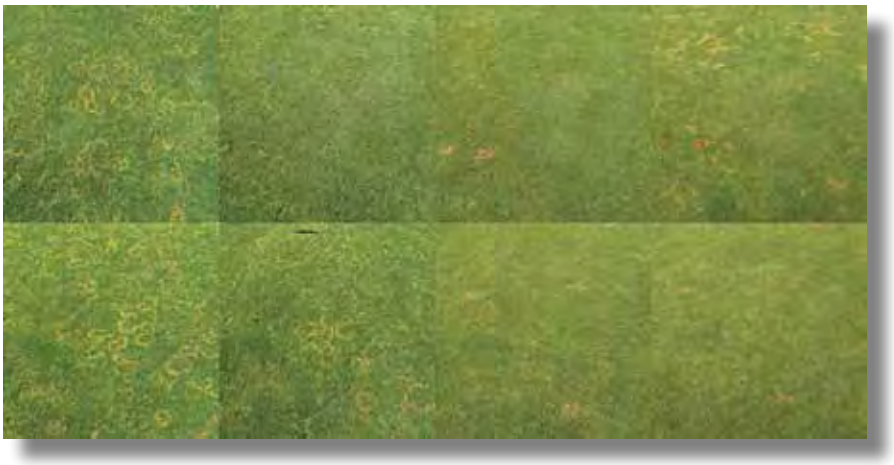
Summary

Brown ring patch (also known as Waitea patch) is an emerging disease in the U.S., affecting annual and roughstalk bluegrass. Best management practices are still being developed for management of the disease.

Research was conducted on putting greens at three locations. A number of fungicides were applied alone or in combinations and at various rates to greens dominated by annual bluegrass after brown ring patch symptoms had appeared. Disease severity was visually rated after treatments were applied.

Results

- Fungicides vary in their speed and longevity for brown ring patch control.
- Some DMI fungicides are very effective and should be used as tank-mix partners.
- Fungicide should be applied very soon after the disease appears or preventively at times when the disease has been historically active.



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EIFG Environmental Institute for Golf

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Preventive fairy ring control on putting greens

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North Carolina State University

Objective

Evaluate the impact of a single preventive application, timing and fungicide rate on fairy ring control, and investigate the influence of irrigation timing and soil-surfactant tank mixtures on preventive fungicide performance.

Summary

Fairy rings are a severe disease problem on golf courses. The most severe fairy ring leaves necrotic bands, which are most commonly an artifact of drought-stressed turf, caused by a combination of dense fungal mycelium and the production of organic acids that coat sand particles and render the underlying soil hydrophobic. Despite the problems associated with curative fungicide applications, a preventive fungicide program for fairy ring control has not been investigated fully.

Two field experiments were conducted at the Lake Wheeler Turfgrass Field Laboratory in Raleigh, N.C., on a Penn A-1 creeping bent-grass (*Agrostis palustris* Hud.) research green. A three-year experiment was initiated in 2007 to determine the optimal rate and soil temperature-based timing of triadimefon (Bayleton 50 DF, Bayer) and tebuconazole applications for fairy ring prevention. A two-year experiment was initiated in 2008 to examine the impact of irrigation timing and fungicide + surfactant tank mixtures on the performance of preventive DMI applications.

Results

- Plots treated with tebuconazole and Bayleton had lower disease severity in 2007 and 2008 compared with the untreated control. The study demonstrates the efficacy of using certain DMI fungicides for preventive fairy ring control. Proper timing of preventive applications is necessary to maximize the residual effectiveness of the fungicide and target a vulnerable portion of the pathogen's life cycle. Applications were made before plant symptoms are evident and based upon environmental cues like soil temperature, but further study is necessary to confirm results based upon soil temperatures.
- Fungicide application methods may affect the efficacy and duration of preventive control. Other surfactant chemistries may respond differently, but data in this research suggest that tank-mixing a surfactant with a preventive fungicide does not increase disease control and may result in slight phytotoxicity.

Funded by

Published in GCM, December 2012, pages 74-82.

Turfgrasses evaluated for tolerance to rapid blight

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David Kopec, Ph.D., and
Jeffrey Gilbert, M.S.
University of Arizona

Objective

Determine whether mixing perennial ryegrass with more-tolerant turfgrasses provides control of rapid blight.

Summary

Perennial ryegrass is used for overseeding bermudagrass in fairways and tees on golf courses in low desert regions of the Southwest and throughout much of the southern U.S. Rapid blight is caused by an aggressive pathogen/saprophyte, *Labyrinthula terrestris,* and has become a chronic problem on cool-season turfgrasses irrigated with water with elevated salinity and where leaching is not adequate to manage sodium chloride in soils.

Field trials were conducted in 2008-2010 at a golf course in Goodyear, Ariz., on a large practice tee known to be infested with the rapid blight pathogen. During this period, 14 varieties of experimental perennial ryegrass and 24 varieties of commercially available perennial ryegrass were tested. In addition, laboratory assays were integrated into the 2008 field trials to determine whether non-symptomatic plants in the field were colonized with the pathogen.

Results

- Perennial ryegrass is less susceptible than *Poa trivialis,* Chewings fescue and velvet and colonial bentgrasses. The perennial ryegrass varieties tested were all equally susceptible to rapid blight; perennial ryegrass is susceptible under disease pressure and elevated salinity.
- Mixing perennial ryegrass with more-tolerant turfgrasses such as slender creeping red fescue and alkaligrasses is one strategy for rapid blight control for the immediate future.

Funded by

Golf and Environment Foundation of Arizona

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Insect Management

Photos by C. Cox

Suppressing Sting Nematodes Using Botanical Extracts

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Objective

Investigate whether sting nematode can be controlled by applications of selected plant extracts to soil and whether irrigation would enhance the effectiveness of control.

Summary

Golf courses often provide an ideal environment for elevated populations of sting nematode: sandy soil, warm temperatures, ample soil moisture and susceptible turfgrass cultivars. Under these conditions, sting nematode can cause loss of turfgrass which reduces playing quality and possibly revenue. In anticipation of the restricted availability of commercial products for nematode control, botanical extracts may provide a way to suppress sting nematodes.

In laboratory experiments, known populations of sting nematodes were exposed to shoot or root extracts from spotted spurge, poinsettia, lantana, tall lettuce, and golden rod plus a seed meal extract from wild mustard. Following application of the extracts, selected pots were irrigated to ensure proper infiltration and distribution of the extract.

Results

- Plant extracts from members of the Euphorbiaceous and seed meal extract from wild mustard families can be a potential alternative for nematode suppression if the environment in which they are applied will sustain the compounds.
- Plants producing isothiocyanate compounds (seed meal extract from wild mustard) appear more likely to reduce a plant parasitic nematode population in a naturally infested soil than the members of the Euphorbiaceous family selected for investigation in this study.
- Irrigation appears important in distributing the nematicidal extract and in protecting plants from severe shoot and root phytotoxicity.

Funded by

Published in GCM, September 2007, pages 94-97.

Photos by T. Royer

May or June Beetles Infesting Oklahoma Turf

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Objective

Determine which May or June beetles infest bermudagrass on Oklahoma golf courses and document their seasonal flight patterns.

Summary

White grubs are the larvae of a group of Scarab beetles, including several species of Phyllophaga (May or June beetles), that are pests of managed turfgrass. More than 70 species of May or June beetles occur in Oklahoma, but little is known about which species are potential turf pests. To determine the best timing for pesticide applications for controlling white grubs, it is necessary to identify the pest species, their locations and seasonal flight patterns.

Ultraviolet light traps were placed at seven golf courses throughout Oklahoma in 2005 and 2006 to capture beetles. Captured beetles were collected and identified.

Results

- By sampling throughout the state and using DNA testing to identify species, nine Phyllophaga species were identified as turf pests in Oklahoma.
- It is recommended that preventive white grub treatments be applied in Oklahoma from June 1 through July 1 to control May or June beetles in turfgrass.

Funded by

Oklahoma Chapter GCSAA

Oklahoma Turfgrass Research Foundation

EIFG Environmental Institute for Golf

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Photo by T. Cook

Geographic Distribution and Local Incidence of Invasive Crane Flies in the Northeast

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Objective

Ascertain how widespread the European crane fly and common crane fly are in New York and determine how widespread the crane flies are at each local site of establishment.

Summary

European and common crane flies are of European origin and have been detected in New York. Crane flies can cause extensive damage to turfgrass by feeding on below- and aboveground portions of the grass.

Golf course fairways, tees, and greens were scouted for European and common crane flies in spring and fall along two north-south corridors and one east-west corridor in New York State. At eight golf courses where crane flies had established, greens and tees throughout the golf course were scouted in spring and fall to determine the extent of establishment.

Photo by R. Ferrentino

Results

- European and common crane flies are invasive pests of turfgrass and are becoming established in New York.
- These results have established a baseline that will be useful in monitoring change in crane fly establishment in the Northeast.
- In New York, common crane fly is more widespread geographically than European crane fly, but not more widespread locally.
- Both species were absent between western New York and Long Island, indicating that there may have been two separate establishments in New York.

Funded by

NEW YORK STATE TURFGRASS ASSOCIATION

EIFG Environmental Institute for Golf

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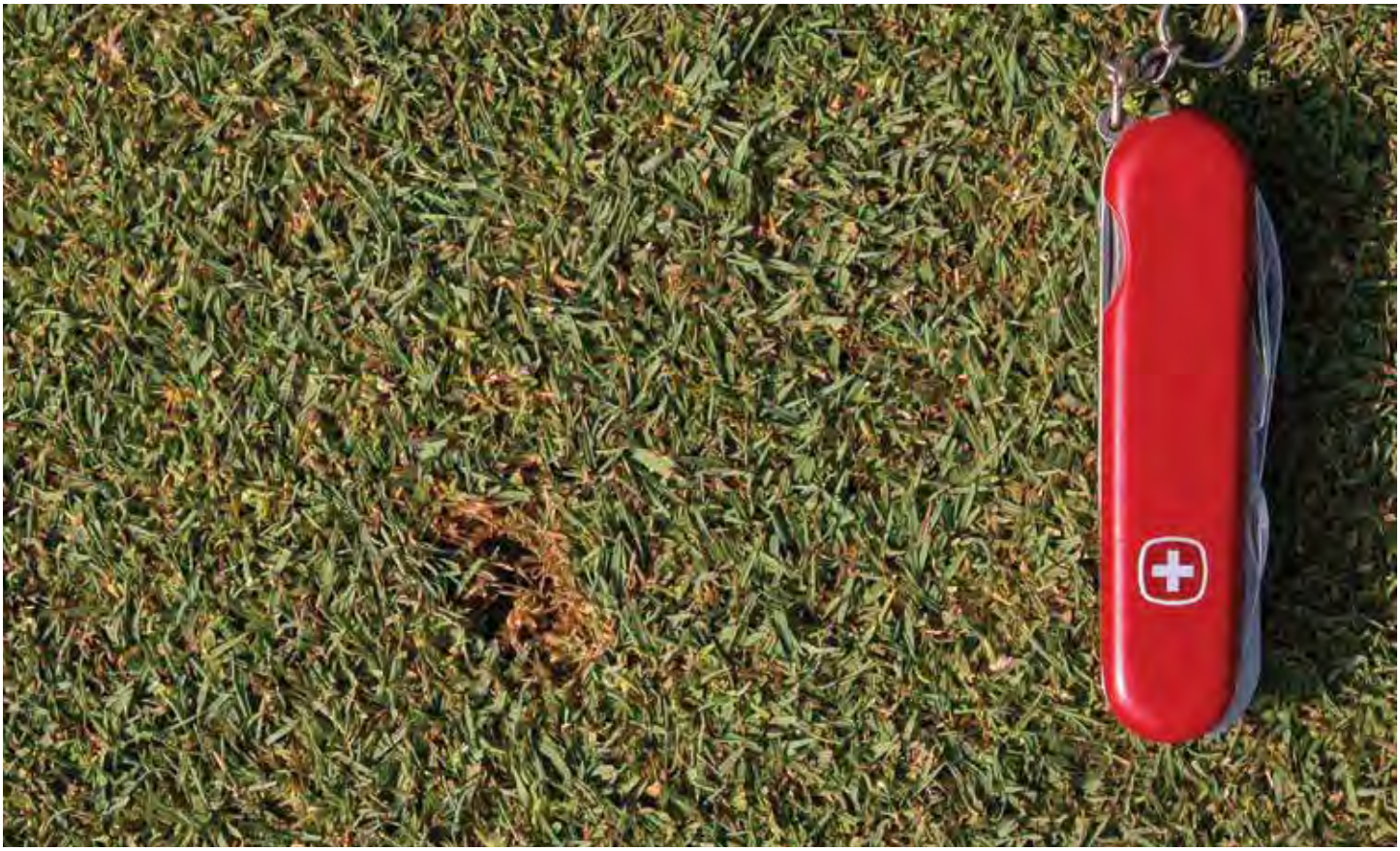

Photos by D. Peck

Insecticidal Control of Invasive Crane Flies in the Northeastern U.S.

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Objective

Evaluate the insecticidal options for controlling European crane fly larvae in the field.

Summary

Crane fly larvae inhabit the top layer of soil and feed on the roots and crowns of turfgrass plants. Damage from their feeding can lead to severe thinning and dieback of turfgrass.

Because crane flies are an emerging pest in turfgrass, relatively few products are labeled for their control. Therefore, a range of active ingredients, products and rates, including some not currently registered for crane flies or golf courses, were evaluated. Insecticidal control for crane flies is preventive in late fall (larvae are too small to scout and damage is uncommon) and curative in early spring (larvae are large and big enough to scout and damage is common).

- There are efficacious products for the insecticidal control of invasive crane fly larvae in turfgrass during both preventative and curative application windows.
- The most efficacious active ingredients for targeting early instars in late-fall application were Talstar, Sevin, Acelepryn, and Dylox 80WP.
- The most efficacious insecticides for targeting large instars in spring applications were Arena and Safari.
- Among the best performing products, Arena and Safari are not labeled for control of invasive crane flies, and neither are registered in New York. Acelepryn is labeled for control of crane fly larvae, but is not yet registered in New York.
- Continuing studies are necessary to strengthen product recommendations and generate information on how to best tailor insecticidal controls to crane fly species, seasonal application window and geographic region.

Funded by

NEW YORK STATE TURFGRASS ASSOCIATION

EIFG Environmental Institute for Golf

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Photo by L. Buss

Seasonality, Development and Cultural Control of the Hunting Billbug

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Objective

Identify the billbug species complex present on golf courses in north central and southern Florida and determine how long hunting billbugs require for development.

Summary

Billbugs can severely damage turfgrass by feeding on stems, stolons, and rhizomes. There are 25 species of billbugs in Florida but little is known about the billbug species complex or biology. Expanding the knowledge of billbugs will lead to more effective control strategies.

The composition, abundance and seasonal activity of billbugs on four Florida golf courses were determined weekly by taking 24-hour samples with large linear pitfall traps. Any billbugs caught in the traps were identified to species.

Results

- The hunting billbug is the most abundant and damaging billbug species in warm-season grasses and was the most common species collected on the four golf courses in this study.
- Bermudagrass can tolerate a large hunting billbug population before noticeable damage occurs.
- Proper monitoring and identification of this pest can prevent turf loss and costly renovation.
- Overseeding or planting a pure stand of endophytic turfgrass has a strong likelihood of preventing serious outbreaks of hunting billbugs.

Photo by E.A. Buss

Funded by

Florida Turfgrass Association

Florida GCSA

EIFG Environmental Institute for Golf

Published in GCM, October 2009, pages 90-96.

Nematodes for Control of Annual Bluegrass Weevil

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Objective

To determine if entomopathonogenic nematodes could effectively and reliably reduce populations of the annual bluegrass weevil on golf courses.

Summary

The annual bluegrass weevil (*Listronotus maculicollis,* formerly *Hyperodes maculicollis*) is a problem insect on golf courses throughout the northeastern U.S. and eastern Canada. Unacceptable damage from their feeding is commonly found in dense stands of annual bluegrass (*Poa annua*) on fairways, tees, collars and putting greens. Pesticide products were commonly used to reduce the population of the weevil, but resistance to insecticides, particularly pyrethroids has intensified the need for broader management techniques. Five commercially available and two native strains of parasitic nematodes were tested in the laboratory for virulence on annual bluegrass adults with low to moderate effectiveness. Field-testing of the nematodes on bluegrass weevil larvae and pupa was more successful under certain conditions. The effectiveness of nematode application concentrations, timing and instar stage of weevil larvae and pupa were tested and some combinations provided effective control of bluegrass weevil populations. Overall, control was variable and more work is needed to make it commercially viable.

Results

- Two species of entomopathogenic nematodes have been found to infect annual bluegrass weevil larvae and pupae. On insecticide-free fairways, they can reduce a single weevil generation up to 50 percent, but damage can still occur, especially if population densities are more than 80 larvae/square foot.
- Laboratory screening showed that the nematodes are not effective at controlling annual bluegrass weevil adults.
- Two nematode species demonstrated a high level of weevil control, but currently control is too variable for reliable use on golf courses.
- Identifying the sources of variability from the annual bluegrass weevil and the applied nematodes will help scientists develop release strategies that lead to greater control in the future.



Funded by

Keystone Association of Golf Course Superintendents

Published in GCM, February 2011, pages 88 - 94.

Annual Bluegrass Weevils: Distribution and Damage

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Objective

To develop a reliable sampling method to accurately predict annual bluegrass weevil population density and distribution on golf courses.

Summary

The annual bluegrass weevil (*Listronotus maculicollis*, formerly *Hyperodes maculicollis*) is a problem insect on golf courses throughout the northeastern U.S. and eastern Canada. Unacceptable damage from their feeding is commonly found in dense stands of annual bluegrass (*Poa annua*) on fairways, tees, collars and putting greens. No reliable sampling methods are known to effectively forecast the probability of damage from weevil feeding. New methods of understanding their population density, distribution and stage of development are needed to accurately set thresholds and more precisely execute control strategies. The use of vacuums to dislodge the weevils from the turf was compared to standard sampling tests that are more destructive and time consuming. Results indicate that vacuum sampling methods are effective in identifying growth stage and correlating distribution of annual bluegrass weevils on golf courses.

Results

- Vacuum sampling can be an effective tool in assessing the presence and density of adult annual bluegrass weevils.
- Vacuum sampling methods are less time-consuming and less destructive when compared to traditional methods. They allow golf course superintendents to sample larger areas in a reliable manner.
- Adult counts on fairways are correlated to future larval densities.
- Distribution of adults along the edges of fairways suggests that adults prefer to deposit eggs in short-mowed grass which challenges traditional assumptions.
- Creeping bentgrass is more tolerant to annual bluegrass weevil feeding than annual bluegrass.
- Annual bluegrass weevil has been shown to deposit fewer eggs into and develop more slowly in creeping bentgrass than in annual bluegrass.
- Removing annual bluegrass and reseeding more-tolerant turfgrass species may suppress annual bluegrass weevil populations.

Funded by

EIFG Environmental Institute for Golf

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War of the worlds: bacteria vs. nematodes

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Objective

Determine the number of *Pasteuria* endospores needed to suppress sting nematode populations and the effect of thatch and watering on movement of these endospores in the soil profile. Determine whether *Pasteuria* reared on

media preferred sting nematodes from different regions and evaluate a commercial *Pasteuria* product in the field.

Summary

Sting nematode (*Belonolaimsus longicaudatus*) is considered the most destructive nematode on turf. Management of this pest is challenging with the limited number of effective nematicides that can be applied to growing plants. Biological control may be a viable alternative or provide supplemental management of the pest. Many species of the bacteria genus *Pasteuria* are obligate parasites of nematodes.

The rate study was conducted in the growth room at the University of Florida, Gainesville, and the thatch and water study was conducted in the turfgrass envirotron (glass house study) at the university. In addition, the isolate study was conducted in the growth room with samples from different locations across Florida and other southeastern states. Field trials for product evaluation for EcoNem (*Pasteuria* endospores) were conducted from 2006 through 2010 at the university.

Results

- Greenhouse studies indicate that inoculation with *Pasteuria* endospores produced in vitro can suppress sting nematode populations. Thatch did not appear to hinder introduction of endospores into the root zone. This may suggest that control of sting nematodes in the field may require repeated applications of endospores.
- *Pasteuria* produced in vitro should have similar effects on sting nematodes in various locations.
- EcoNem was effective in the green house studies, but field trials were unsuccessful in reducing numbers of sting nematodes to the level superintendents would expect. There are a number of factors that could have contributed to the difference between the green house study and field studies.

Funded by

EIFG Environmental Institute for Golf

Dow AgroSciences **Pasteuria Bioscience** Florida Chapter GCSAA **Florida Turfgrass Association**

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Turfgrass Management


78-79


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Photo by J. Kuddes

Soil Physical and Chemical Characteristics of Aging Golf Greens

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Objective

Monitor changes in physical and chemical properties of greens over time.

Summary

As greens age, they undergo physical and chemical changes which may affect management practices.

Four experimental greens were constructed following USGA recommendations in sequential years from 1997 to 2000. Treatments included two root zones, 80:20 (v:v) sand and sphagnum peat and 85:15:5 (v:v:v) sand, sphagnum peat and soil (silty clay loam), and two grow-in programs, accelerated and controlled.

Photo by R. Gaussoin

Results

- Water infiltration decreases as a sand-based root zone matures, possibly because of fine particles from topdressing sand.
- Adding soil to the root zone does not decrease infiltration with maturity, and soil may be an economical alternative to peat in root zone construction.
- Beyond the grow-in year, phosphorus was the only element that accumulated in the root zone from initial applications during establishment.
- Nitrogen and phosphorus begin to accumulate in the later years of a green's maturity, indicating the potential for decreasing these inputs as greens mature.

Funded by

USGA

EIFG Environmental Institute for Golf

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Photos by D. Karcher

Water Retention of Sand-Based Root Zones with Organic and Inorganic Amendments

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Objective

Determine the water-holding capacity of sand root zones (meeting USGA recommendations) modified with various amendments and determine the effect of amendments on grow-in rate and dry-down characteristics of creeping bentgrass established in the amended root zones.

Summary

Previous research has shown that while some inorganic amendments increase the total water-holding capacity of a root zone, they may have little impact on plant-available water. Given that the cost of inorganic amendments is greater than peat, it is important to understand the benefits of inorganic amendments so superintendents can make well informed decisions when selecting amendments.

Moist sand:amendment root zones were mixed at the appropriate ratio and were packed into cylinders, and plant-available water was determined through laboratory testing procedures. The same sand:amendment root zones were packed into lysimeters, established with creeping bentgrass in the greenhouse and were subjected to a dry-down period during which irrigation was withheld.

Results

- All root-zone treatments met USGA recommendations except for capillary porosity in the sand control.
- In the laboratory, reed sedge peat was the only amendment that significantly increased plant-available water compared to the sand control.
- Increasing amendment ratios from 10% to 20% enhanced germination, but the difference was significant in only one of two trials.
- Diatomaceous earth enhanced establishment rate, green cover during dry-down and resistance to wilt, but using it for putting green construction would greatly increase costs. Long-term studies must be conducted to determine whether this product has long-term benefits compared to traditional peats.
- This experiment was performed in a controlled setting that favored turfgrass growth. The results might be different if this experiment were performed under field conditions that included foot traffic, mowing stress and greater environmental variability.

Funded by

EIFG Environmental Institute for Golf

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Photos by E. Guertal

Adding Inorganic Amendments to a Poorly Performing Green

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and Clint Waltz, Ph.D.,
University of Georgia

Objective

Examine the impact of common inorganic soil amendments on bermudagrass putting green performance when amendments were used as part of a drill-and-fill greens renovation project.

Summary

The incorporation of inorganic soil amendments in aerification holes created in a poorly performing putting green has been suggested as means to improve the performance of the green with rebuilding. Little research has been conducted to examine the use of inorganic soil amendments in this manner.

A poorly performing push-up Tifdwarf bermudagrass green was used for the three-year experiment. Three inorganic soil amendments, sand, and control with no amendment were applied using a commercial drilling and injection machine.

Results

- Three years of cumulative amendment incorporation did not result in a substantial improvement in infiltration, nutrient-holding capacity or turf performance (shoot density, root mass).
- Turf quality, turf color, spring green-up and fall color retention were not affected by the addition of amendments.
- In this study, incorporation of amendments in aerification holes showed no benefits.

Funded by

EIFG Environmental Institute for Golf

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Photos by K. Morris

Grasses for Overseeding Bermudagrass Fairways

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Objective

Evaluate the performance of 31 grasses and blends for fairway overseeding.

Summary

Overseeding bermudagrass fairways is a common practice in much of the southern U.S. One key to overseeding success is selecting the appropriate species and/or variety.

Various species and seed blends used in overseeding were established on fairways on 12 golf courses. The golf courses were located in the Southwest, Southeast and transition zone. Turf was rated for establishment in fall, winter performance and spring transition.

Results

- At most locations, the perennial ryegrass entries or blends of perennial ryegrass were the best performers.
- *Poa trivialis* varieties had the lowest turfgrass quality ratings at most locations, were slower to establish and were lighter green in color than the perennial ryegrasses.
- The newer intermediate ryegrasses have quality closer to that of perennial ryegrass, and they tend to die back earlier, allowing the bermudagrass to grow in.
- Making the transition from overseeding to bermudagrass in spring is extremely difficult, and the results are greatly influenced by weather. Courses committed to overseeding should have realistic expectations of the outcome.

Funded by

USGA NTEP National Turfgrass Evaluation Program EIFG Environmental Institute for Golf

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Photos by B. Horgan

Fine Fescues and Colonial Bentgrasses for Fairways

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Objective

Determine the best cultivars and combination(s) of fine fescues and colonial bentgrasses for use as fairway turfgrass.

Summary

There is interest in low-input turfgrass systems that meet the expectations of golfers. Fine fescue and colonial bentgrass have attributes that make them good candidates for low-input fairways.

Selected fine fescue and colonial bentgrass cultivars were either planted alone or in combination in field plots in Minnesota and Wisconsin. Fertilizer was applied at low and high rates using either an organic or synthetic water-soluble nitrogen fertilizer. Irrigation was applied only to prevent significant stand loss during drought.

Results

- There were no significant differences among mixtures containing colonial bentgrass and fine fescue regardless of the fertility source or rate.
- Water-soluble fertilizer provided better turf quality, higher percent of living ground cover, fewer weeds, higher colonial bentgrass percentages and quicker divot recovery.
- Because plots were irrigated only to prevent turf death, the lack of moisture in summer may have limited mineralization of organic fertilizers and thus, led to lower turf quality.
- Overall, monostands of chewing fescues SR 5100 and Longfellow II provided the best turf quality in sites receiving traffic and limited supplemental irrigation.

Funded by

EIFG Environmental Institute for Golf

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Photos by T. Voigt

Warm-Season Native Grasses for Playable Roughs

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Objective

Evaluate the playability of cultivars of blue grama alone or mixed with buffalograss for unmowed rough and determine the impact of chemical weed control, burning, and mowing on performance of the grasses.

Summary

Unmowed rough is found on many golf courses in the Midwest. While unmowed rough offers many benefits, these areas still require some care so play is not slowed and nuisance pests are managed properly.

Five cultivars of blue grama were planted alone and as a mixture with buffalograss and were not mowed to determine performance as an unmowed rough. Chemical weed control was applied once and weed control was evaluated and plots were either mowed or burned once each spring to manage undesired aboveground vegetation.

Results

- Previous studies and results from a survey of Midwestern superintendents indicated that two native grasses, blue grama and buffalograss, can create attractive unmowed roughs that are playable.

- A three-year study of blue grama and buffalograss alone and in combinations showed that, alone or in combination, the grasses are unattractive after mowing or burning in spring and therefore not acceptable for golf course roughs in the Midwest.

Funded by

Central Illinois Chapter GCSAA

Association of Golf Course Superintendents MIDWEST

EIFG Environmental Institute for Golf

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Photos by M. Goatley

Turf Covers for Winter Protection of Bermudagrass Greens

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Objective

Determine how various commercially available and experimental turf covers modify surface temperatures of a bermudagrass green when covers are applied before predicted severe winter temperatures.

Summary

Because golf can be played throughout much of the winter in areas where bermudagrass is adapted, turf covers are often applied to greens on a temporary basis to provide short-term, low-temperature protection. Little published research is available that details the value of using turf covers on a temporary basis on bermudagrass greens and which covers perform the best.

Ten different turf covers were applied to a bermudagrass green whenever a minimum temperature of less than 28F was forecast for at least two consecutive nights during the winters of 2000-2003. Spring green-up, photosynthetically active radiation, and temperature modification under the covers were measured to assess the benefits of the turf covers.

Results

- Temperature responses varied with cover composition, permeability, color and, to a lesser extent, thickness.
- An experimental translucent overwintering blanket provided the highest average daily maximum temperatures, but also had the greatest temperature range, indicating the potential for excessive heating under the cover.
- A commercially available interwoven polyethylene cover also provided high daily mean soil surface temperatures, but its mean daily minimum temperatures were not significantly different from the uncovered control in two of the three years, apparently indicating much of the energy acquired during the day was lost after sundown.
- Doubled layers of commercially available white or black polypropylene covers had only slightly increased mean daily minimum temperatures as compared to single layers.
- All covers provided some degree of potentially desirable temperature modifications, but selection and use would depend on the particular needs of the superintendent.

Funded by

Louisiana-Mississippi Chapter GCSAA

EIFG Environmental Institute for Golf

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Photos by D. Minner

Field Evaluation of Winterkill in Annual Bluegrass and Creeping Bentgrass

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Objective

Determine the specific cause of winter injury on greens and determine whether superintendents should allow winter to take its natural course or actively manage to reduce winter injury.

Summary

Every year, greens north of the transition zone suffer winter injury. When turf loss is substantial, the superintendent must explain why the grass died, and why it died on that particular course and not on other nearby courses.

The study was carried out on two separate greens for three years. The 10 potential winter injury scenarios were: dry, open; wet, no ice; continuous ice; continuous snow; impermeable cover with ice on top; ice removed after 60 days; natural melt-freeze cycles in spring; snow removed after 60 days; permeable cover with ice/snow removed; and permeable cover with ice/snow present.

Results

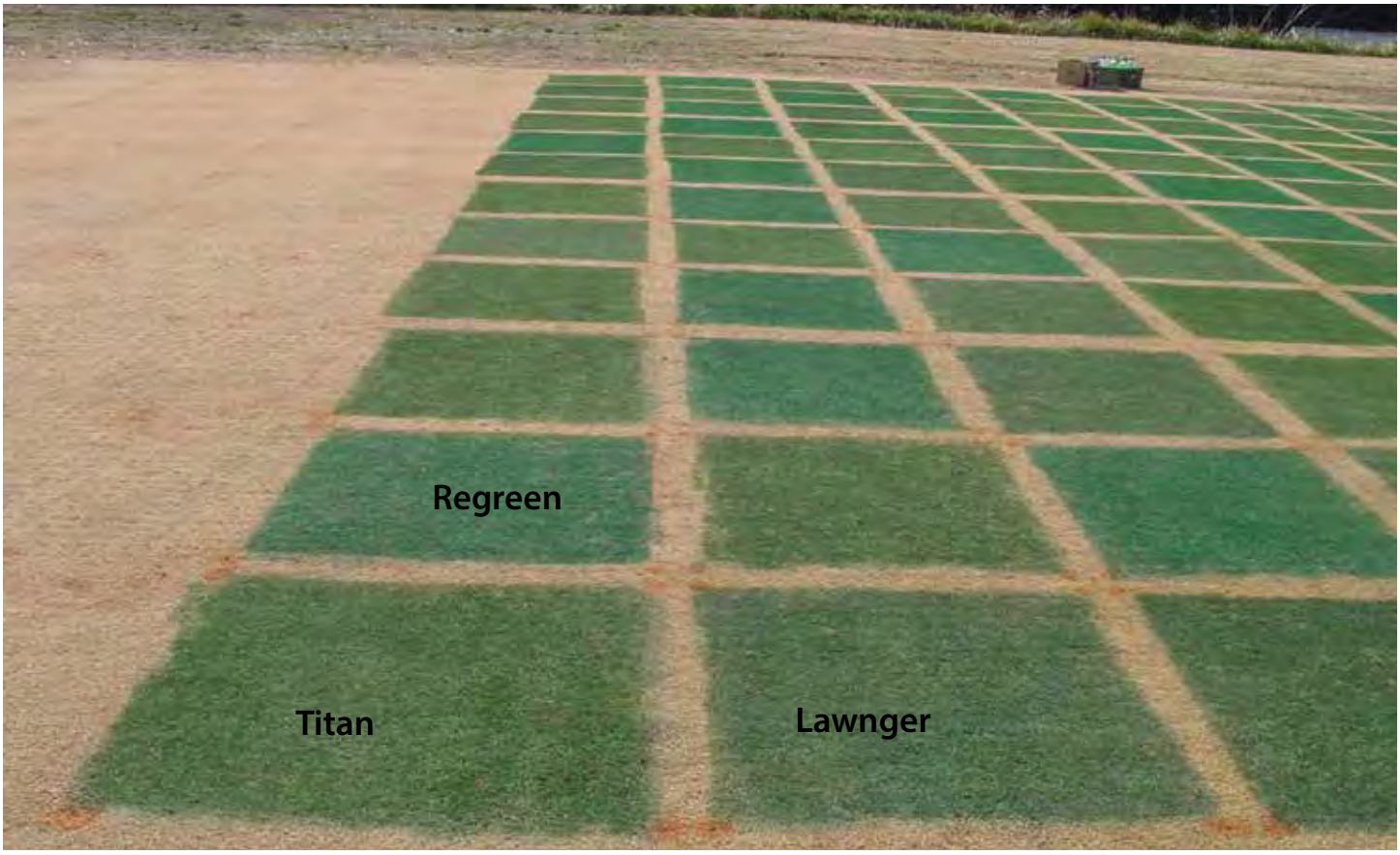
- Annual bluegrass is far more likely than creeping bentgrass to be injured in winter.
- Continuous ice cover of 66 days caused bleaching of creeping bentgrass but never caused turfgrass kill.
- Annual bluegrass was injured under ice cover.
- The formation of ice may be more important than the duration of ice cover in predicting annual bluegrass winter injury when ice is present.
- There was no advantage in removing ice cover once it had formed. A better strategy might be to prevent any amount of ice forming on annual bluegrass.

Funded by

Iowa Chapter GCSAA

EIFG Environmental Institute for Golf

Published in GCM, September 2007, pages 88-93.



Photos by H. Liu

Painting Dormant Bermudagrass Putting Greens

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Objective

Evaluate the effects of paints and turfgrass management practices on winter, spring and summer bermudagrass putting green performance.

Summary

Bermudagrass greens traditionally have been overseeded to provide winter color. Overseeding can damage the bermudagrass turf and is expensive. Painting dormant bermudagrass greens offers a simple, inexpensive way to transform a brown putting green to a green one.

TifEagle bermudagrass was mowed at three mowing heights four weeks before painting, fertilized with either 100% granular or 100% liquid fertilizer, treated or not treated with a plant growth regulator during the growing season and either overseeded with *Poa trivialis*, painted with one of three brands of paint or allowed to go dormant.

Results

- All the paints evaluated provided acceptable or better quality. Fall mowing height had no effect on the quality of painted turfgrass.
- Painted turfgrass had longer ball roll distance than overseeded turf at the same mowing height.
- Painted turfgrass had slightly higher surface and soil temperatures, which enhanced spring green-up.
- Among the overseeded plots, turfgrass treated with 100% foliar fertilizers in summer and winter had the best turf quality.

Funded by

GOLF COURSE SUPERINTENDENTS CAROLINAS 1954

EIFG Environmental Institute for Golf

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Photos by H. Liu

Foliar vs. Granular Fertilization on Creeping Bentgrass

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Objective

Evaluate the effects of two relatively low nitrogen fertilization rates applied as 100% granular fertilizer, 50% granular + 50% foliar fertilizer, or 100% foliar fertilizer on turfgrass performance of a creeping bentgrass green.

Summary

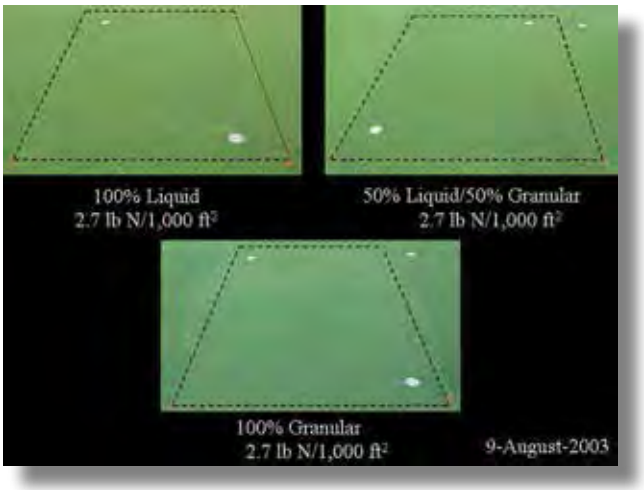
Superintendents apply nutrients to turfgrass in both granular and foliar forms. There are advantages and disadvantages associated with both forms of fertilizer. It is important to understand how turfgrass performs when fertilized with granular and foliar fertilizer so superintendents can develop effective fertilization programs that utilize the advantages of both forms of fertilizer.

A creeping bentgrass green was fertilized with 2.7 and 3.8 pounds nitrogen/1,000 square feet/year using 100% granular fertilizer, 50% granular + 50% foliar fertilizer, or 100% foliar fertilizer. Turfgrass performance was evaluated over the two-year field study.

Results

- Evaluations of visual turfgrass quality, clipping yield and percent total nitrogen in clippings showed that a rate of at least 3.8 pounds nitrogen/1,000 square feet provided higher creeping bentgrass quality in the transition zone of the U.S.

- Combining both liquid and granular fertilizer application methods appears to provide better results than relying exclusively on one method.



Funded by

EIFG Environmental Institute for Golf

Published in GCM, October 2009, pages 74-80.

The Nature and Control of Black Layer

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Objective

To determine whether hydrogen sulfide could be responsible for the turf decline observed on greens with black layer and if elemental sulfur or sulfur-containing compounds could directly lower the redox potential of soil, which is necessary for black layer development.

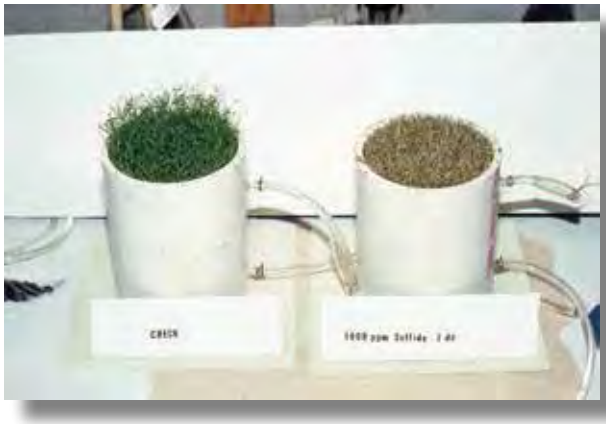
Summary

Black layer is a dark-colored layer in the soil profile of some putting greens. The layer has a rotten egg odor and is associated with a decline in turf quality ranging from thinning and bronzing of turf to turf death.

A series of laboratory experiments using cores of soil from putting greens were conducted to determine if: 1) elemental sulfur reduced to metal sulfide in black layer soil; 2) hydrogen sulfide could be responsible for turfgrass decline in soil with black layer; 3) elemental sulfur or sulfur-containing compounds could lower soil redox potential; and 4) nitrate could be used to prevent the release of hydrogen sulfide when applied at a suitable level for turfgrass fertilization.

Results

- Applications of elemental sulfur to putting greens can induce anaerobiosis and stimulate the production of both free hydrogen sulfide and metal sulfide.
- Hydrogen sulfide is toxic to turfgrass roots and the release of hydrogen sulfide in the soil profile of putting greens has the potential to cause turfgrass decline.
- Fertilizing with nitrate and withholding elemental sulfur helps to control the release of hydrogen sulfide, thereby preventing black layer formation.



Funded by

EIFG Environmental Institute for Golf

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Controlling Roughstalk Bluegrass

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Objective

Determine whether Velocity or Certainty could selectively control seedling roughstalk bluegrass (*Poa trivialis*) in seedling creeping bentgrass.

Summary

Roughstalk bluegrass is a troublesome stoloniferous weed commonly found in creeping bentgrass fairways. Roughstalk bluegrass performs poorly under summer stress and often suffers significant stand loss by late summer. A strategy to control roughstalk bluegrass as a seedling would reduce or eliminate it from mature stands improving creeping bentgrass fairway quality.

Separate field studies were conducted on fall- or spring-seeded stands of seedling creeping bentgrass and roughstalk bluegrass so response of each grass could be determined without interference. Several rates of Velocity and Certainty were applied seven, 14, 21 and 28 days after seedling emergence. Percent cover was visually rated on regular intervals after herbicide treatments were applied.

Results

- Roughstalk bluegrass is most effectively controlled when Velocity 17.6 SG or Certainty is applied seven to 14 days after seedling emergence.
- Velocity 17.6 SG at rates of up to 4.5 ounces per acre may be safely applied to creeping bentgrass as early as seven days after seedling emergence in spring or fall seedlings.
- Certainty applications should conservatively be delayed until 28 days after seedling emergence or later when seeding creeping bentgrass in spring or fall.

Funded by

MRTF Midwest Regional Turf Foundation

EIFG Environmental Institute for Golf

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Bringing IPM to the Next Level

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Objective

GCSAA and The Environmental Institute for Golf encourages and supports superintendents to create and implement written IPM plans for all golf courses by providing an electronic resource to guide the development of IPM plans.

Summary

IPM (Integrated Pest Management) relies on a variety of pest management methods to prevent pest problems from reaching unacceptable levels and has proven to be an effective approach to pest and turfgrass management. To promote the implementation of written IPM plans on golf courses, the IPM Planning Guide was created to help superintendents, whether the superintendent is just starting an IPM plan or already has a sophisticated plan, improve their IPM plans.
The IPM Planning Guide includes: 1) references — a centralized source of information on IPM strategies; 2) Instructions — clear procedures for incorporating this information into IPM plans; and 3) Forms and spreadsheets — forms, calendars and simple spreadsheets for documenting, record keeping and budgeting that will facilitate IPM planning.

Results

The IPM Planning Guide is free and available to everyone in the golf industry and is located at www.eifg.org/ipmguide.

Funding for the development of the IPM Planning Guide was provided by

EIFG Environmental Institute for Golf

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Overseeded Bermudagrass: Improving Turf Aesthetics During Spring Transition

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Objective

Determine whether partial herbicidal control of overseeded perennial ryegrass in May will increase bermudagrass cover and aesthetics when the remaining perennial ryegrass is controlled with herbicides in July.

Summary

Removing overseeded perennial ryegrass from bermudagrass is a challenge for golf courses, which must maintain playability during the transition. Research conducted at Virginia Tech pioneered two new partial-control application techniques for removing overseeded perennial ryegrass. The concept is that bermudagrass cover and aesthetics can be improved by one or several partial-control herbicide applications early in the season so that turfgrass quality remains high while the remaining perennial ryegrass is controlled later in the season.

Three partial-control techniques (drip, sponge and strip) to remove overseeded perennial ryegrass were evaluated on golf courses in Charlottesville, Va., in 2006 and Blacksburg, Va., in 2007. The first partial control was applied in late April or May, followed by a sequential partial-control application three weeks later for some treatments and a blanket herbicide application for all treatments one month after the sequential application. Bermudagrass cover and turfgrass quality were visually rated at regular intervals following the herbicide applications.

Results

- Partially controlling perennial ryegrass using drip, sponge and strip application techniques can increase bermudagrass cover and turfgrass quality after a blanket herbicide application in June or July.

- The drip and sponge treatments were shown to improve turfgrass quality over strip application, while all partial-control techniques provided similar improvement in bermudagrass cover.

Funded by

Virginia Chapter GCSAA Golf Course Superintendents Association of America

The Virginia Turfgrass Foundation

EIFG Environmental Institute for Golf

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Perennial Ryegrass Competition Affects Bermudagrass Health

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Objective

Determine how duration of overseeded perennial ryegrass competition affects bermudagrass cover and biomass accumulation.

Summary

In the transition zone and desert Southwest, bermudagrass requires considerable competition-free time to remain healthy. Competition from overseeded grasses and an extreme environment can lead to thin bermudagrass cover and poor playing conditions while overseeded grasses are removed. Poor bermudagrass performance can extend into the summer.

In each of two years, individual plots of Patriot, Midiron and Riviera bermudagrass were overseeded with perennial ryegrass in the fall. In spring, a herbicide was applied every week for 24 weeks to a previously untreated plot to remove the overseeded perennial ryegrass. Bermudagrass cover was visually rated in mid-August to assess the performance of the herbicide application dates. The number of competition-free days was counted and growing degree days (GDD) or heat units were determined for the competition-free period to determine quality of those days for bermudagrass recovery.

Results

- Bermudagrass needs both time and heat units to recover from overseeding after perennial ryegrass has been removed.
- In most cases, 60 to 120 competition-free days will provide a full recovery, given sufficient heat-unit accumulation during the recovery period.
- More aggressive bermudagrass varieties need fewer days of noncompetitive growth and cumulative noncompetitive growing degree days to obtain acceptable bermudagrass cover.

Funded by

Virginia Chapter GCSAA Golf Course Superintendents Association of America

The Virginia Turfgrass Foundation

EIFG Environmental Institute for Golf

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Reducing annual bluegrass during fairway conversion to Kentucky bluegrass

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Bruce Branham, Ph.D.
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Objective

Determine specific herbicide and seeding strategies that can be used to successfully convert existing cool-season grass fairways to improved low-mow Kentucky bluegrass varieties with minimal annual bluegrass infestation.

Summary

Golf course superintendents in the Midwest are very interested in improving their fairway conditions by converting to the new generation of low-mow Kentucky bluegrass varieties. Infestation of annual bluegrass during the renovation process is the major reason for not converting to the newer Kentucky bluegrass varieties.

Two separate studies initiated in 2007 and 2008 were conducted at three Iowa golf courses over three years to evaluate establishment season, seeding rate, and post-emergence herbicide strategies to convert cool-season fairways contaminated with annual bluegrass to the improved Kentucky bluegrass varieties.

Results

- Seeding rate did not affect percentage cover of Kentucky bluegrass in the study, indicating that seeding rate alone is not enough to suppress annual bluegrass populations.
- Seeding low-mowing-tolerant Kentucky bluegrass varieties in August or September resulted in 93%-95% Kentucky bluegrass in plots treated with three sequential applications of Tenacity (mesotrione, Syngenta) in October of both the year of establishment and the year following establishment.

Funded by

Iowa GCSA

EIFG Environmental Institute for Golf

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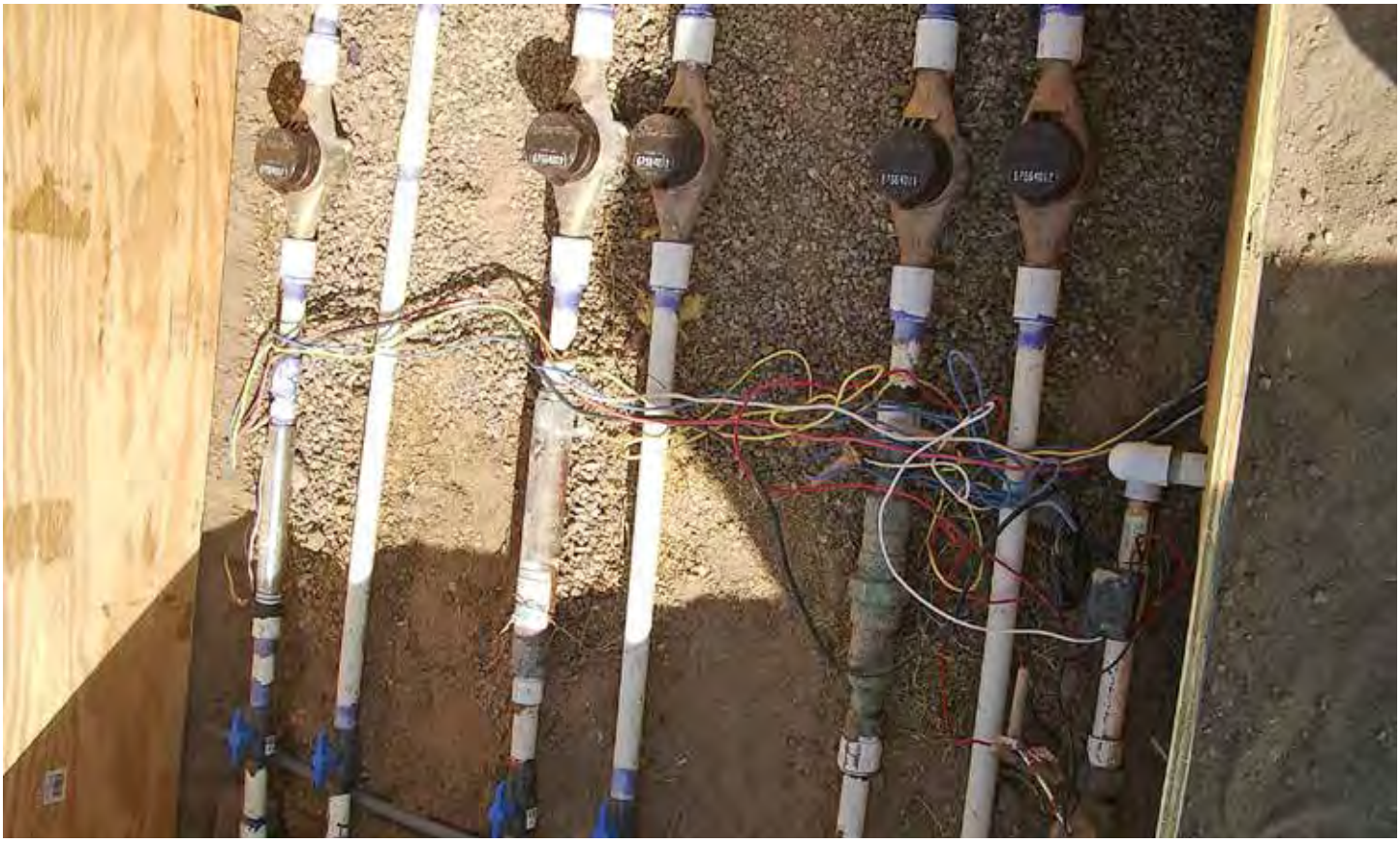

Physical water conditioners for managing turfgrasses

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New Mexico State University

Objective

Determine whether permanent applications of physically treated irrigation water improve perennial ryegrass establishment and quality and affect salinity buildup in the root zone.

Summary

Physical water conditioners have been suggested by manufacturers to lessen the impact of reduced-quality waters on soil and plant stand quality. Scientific and unbiased information is lacking as to whether turf quality and soil salinity improve over a longer period of time when saline irrigation water is treated with non-chemical water conditioners.

A four-year study was conducted at New Mexico State University's golf course to investigate the effects of magnetic, catalytic and hydroelectrical water treatment on perennial ryegrass establishment and quality and on soil chemical characteristics. Digital image analysis was used to assess stand establishment. Turfgrass quality was assessed by means of a visual rating scale of 1 to 9, recommended by the National Turfgrass Evaluation Program. Normalized difference vegetation index (NDVI) readings were collected to substantiate visual quality ratings. Salinity buildup in the root zone was determined on soil samples. Samples were subsequently analyzed for electrical conductivity, sodium and sodium adsorption ratio (SAR).

Results

- Physical conditioning treatments did not affect perennial ryegrass establishment; only saline irrigation delayed establishment.
- Turfgrass quality on control plots did not differ from conditioner-treated plots for both potable and saline water on all but one sampling date.
- The root-zone salinity results were inconclusive; no clear consistent trends were found for individual measured parameters.
- After four years of research, a consistent positive impact of these conditioning units on turf quality and root-zone salinity could not be substantiated.

Funded by

Southwest Turfgrass Association **U.S. Department of Agriculture**

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Managing thatch with fungal laccase

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University of Georgia

Objective

Determine whether the degradation of organic matter can be enhanced by applying laccase to the thatch layer and whether laccase has no appreciable adverse effects to the turf quality.

Summary

High organic matter accumulation in the form of thatch or mat is one of the major problems in modern turfgrass greens. It is believed that the rate of degradation of organic matter is related to the presence of lignin content in the organic residue. Lignin is extremely resistant to degradation. Fungal laccase, a lignolytic enzyme, may enhance the rate of organic matter degradation in the thatch layer.

A greenhouse experiment was established at the University of Georgia's Griffin Campus using Crenshaw creeping bentgrass (*Agrostis stolonifera*) sod, which was approximately 1.18 inch (3 centimeters) thick and consisted of existing thatch and mat, but not the underlying soil. The laccase enzyme used was from *Trametes versicolor*, a white rot fungus. Parameters used to determine the effectiveness of treatments were total organic matter content for a depth of 0-2 inches (0-5 centimeters), saturated hydraulic conductivity, organic layer thickness, extractive-free acid-soluble lignin, acid-insoluble lignin and total lignin content.

Results

- Applying active laccase once every two weeks reduced buildup of organic matter and thatch layer in highly maintained turf, with good results observed after nine months.
- Using laccase enzymes could prove to be a nondisruptive treatment for reducing organic matter buildup in greens.

Funded by

Georgia Golf Environmental Foundation

EIFG Environmental Institute for Golf

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Overseeding preparation techniques for fairway seashore paspalum

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University of Arizona

Objective

Evaluate the cultural management effects of adjusted mowing heights, vertical moving, and the use of a herbicide, plant growth regulator or plant desiccant — all as management tools for preparing the turf surface of seashore paspalum for overseeding.

Summary

Seashore paspalum (*Paspalum vaginatum*) does not respond well to the mechanical disturbance of stolons caused by deep divots, vertical mowing or scalping caused from mowing. Past observations over several years have shown that excessive regrowth periods are often required during the summer for recovery from such events.

A three-year field experiment was conducted on Sea Isle 1 seashore paspalum at the University of Arizona's Karsten Turfgrass Research Center in Tuscon. A 10-year-old stand of Sea Isle 1 was used for the test site. Starting in 2009, 42 treatment combinations of preparatory mowing heights, vertical mowing (none vs. two passes at 0.375 inch [9.5 millimeters]) and five chemical treatments (none, Finale, Scythe, Reward or Turflon Ester) were repeated on the same plots for three years.

Results

- The use of chemicals alone (without mechanical canopy manipulation) did not produce acceptable turfgrass quality. When the turf was mowed back to 0.375 inch without herbicides, quality means were generally acceptable every year, but quality was reduced at transition in year 3.
- The three-way combination of the 0.375-inch preparatory mowing height, verticut mowing and the use of Reward produced the best season-long overall turfgrass quality and proved to be consistent for the turfgrass quality during the three-year trial.

Funded by

Golf & Environment Foundation of Arizona

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Frequent venting of bermudagrass greens: Effects on infiltration and water content

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Objective

Evaluate the curative effects, namely turf quality and soil-water relations of PlanetAir venting in comparison to solid- and hollow-tine core aeration on a neglected golf green containing a thick layer of thatch.

Summary

Thatch management has been a long-standing objective of turfgrass science. Excessive thatch negatively affects intensively managed turf and golf course superintendents have relied on hollow-tine core aeration to remove organic matter and renew infiltration characteristics of the root zone. New forms of venting like PlanetAir have gained popularity because of efficiency and minimal surface disruption.

This study was conducted from 2008 to 2009 at the Texas A&M Turfgrass Field Laboratory on a mature hybrid bermudagrass putting green that had not been cultivated for several years and contained a substantial organic layer. The green was maintained using agronomic best practices and treatment applications were made using the PlanetAir 50 Tow unit and other treatments for aeration with a Ryan Greensaire 24 walk aerator. Plots were irrigated following treatments and did not receive topdressing sand during the study. Turf quality and soil volumetric water content were measured throughout the growing season.

Results

- Neither venting nor core aeration alone effectively reduced thatch or organic matter in Tifdwarf, TifEagle or Mini-Verde on the study green.
- Frequent venting of a neglected golf green reduced turf quality and infiltration and increased upper-profile soil moisture.
- The best treatment appeared to be small-diameter solid-tine aeration at three- to four-week intervals.

Funded by

EIFG Environmental Institute for Golf

South Texas Chapter GCSAA Golf Course Superintendents Association of America

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Water Management

Photos by E. Miltner

Surface Water-Quality Monitoring on Golf Courses in the Pacific Northwest

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Objective

Evaluate the impacts of fertilizer and pesticide applications on surface water quality on a field-scale level at two Pacific Northwest golf courses.

Summary

Regulatory standards and public expectations increasingly demand protection of water quality from chemicals applied to golf courses. The perception exists that fertilizers and pesticides applied to golf courses are transported to surface water and/or ground water. Studies conducted on golf courses are needed to determine the fate of fertilizers and pesticides applied to golf courses.

Water samples were collected monthly over a two-year period at the entry and exit points of streams flowing through two western Washington golf courses. The water samples were analyzed for the presence of nutrients and pesticides. No treatments were imposed by the scientists; they monitored the potential water quality impacts of management practices employed on the golf course.

Results

- Concentrations of nitrate-nitrogen and orthophosphates were marginally but statistically lower in exit-point samples than in entry samples at one golf course, and there were no differences between entry points and exit samples for the second golf course.

- At each golf course, there was one instance in which a pesticide detected in the exit-point sample could be attributed to product application on the golf course. In one case, the concentration of the pesticide was 1,000,000 times lower that the LC^{50} for the most sensitive species, and in the other case, the concentration was more than 1,000 times lower.

- These results show that management practices typical of many Pacific Northwest golf courses pose little risk to water quality in course streams.

Funded by

EIFG Environmental Institute for Golf

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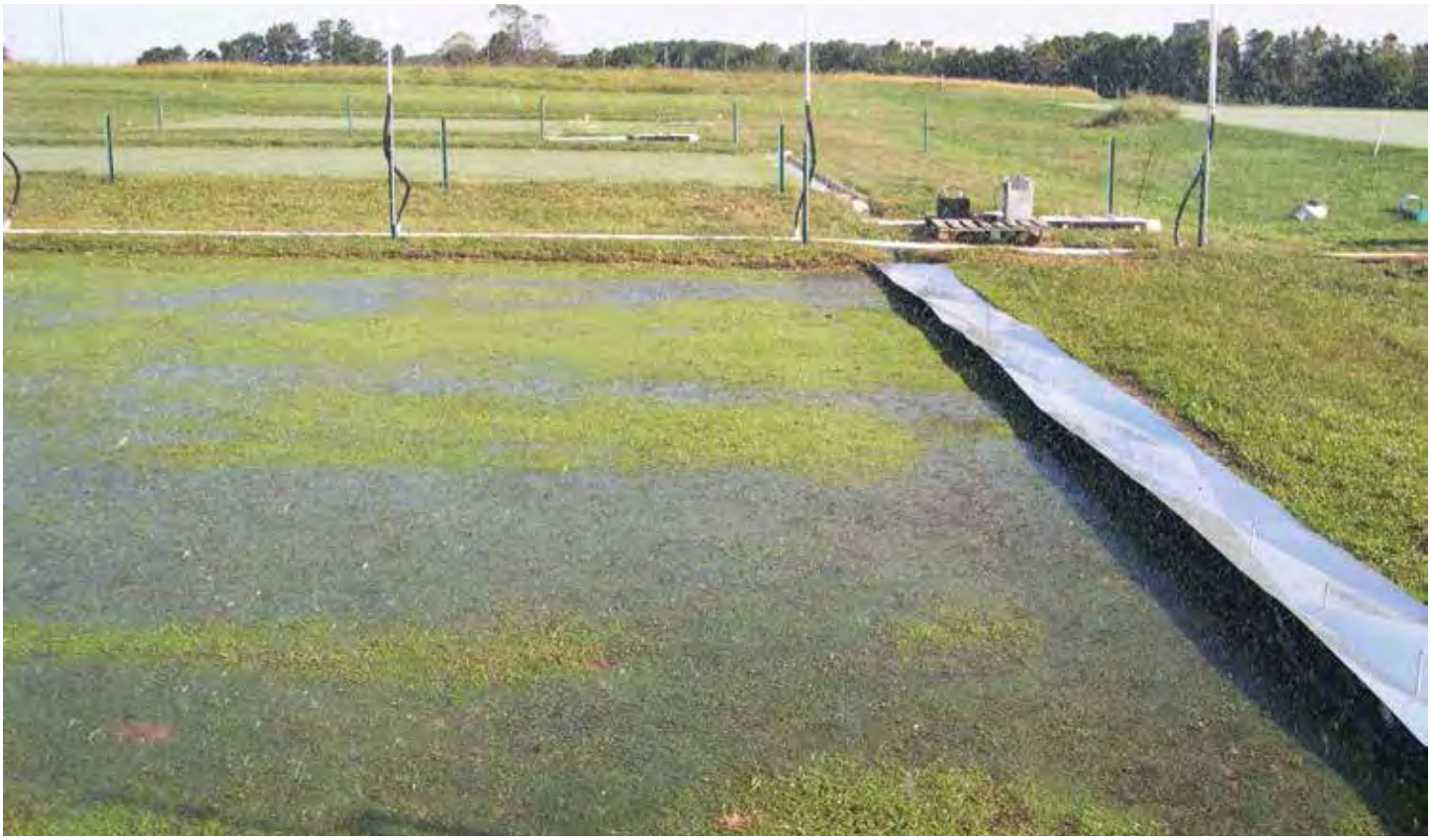

Photos by M. Carroll

Pesticide Runoff from Simulated Golf Turf

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Objective

Evaluate the effect of plot size on the runoff of pesticides from creeping bentgrass maintained as a fairway.

Summary

Pesticide runoff can be measured at small-plot, field or watershed scale of measurement. Demonstrating that plot size has little effect on runoff from turfgrass would aid in alleviating concern that model calibration based on small-plot data are inherently biased.

Runoff of a fungicide, herbicide and an insecticide was measured from small plots (12 x 30 feet) and large plots (40 x 120 feet). Approximately 24 hours after pesticide application, a simulated rainstorm was applied for the time needed to initiate runoff plus 90 additional minutes.

Results

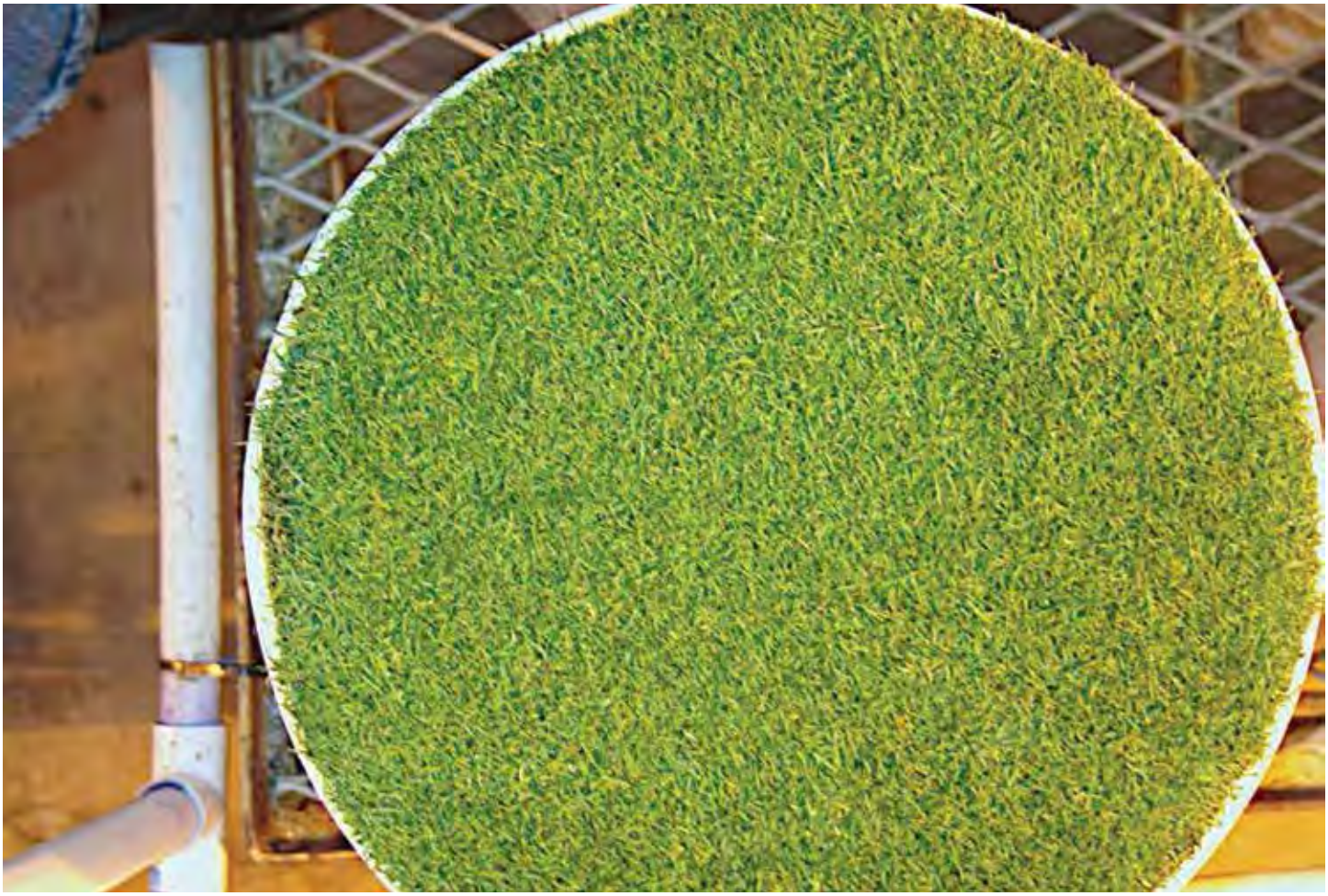
- Plot size had no effect on the runoff of foliar-applied pesticides when pesticide loss was evaluated on a per-unit-area basis.
- Total runoff losses of 2,4-D and flutolanil were similar to those reported by others.
- The relatively high pesticide runoff losses observed for these two pesticides one day after application demonstrates the importance of scheduling pesticides applications around weather conditions that favor storms that could generate runoff.
- The results of this project support the continued use of relatively small plot sizes (that is, on the order of several hundred square feet) to investigate pesticide runoff from turf.

Funded by

USGA

EIFG Environmental Institute for Golf

Published in GCM, November 2009, pages 70 - 80.



Removing Nitrate and Phosphate in Drain Tile Leachate

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Objective

Determine the efficacy of a combination of materials to selectively filter nitrate and phosphate from simulated putting greens in laboratory and greenhouse experiments.

Summary

Sand-based root zones are well suited for putting greens but have a low capacity for retaining nutrients and water. Frequent fertilization and irrigation are used during establishment to promote rapid turfgrass growth and development. This combination of factors, plus the tile drainage system beneath many putting greens, can lead to movement of nutrients into the surrounding watershed.

Nitrate and phosphate were the targets for removal from drain tile leachate, and since both are negatively charged, materials that trap anions were used in the filters. Creeping bentgrass was grown in a sand-based root zone in plastic containers in a greenhouse. The turfgrass was fertilized and watered to simulate a grow-in, and leachate was allowed to drain through the containers. Individual filters were attached to half the containers, and leachate was allowed to pass through the filter. All leachate, whether filtered or not, was analyzed for nitrate and phosphate content.

Results

- In greenhouse studies, the filter greatly reduced the amount of nitrate and phosphate in leachate from simulated greens.
- The level of nitrate-nitrogen in filtered leachate was well below contaminant levels established by the U.S. EPA.
- The level of phosphate-phosphorus in filtered leachate was reduced by 94% compared to unfiltered leachate but remained above contaminant levels established by the EPA.

Funded by

Virginia Chapter GCSAA Golf Course Superintendents Association of America

The Virginia Turfgrass Foundation

EIFG Environmental Institute for Golf

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Conserve Water Through Infrequent Irrigation of Bentgrass Fairways

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Objective

Determine irrigation frequencies that maintain high-quality creeping bentgrass, colonial bentgrass and velvet bentgrass fairways while reducing water use.

Summary

Turfgrass irrigation practices have gained increasing importance as communities place greater restrictions on water use. Determining the optimum irrigation frequency for creeping bentgrass, colonial bentgrass and velvet bentgrass fairways will provide a means to reduce water use without sacrificing turfgrass performance.

Research plots of creeping bentgrass, colonial bentgrass and velvet bentgrass were established under a rainout shelter and maintained as high-quality fairway turf. Turfgrass was watered with 100% ET replacement at four irrigation frequencies: four times per week; three times per week; twice per week; and every 14 days from June to September. Mini-lysimeters were used to determine daily ET rate and turfgrass quality was rated visually at regular intervals throughout the study.

Results

- Irrigating one to three times weekly based on 100% ET replacement produced turfgrass above the minimum acceptable visual quality rating (6.0). Irrigation at 14-day intervals produced unacceptable turfgrass quality.
- In 2005, turfgrass irrigated three times per week had a higher ET rate than turfgrass irrigated twice or once per week.
- It was necessary to irrigate two or three times per week during July and August to maintain acceptable turfgrass quality.

Funded by

O.J. Noer Research Foundation
Sustaining Turfgrass Research

EIFG Environmental Institute for Golf

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Quantitative Analysis of 20-Plus Years of Golf Course Monitoring Studies

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Objective

Evaluate golf course water-quality data and assess the impacts of golf courses on surface water and ground water quality.

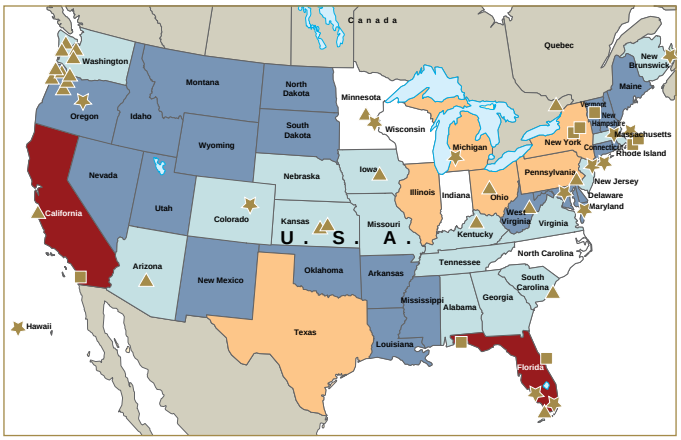
Summary

Comprehensive data and assessments of the impacts of golf courses on water quality are needed to address the concerns of government agencies and the general public. This type of information is invaluable when seeking environmental permits, in making state and national decisions on pesticide registration and analyzing the impact of golf courses on ecosystems.

Water-quality monitoring data from 80 golf courses, 78 in the U.S. and two in Canada, were included in this study. A total of 38,827 data entries from pesticide, pesticide metabolite, nitrate-nitrogen and total phosphorus analyses of surface water and ground water were evaluated.

Results

- Golf courses did not have widespread or repeated effects on water quality at the sites studied. Of the individual pesticide database entries, 0.15% exceeded toxicity reference points for ground water and 0.56% for surface water.
- The maximum contaminant level (MCL; 10 milligrams/liter) for nitrate-nitrogen was exceeded in 16 of the 1,683 (0.95%) ground water samples.
- Of 1,429 data entries, 1,236 (86.5%) were exceedances of total phosphorus ecoregional criteria in five ecoregions. Thus, phosphorus appears to present the greatest water-quality problem in these studies.



Funded by

USGA

EIFG Environmental Institute for Golf

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Deficit Irrigation of Seashore Paspalum and Bermudagrass

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Objective

Examine the performance of selected cultivars of seashore paspalum and hybrid bermudagrass to conditions of suboptimal irrigation and heat in the desert Southwest U.S.

Summary

In order to develop best management practices and guidance for practical irrigation regulations, more information is needed on the ability of hybrid bermudagrass and seashore paspalum to perform under optimal and sub-optimal irrigation desert conditions of Arizona, Nevada and Southern California. Four bermudagrass (*Cynodon dactylon* (L.) Pers. × Cynodon transvaalensis Davy) cultivars (Tifsport, Tifway 419, Tifgreen 328 and Midiron) and three seashore paspalum (*Paspalum vaginatum* Swartz) cultivars (SeaSpray, SeaDwarf and Sea Isle 1) were selected for the study. Each turfgrass received irrigation levels equivalent to 100, 80, 60 and 40 percent of a standardized reference evapotranspiration (ETos) in summer 2009 and 100, 80, 70, 60 and 40 percent of ETos in summer 2010. Bermudagrasses appeared better able to maintain higher turf quality and recovery potential at low irrigation levels. Seashore paspalum cultivars were less able to tolerate drought stress and declined more rapidly at the lower irrigation levels than bermudagrass.

Results

- High levels of winter precipitation did not appreciably improve the subsequent spring performance of turfgrass subjected to serve deficit irrigation regimes during the previous growing season.
- Irrigation treatment levels in the range of 70 to 80 percent of ETos, which equated to a total water application level of 75 to 83 percent of ETos, were required to maintain optimal quality turf for all cultivars during the summer growing season.
- Midiron bermudagrass exhibited the highest drought resistance among all cultivars and should be considered for turf systems developed in areas with limited water supplies.
- Relative to 100 percent ETos, spring green-up was delayed two weeks with 80 percent, four weeks with 70 percent and six weeks with 60 percent ETos.

Funded by

EIFG Environmental Institute for Golf

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Water-Use Efficiency in Golf: An Economic Analysis of Colorado Golf Courses

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Objective

To examine the economic impact and efficiency of water use and water conservation practices of golf courses in Colorado.

Summary

Golf and turf management sectors have received a great deal of negative press over the past decade for their resource use and perceived negative environmental impacts. The perception is that golf courses take up a great deal of land and habitat, pollute with turf chemicals and use an inordinate amount of water. Drought conditions and increasing population pressure in the western U.S. recently have led to greater regulatory and economic pressure on golf courses to use water efficiently. This study examined the water use and conservation practices on Colorado golf courses from 2000-2002, economic impact of golf courses, alternative uses of water, cost of water and water-use policy in Colorado.

Results

- This study indicates that golf courses in Colorado are engaged in water conservation techniques and they generate significant economic return per irrigated acre.
- Colorado's golf courses are minor users of water compared to the total water demand in the state.
- Compared to other uses such as crop production and residential lawns, golf courses generate more direct economic activity and use less water per acre.
- Water use in Colorado has been regulated by quotas and threats of restriction, but requiring all golf courses to pay more market-driven prices for water appears to be a more effective means of reducing water use on golf courses.
- In 2002, golf courses in Colorado adopted a variety of strategies to reduce water usage in response to the drought, and nearly every golf course surveyed in this study employed at least one water-conservation technique.
- The most popular water-reduction strategies were application of wetting agents (85%), the elimination of irrigation in selected areas (76%), reducing rough irrigation (74%), hand-watering tees (70%) and adjusting fertilization practices (71%).
- Using native grass in roughs and out-of-bounds areas is also an effective way for golf courses to reduce water use.

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EIFG Environmental Institute for Golf

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Wetting agent effects on root-zone moisture distribution

Doug Karcher, Ph.D., and
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University of Arkansas

Objective

Determine how commonly used wetting agents affect root-zone moisture distribution when applied to a sand-based putting green under wet, moderate and dry irrigation regimes.

Summary

Previous research has demonstrated that most commercially available wetting agents (applied to sand-based putting greens) are effective in reducing soil hydrophobicity and decreasing localized dry spot symptoms. However, many golf course superintendents are also concerned with how wetting agent application affects soil moisture distribution throughout the putting green root zone.

The experiment was conducted from June through August in 2008 and 2009 at the University of Arkansas Research and Extension Center in Fayetteville, Ark., on an L-93 creeping bentgrass (*Agrostis stolonifera*) putting green built according to USGA recommendations. Wetting agent treatments consisted of five commercially available wetting agent products plus an untreated control. Treatments were evaluated for localized dry spot incidence, visual turf quality and soil moisture characteristics.

Results

- The commonly used wetting agent products tested in this trial effectively reduced localized dry spot incidence and increased soil moisture uniformity over a wide range of depths (3 to 8 inches) compared to untreated turf.
- None of the wetting agents significantly increased soil moisture values during periods of frequent or moderate irrigation, but they significantly increased soil moisture uniformity across depths.
- The results suggest that these commonly used wetting agents can be used to manage localized dry spot without adversely affecting root-zone moisture distribution.

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