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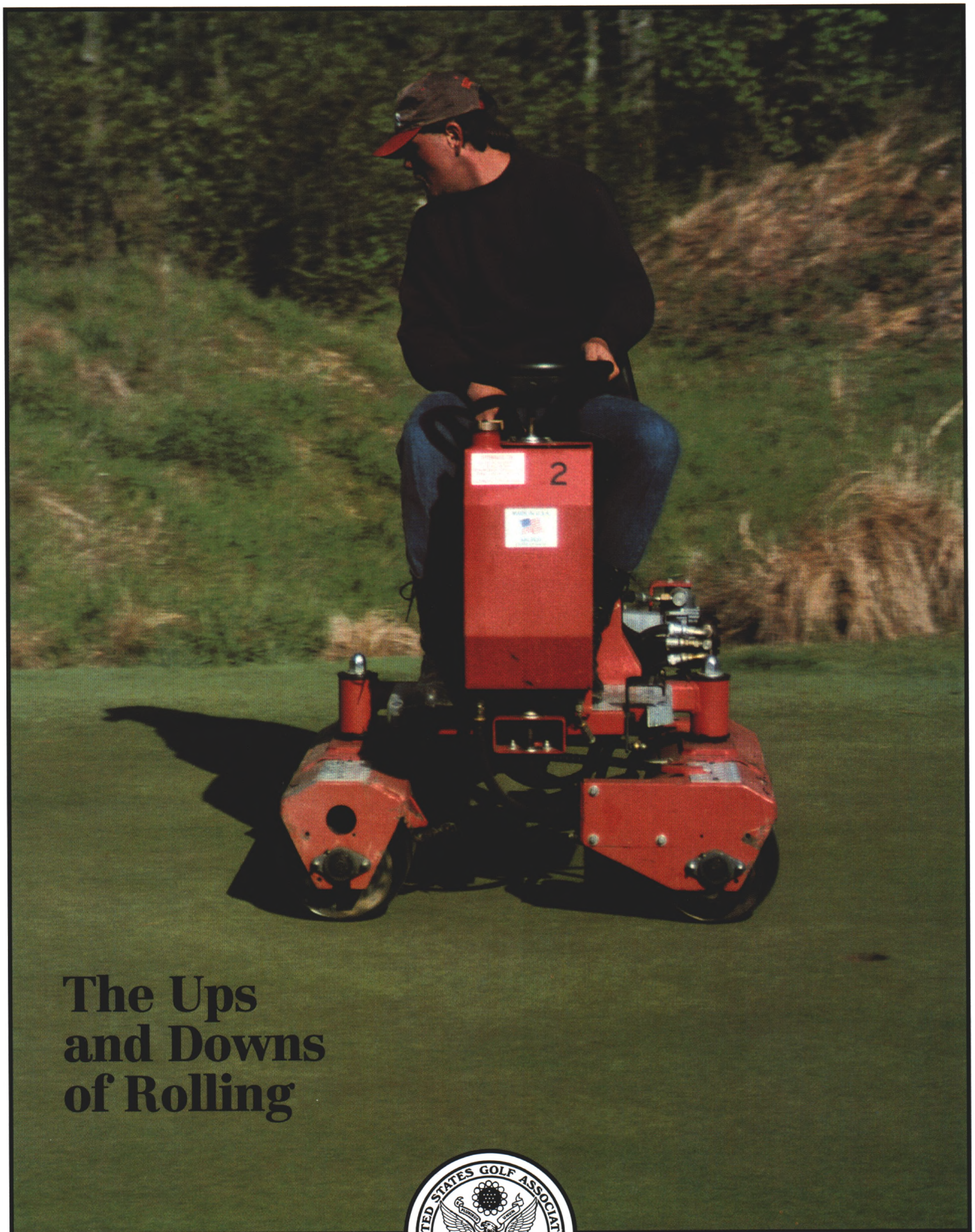

The Ups and Downs of Rolling

A PUBLICATION ON TURFGRASS MANAGEMENT BY THE UNITED STATES GOLF ASSOCIATION®

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Cover Photo: Rolling can improve green speed and smoothness.

USGA® GREEN SECTION Record

Oscillating fans are a popular new tool used in golf course maintenance programs. See page 9.

Weather stations located on the golf course provide valuable information that is used in irrigation programs. See page 18.

Rolling during golf tournaments is a common practice to maximize green speed and improve putting quality.

The Ups and Downs of Rolling Putting Greens

A practical guide for developing a rolling program.

by CHRIS HARTWIGER

HISTORY has an uncanny ability to repeat itself. Nowhere is this more apparent than in the turfgrass management practice of rolling putting greens. Once an important tool in a superintendent's management program in the early 1900s, the practice of rolling has endured periods of popularity and disdain. Nevertheless, rolling putting greens has received considerable attention during the early 1990s, and its merits are being debated at many golf courses.

The attitudes toward rolling vary widely today. Some golf course superintendents view rolling as a means of improving putting quality, while others believe rolling is just another stress that makes putting green management just that much more difficult. While the debate over rolling continues, a large portion of the golf course management industry is interested in revisiting this old maintenance practice and learning about its potential for use today.

This article will serve as a guide to developing an agronomically appropriate greens rolling program through careful consideration of several factors. To accomplish this, a brief history of rolling and the advantages and disadvantages associated with greens rolling will be reviewed. Next, research results on the effects of rolling putting greens will be presented in order to understand appropriate frequencies of rolling putting greens. Finally, the different types of rollers available today will be reviewed, and methods to compare different rollers will be offered.

Rolling History

Historically, superintendents used rolling as a supplement to mowing to improve the smoothness of putting greens. The mowing equipment, turfgrass varieties, and cultural practices for putting greens during the early 1900s were much less sophisticated than those available today, and the practice of rolling provided an immediate improvement in putting conditions. As golf course management evolved, the attitudes about rolling changed too. New bentgrass varieties and improved mowers allowed superintendents to make major improvements in putting quality. Also, turfgrass scientists discovered the negative effects of compaction on turfgrass growth and development. Needless to say, many rollers were relegated to the back corner of the equipment storage facility.

Several events have occurred during the last 20 to 30 years that have made superintendents reconsider the practice of rolling putting greens. The first is the proliferation of high-sand-content putting greens, which are less susceptible to compaction. Also, many equipment manufacturers have introduced new lightweight rollers designed specifically to provide an efficient and reliable means of rolling greens. A final consideration is the increasing pressure being placed on superintendents to provide faster and smoother putting surfaces.

Historically, golf course superintendents used rolling as a mowing supplement in turfgrass management programs.

Rolling Perceptions

With the renewed interest in rolling, is is important to understand the potential advantages and disadvantages associated with an appropriate putting green rolling program. Under reasonable mowing heights, rolling will increase green speed. Accompanying the benefit of green speed is an improvement in smoothness and uniformity. After rolling, improved smoothness is readily apparent, especially to golfers. Some superintendents roll greens in conjunction with mowing, while others roll as a substitute for mowing. This approach reduces the stress associated with mowing and can smooth spike marks, remove dew, and provide an immediate improvement in smoothness.

While golf's Scottish ancestors considered inconsistent greens a challenge, the demands of today's players dictate a consistent surface from the first green through the 18th green. Rolling all 18 greens can improve the uniformity and consistency of speed among greens.

Aerification is a practice that's essential for high-quality putting greens, but unfortunately golfers have a poor understanding of this practice. Some superintendents are using rolling as a way to minimize the surface disruption caused by aerification and improve post-aerification putting quality for golfers.

Equipment used to maintain turfgrass has limitations, and rollers are no different. Over the years, several areas of concern with rolling have arisen. Turf scientists have demonstrated that compaction hinders turfgrass growth, and some fear that rolling increases compaction. Along with this change, some believe that rolling may cause a decrease in the infiltration rate that could hinder oxygen and water availability to the roots. Also, there is a concern that rolling may result in wear injury or bruising of the turfgrass on the putting green.

Until recently, researchers had not investigated these concerns, and the result was a cautious approach to rolling by superintendents. For example, some use rollers prior to a tournament or special event and use it sparingly at other times. Two major forces are driving this conservative approach. The first is a lack of research on the effects of rolling. Additionally, superintendents do not want to raise golfers' expectations without knowing more about the negative effects of rolling.

The Effects of Rolling

If the practice of rolling is to find its place in the future of putting green management programs, several important issues need to be resolved. First, the practice of rolling appears to increase green speed, but both the immediate effects on green speed and the residual effects on green speed are not understood completely. Also, turf managers are aware of the negative effects associated with compaction, but no one has determined if the new lightweight rollers compact putting green soils. Finally, examples of rollers injuring turf through abrasion have been observed, but little is known about what conditions and frequencies of rolling can cause this injury.

In 1992, I identified these questions and initiated a research project at North Carolina State University under the guidance of Drs. Joe DiPaola, Charles Peacock, Leon Lucas, and Bill Cassel. The goal of this project was to evaluate the effects of lightweight rolling on green speed, compaction, and turf quality. This experiment was conducted on bentgrass greens constructed with a USGA specification rootzone and a native soil rootzone. The initial study was conducted for 10 weeks in the summer of 1993 and was repeated in the summer of 1994. Rolling frequencies on the bentgrass test plots were either 0, 1, 4, or 7 times per week.

Outlined below is a brief summary of the results of this research.

Green Speed — The experiments performed on green speed revealed two important points. First, green speed measurements taken one to two hours after rolling were 10 to 15 percent faster than an untreated area. Also, a residual effect was observed. Approximately 48 hours after rolling, the plots receiving the rolling treatment had green speeds approximately 2 to 4 percent faster than untreated plots.

Bulk Density — Bulk density measurements were used to assess the level of compaction of both the USGA and native soil rootzones. On the USGA specification green, no change in compaction was detected in either of the treatment years for any of the rolling frequencies. In essence, rolling as much as seven times per week for ten weeks did not produce a measurable change in bulk density.

On the native soil green, mixed results were observed. In the 1993 experiment, rolling frequencies of four or seven times per week produced an increase in bulk density. No change in bulk density was noted for the plots receiving zero or one rolling treatment per week. In the second year, no change in bulk density was detected regardless of rolling frequency.

Turf Quality — Results of the study indicated that, depending on the rolling frequency, turfgrass thinning and decreased turf quality can result from rolling. At a frequency of rolling one time per week, no decrease in turf quality was evident when compared to an untreated plot. However, rolling frequencies of four or seven times per week did result in turfgrass thinning after approximately three to four weeks of rolling treatments. When thinning did appear, it began in isolated areas and increased as treatments continued. Rolling four or seven times per week did reduce turf quality, but only if practiced for several consecutive weeks. Therefore, superintendents can roll at low frequencies for extended periods of time and at high frequencies for short durations.

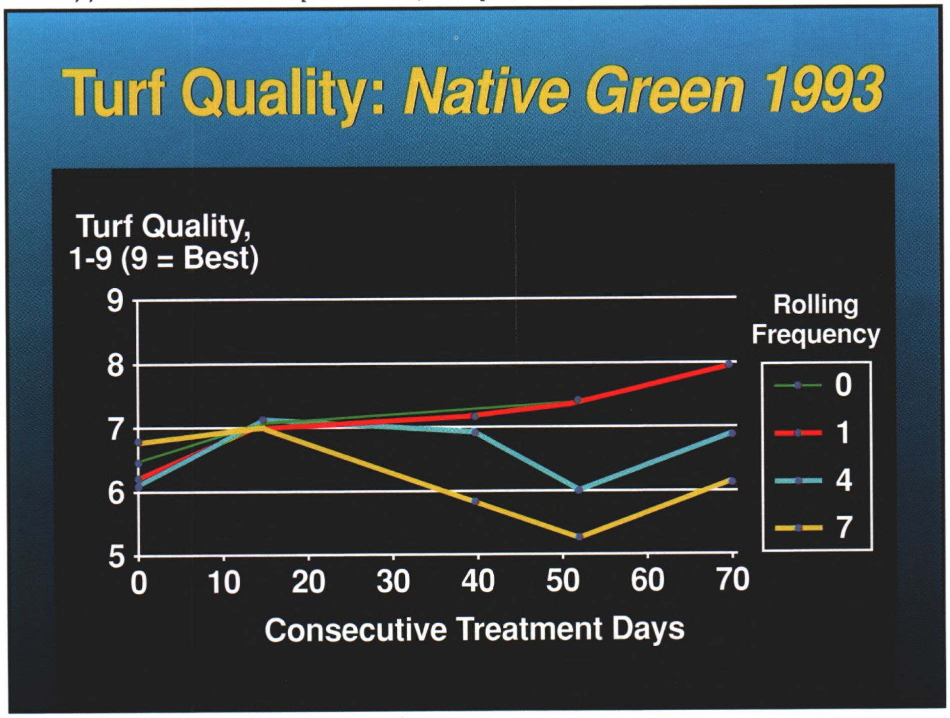
Types of Rollers

There are three primary types of rollers available for putting greens. The drum roller is the oldest type of roller in use today. Drum rollers have been used for many years and they vary in size, shape, and weight. Typically, these units were constructed by a creative golf course mechanic. During operation, drum rollers are pulled behind a utility vehicle.

The second type of roller is called a triplex attachment. These rollers are attachments substituted for the reels on a triplex mower. The actual operation of these units is virtually identical to mowing a green with a triplex mower. As a result, little operator training is needed for effective use. A difference between these units and the other two categories is that tires of the triplex, and not the rollers themselves, are the last part of the unit to impact the turf.

Dedicated lightweight rollers are the third category of roller available today. These units have been receiving the majority of the publicity surrounding the renewed interest in rolling. Designed only to roll putting greens, these models come in a variety of sizes, shapes, and weights. The major differences between various models of dedicated lightweight rollers are the number and size of actual rollers on the unit, the presence or absence of hydraulics, and the weight of the unit. A dedicated lightweight roller usually has two or three rollers underneath the unit. The presence of hydraulics, which is a source of concern to superintendents who worry about hydraulic leaks, is found on some of the models, while others have a belt-only drive system with no hydraulics.

Research at North Carolina State University demonstrated that rolling once a week did not decrease turf quality. Turf quality declined after rolling the turf four or seven times per week after a period of three to five weeks.



Comparing Rollers

Choosing the type of roller for your golf course is an important decision that involves several factors. The cost of the roller is a key consideration. Typically, drum rollers are least expensive, followed by triplex attachments and dedicated lightweight rollers. The need for operator training must be examined closely. Triplex attachment rollers require the least amount of operator skill, while dedicated lightweight rollers are the most difficult to operate. The terrain of the greens and surrounds can dictate the level of operator skill needed. The more undulations or steep slopes present, the greater the need for operator skill and the capability of a roller to handle these conditions.

The amount of force per unit area that a roller imparts on the green is another important consideration. Historically, measures such as pounds per square inch (PSI) or pounds per lateral inch (PLI) have been used to determine the force applied to a green by a piece of turf equipment. Unfortunately, both PSI and PLI are difficult to apply to rollers. PSI and PLI will be reviewed to understand their limitations, and a formula called the Roll Factor will be presented as a means to compare the compaction potential of different rollers.

In simple terms, PSI can be calculated by dividing the weight of the roller by the area of surface contact. Often, the technical specifications for the roller will contain the weight, but not the areas of surface contact. On a concrete floor, the surface area is easy to determine. Unfortunately, rollers are used on a putting green and not on concrete. When a roller is placed on a

Compaction potential of various roller units can be compared by calculating the roll factor, *which includes the unit weight, length of the rollers, and the diameter of the rollers in the equation.*

putting green, there is some amount of depression into the putting surface, which changes the area of contact. To complicate matters, the area of contact is not linear but circular, and the weight of the unit is not distributed equally at all surface points. The amount of depression into a green can vary with thatch levels, mowing height, soil moisture, rootzone construction, and other factors. As a result, PSI can be extremely variable and difficult to determine. In determining PSI, it is unlikely that each manufacturer has used the same assumptions, leaving the superintendent to try and compare apples to oranges.

Another popular method of comparing rollers is to measure pounds per lateral inch. The PLI equation is calculated by dividing the weight of a unit by the lateral inches of all the rollers on the unit. For example, a roller weighing 525 pounds with three rollers of 36 inches each would have the following PLI measurement: $525 \div (36 \times 3) = 8$ PLI. While this method is certainly easy to compute, it does not take into account the diameter of the rollers. Theoretically, two different models each could weigh 525 pounds with three rollers 36 inches long, but with different roller diameters. In theory, the model with the larger roller diameter would have a larger area of surface contact and would affect the turf differently. By not taking roller diameter into account, the PLI equation is limited and is not a good method to compare rollers.

Introducing the Roll Factor

While neither of the two methods above appears to be effective in comparing rollers, all hope should not be lost. There is a formula called the *roll factor* that can be used effectively to compare different pieces of turf equipment, including putting green rollers. As we have noted above, the important factors to consider when evaluating rollers are the weight of the unit, the length of the rollers, and the diameter of the rollers. The formula for the roll factor takes all of these factors into account as noted in the following formula: Roll Factor = Weight of Unit ÷ (Diameter of Rollers × Length of Rollers).

To illustrate how this formula works, consider the following example:

Specification	Roller A	Roller B
Roller Weight	525 lbs.	750 lbs.
Number of Rollers	3	3
Length of Rollers	36 in.	36 in.
Diameter of Rollers	5 in.	8 in.
Roll Factor Formula	$\frac{525}{5 \times (36 \times 3)}$	$\frac{750}{8 \times (36 \times 3)}$
Roll Factor Value	0.97	0.87

In the example, Roller B has a roll factor value of 0.87, while Roller A has a roll factor value of 0.97. Based on the higher roll factor value, Roller A has a greater potential for compaction than Roller B. Remember that the roll factor does not offer a measure of force per unit area, but is a method to rank the relative potential for compaction of two or more rollers. This formula is easy to use and all the information needed is readily available. By using the roll factor, a superintendent has an excellent means to compare rollers and other turf equipment used on the golf course.

The "Do's and Don'ts" of Rolling

Now that we have reviewed the effects of rolling on the putting surface, the types of rollers available, and a method to compare rollers, some final thoughts on developing a rolling program are in order.

Realize that a roller is a tool and not a quick fix or a substitute for a good agronomic program. As demonstrated through research, proper frequencies of rolling can improve the smoothness and speed of a green. Generally, low rates of rolling, such as once or twice a week during non-stress periods, can be practiced without detriment to the turf. Higher rates of rolling can be practiced for short durations only. When injury occurs, it is gradual and does not happen overnight. However, high frequencies of rolling, such as four or seven times per week for an extended period, may result in diminished turf quality.

Rolling does not always have to be used as a means to improve existing green speed. During the off-season, when clipping production is minimal, rolling greens is an excellent means to remove dew and provide a putting surface comparable to a freshly mowed green. Rolling also can be used after aerification as a way to minimize the surface disruption associated with this practice.

The education of golfers and course officials is essential to any rolling program. Spoiling golfers with continual rolling may help create a standard that no one can sustain. It is important to make a distinction between the proper and improper use of a roller. There are times when rolling can be practiced and time when rolling is not advised. The more these groups understand the principles of a proper rolling program, the more successful the superintendent will be.

It is not known whether the practice of rolling will continue to follow a roller coaster of popularity. What *is* known is that superintendents now have more information about the effects of rolling and a wider choice of rolling equipment. This information can be used to develop an agronomically appropriate greens rolling program that will benefit those who enjoy golf.

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WATER QUALITY MONITORING AT QUEENSTOWN HARBOR

The results of five years of groundwater monitoring on a golf course located in an environmentally sensitive area.

by FRANK WM. "BILL" SHIRK

Bill Shirk, CGCS, takes care of Queenstown Harbor Golf Links, which is located in a critical area, *defined as being within 1,000 feet of the Chesapeake Bay and its tributaries.*

THE CONSTRUCTION of new golf courses today requires that a maze of environmental regulations be addressed. In areas where the construction and maintenance of golf courses potentially could affect surface waters or groundwater resources, water quality monitoring often is required. Following is the story of the monitoring program at the Queenstown Harbor Golf Links.

The story of Queenstown Harbor starts at its location. The course is situated at the mouth of the Chester River and the Little Queenstown Creek, less than a mile from the Chesapeake Bay. As such, it is designated as being in a *Critical Area* of Maryland's tidewater region. A *Critical Area* can be defined as a site that is within 1,000 feet of the Chesapeake

TABLE 1
Nitrate-Nitrogen Sampling Results at Queenstown Harbor Golf Links (results in mg/l)

Date	B-1	B-2	B-4	B-6	B-7	B-8	B-9	B-10	B-12	B-13	B-14	B-15	B-16	All Wells Average
11/15/90	0.02	0.13	6.10	0.02	14.00	19.00	2.60	0.83	no sample	no sample				5.34
03/20/91	0.03	1.60	8.51	0.04	8.18	17.40	4.36	8.24	no sample	0.05				5.38
05/20/91	0.03	2.90	7.90	0.04	7.50	15.00	6.50	8.90	6.80	0.52				5.61
09/30/91	0.02	0.02	no sample	0.05	8.62	19.00	4.81	1.83	0.41	0.08				3.87
04/06/92	0.33	1.80	7.60	0.05	4.20	10.00	8.30	11.00	0.40	0.05				4.37
06/23/92	0.23	2.90	8.10	0.03	8.40	23.00	8.30	16.00	0.15	0.06				6.72
10/05/92	0.35	1.70	7.70	0.01	7.70	21.00	7.10	3.00	0.10	0.03				4.87
01/12/93	0.03	1.40	11.00	0.13	9.60	21.00	10.20	9.20	0.51	0.02				6.31
03/31/93	0.15	2.10	1.90	0.09	5.30	18.30	6.30	12.10	0.20	0.30				4.67
06/23/93	0.08	2.00	3.40	0.05	7.90	12.70	3.50	23.00	0.05	1.80				5.45
10/06/93	0.07	1.70	5.00	0.86	7.30	8.30	2.40	4.00	0.05	1.30				3.10
01/17/94	0.05	1.40	4.30	0.05	3.30	16.40	1.90	12.50	0.19	2.10	6.50	10.00	1.50	4.63
04/05/94	0.10	1.60	3.50	0.10	1.90	12.50	1.30	5.20	no sample	0.80	18.30	9.50	4.00	4.90
06/20/94	0.30	2.10	4.50	0.40	2.90	11.20	1.20	5.40	0.40	0.80	10.70	7.20	3.20	3.87
10/06/94	0.40	1.40	4.90	0.20	2.00	14.90	0.70	6.10	0.30	1.30	6.60	4.40	2.40	3.51
Average	0.15	1.65	6.03	0.14	6.59	15.98	4.63	8.49	0.80	0.66	10.53	7.78	2.78	4.84

Bay and its tributaries. The concern is that improper management of *Critical Area* sites could impact the overall quality of the Bay waters. Thus, there was great concern about the development of a golf course near the environmentally sensitive Chesapeake Bay.

The property was owned and operated as a working farm for 25 years by Washington Brick and Terra Cotta Company. Prior to breaking ground on the construction of a 27-hole, upscale, public golf course, the approval process consisted of 7½ years of permitting and 43 public hearings. These hearings seemed to be forums for change regarding environmental laws and, more specifically, the interpretation of how to define and best preserve a wetland. Eventually, the Critical Area Commission and the Washington Brick and Terra Cotta Company agreed to the installation of groundwater monitoring stations throughout the property.

Thirteen monitoring wells were installed using a drilling rig with hollow-stem augers in July 1990. Installing the wells prior to construction provided a basis for data comparison. Concentration data were collected on nitrates, phosphates, and other materials within the water supply prior to converting the land to a golf course.

Finally, Washington Brick and Terra Cotta Company broke ground for their project on August 1, 1990. The golf course lies on a 750-acre tract of land that had been used primarily as farmland. Hardwood forest, non-tidal wetlands, and tidal wetlands present on the site were incorporated into the course layout. The course was opened for play in July 1991. An additional nine holes were built in 1994 to complete Queenstown Harbor Golf Links as a 36-hole, upscale, public access golf course.

Environmental Monitoring

The monitoring sites were a critical aspect of the golf course development project, and their locations were carefully determined according to subsurface water flow. The quality of subsurface water that enters the Chesapeake Bay has been and continues to be a major concern to people who inhabit the areas around the Bay. More specifically, the potential for nutrient loading has been a high-priority issue of many environmental groups and governmental agencies in this region of the country. With the implementation of the monitoring program, valuable documentation about the effects of turfgrass management practices on the environment could be collected and analyzed. Needless to say, there were many questions and a great deal of apprehension regarding the conversion of agricultural land to a golf course facility.

Analysis of the groundwater samples is performed by Apogee Research Inc. (an independent lab) of Bethesda, Maryland, four times per year. Steve Roy is in charge of this project. Their reports are used to help me better manage and adjust our integrated pest management (IPM) program. For example, adjustments to fertilizer programs are facilitated by the monitoring results.

The agreement specified that the results of each sampling would be sent to the Critical Area Commission, Queen Anne's County Planning Department, Washington Brick and Terra Cotta Company, in addition to my office. The Critical Area Commission has received the monitoring data with the hope that it will help them decide about the future of golf course development in Critical Area zones of the Chesapeake Bay and its tributaries. For that matter, it is hoped that our experiences can help others in the development and proper management of a golf course in an environmentally sensitive area of the country.

On November 15, 1990, nine wells were tested for the first time. We now have nearly five years of data from the original monitoring wells. During construction, additional wells were installed. The first report and the last report will be highlighted in this discussion.

November 1990 Test Results

The Federal Drinking Water Purity Standard for nitrate-nitrogen is 10 mg/liter (10 ppm). Of the wells sampled, two samples (well B-7 and well B-8) revealed elevated nitrate levels of 14 mg/l and 19 mg/l, respectively, (see Table 1) on the first sampling date. These two wells are located at a groundwater discharge point to the Chester River and demonstrated the significant impact from the previous agricultural land use operations. Well B-4, located in what is now the practice fairway, exhibited a slightly higher nitrate level (6.1 mg/l) than the other monitoring wells. This specific area was also exposed to intense agricultural operations prior to conversion to golf course turf.

The average concentration of nitrate-nitrogen from the first sampling date for all the wells was 5.34 mg/l. Although average concentrations may not tell the complete story, the data provided a reference point. Well B-1 (.02 mg/l) represented what is considered to be background disturbance as water moves onto the site. Phosphorus levels for this well (.88 mg/l total phosphorus and 4.10 mg/l orthophosphate) were quite high. Again, these levels may be indicative of how agricultural land use can affect groundwater.

During the initial testing prior to any applications to the golf course, three wells (B-1, B-7, and B-10) showed contamination. The pesticides included: carbofuran (Furadan) and carbaryl (Sevin), commonly used agricultural insecticides; pendimethalin and atrazine, commonly used herbicides (pre-emergent); and the fungicides chlorothalonil and iprodione. All samples provided results below analytical detection levels. Nevertheless, trace activity was observed, which provided important reference data regarding the trends of

Wetlands and environmentally sensitive habitat areas are designated as protected areas throughout the entire golf course property.

Areas between the golf course and the Chesapeake Bay water were established as low-maintenance and naturalized buffer areas.

the water quality prior to and during construction, and after grassing the golf course (Table 2).

October 1994 Test Results

After nearly five years of testing, nitrate-nitrogen concentrations are the primary area of concern. Data collected on all other nutrients and pesticides have produced results that are classified as *analytically undetectable*. The fact that nutrient and pesticide concentrations in the groundwater supplies have dropped from their pre-golf course levels demonstrates that a well-managed golf course can protect and even enhance water quality compared to other common land uses. Groundwater samples continue to be analyzed for nitrate-nitrogen, primarily for two reasons:

1. to continue to monitor potential nutrient loading of the Chesapeake Bay, in particular nitrogen, and
2. to determine the usefulness of nitrate-nitrogen as an indicator of groundwater quality conditions and to study its movement.

The average nitrate-nitrogen concentration of all the wells has fallen since the testing program was implemented. The average concentration from all wells decreased from the 5.34 mg/l determined in November 1990. This decrease represents a 35% drop in the average nitrate concentrations within the water across all the wells. Despite minor fluctuations that have occurred over time, the phosphate levels continue to drop, and one well, B-8, has had elevated nitrate-nitrogen concentrations above the drinking water standard (Table 1). This well is located next to an active farm. We speculate that since the implementation of the well water testing program, corn, soybeans, and wheat crops have been grown and harvested from the adjacent parcel, perhaps contributing to the elevated nitrate levels.

Wells that had previously been above 10 mg/l (B-7, B-14, B-15) have shown steady improvement, all dropping below the water purity standard. The testing at well sites B-14, B-15, and B-16 began in 1994. The land was aggressively farmed until the fall of 1993. This area was developed into an additional nine golf holes, and we believe the test results for these wells will show a decline in the nitrate levels similar to the other monitoring sites.

In August 1995, members of the Maryland Senate Economic and Environmental Affairs Committee toured Queenstown Harbor Golf Links. The tour provided an opportunity to demonstrate the technology being used to manage our golf course turf. Important information was provided for legislators that will help them make future decisions about golf course issues. More importantly, the legislators learned that integrated pest management programs that contain best management practices can be used to operate a golf course located in a critical area in a responsible manner.

It took a lot of effort and expense to get us to this point. The staff at the Queenstown Harbor Golf Links believe our efforts have contributed to a better understanding that properly maintained turfgrass can have a positive impact on the environment. Golfers, non-golfers, and the area's wildlife are co-existing nicely with the Chesapeake Bay and its tributaries.

BILL SHIRK, CGCS, *is the golf course superintendent at Queenstown Harbor Golf Links, located in Queenstown, Maryland.*

TABLE 2
Queenstown Harbor Golf Links — Water Quality Laboratory Report (Sampling Date: 11/15/90)

Sample ID	Chemical (mg/l)	Nitrate Nitrogen	Ammonia Nitrogen	Kjeldahl Nitrogen	Phosphorus (total)	Orthophosphate Phosphorus	Carbofuran (ppb)	Carbaryl (ppb)	Prowl (ppb)	Chlorothalonil (ppb)	Iprodione (ppb)	Atrazine (ppb)
B-1		0.02	0.90	9.80	0.88	4.10	< 2.00	< 2.00	< 2.00	< 0.05	< 0.10	< 2.00
B-2		0.13	1.10	12.00	0.05	< 0.01						
B-4		6.10	0.20	18.00	0.24	< 0.01						
B-7		14.00	0.60	0.60	0.52	< 0.01	< 2.00	< 2.00	< 2.00	< 0.05	< 0.10	< 2.00
B-6		0.02	< 0.10	< 0.10	0.20	< 0.01						
B-8		19.00	< 0.10	9.10	0.05	< 0.01						
B-9		2.60	0.10	3.70	0.02	< 0.01						
B-10		0.83	< 0.10	1.80	0.02	< 0.01	< 2.00	< 2.00	< 2.00	< 0.05	< 0.10	< 2.00
LQC-1 (Little Queenstown Creek)		0.46										
CR-B-7 (Chester River)		0.39										

Feet:	Depth to Bottom	Tape to Water	Water level on Tape	Depth to Water	Top Casing	Water Level
B-1	17.00	7.00	1.09	5.91	17.28	11.37
B-2	16.50	11.50	0.99	10.51	21.41	10.90
B-4	16.00	13.00	0.94	12.06	20.30	8.24
B-6	14.00	12.20	1.54	10.66	19.90	9.24
B-7	16.00	9.00	1.38	7.62	8.69	1.07
B-8	20.00	14.50	0.95	13.55	19.94	6.39
B-9	20.00	10.50	0.45	10.05	21.53	11.48
B-10	22.00	16.00	0.96	15.04	24.31	9.27
B-12	16.50	11.00	0.58	10.42	22.85	12.43

Optimizing The Turfgrass Canopy Environment With Fans

Fans can help overcome poor growing environments.

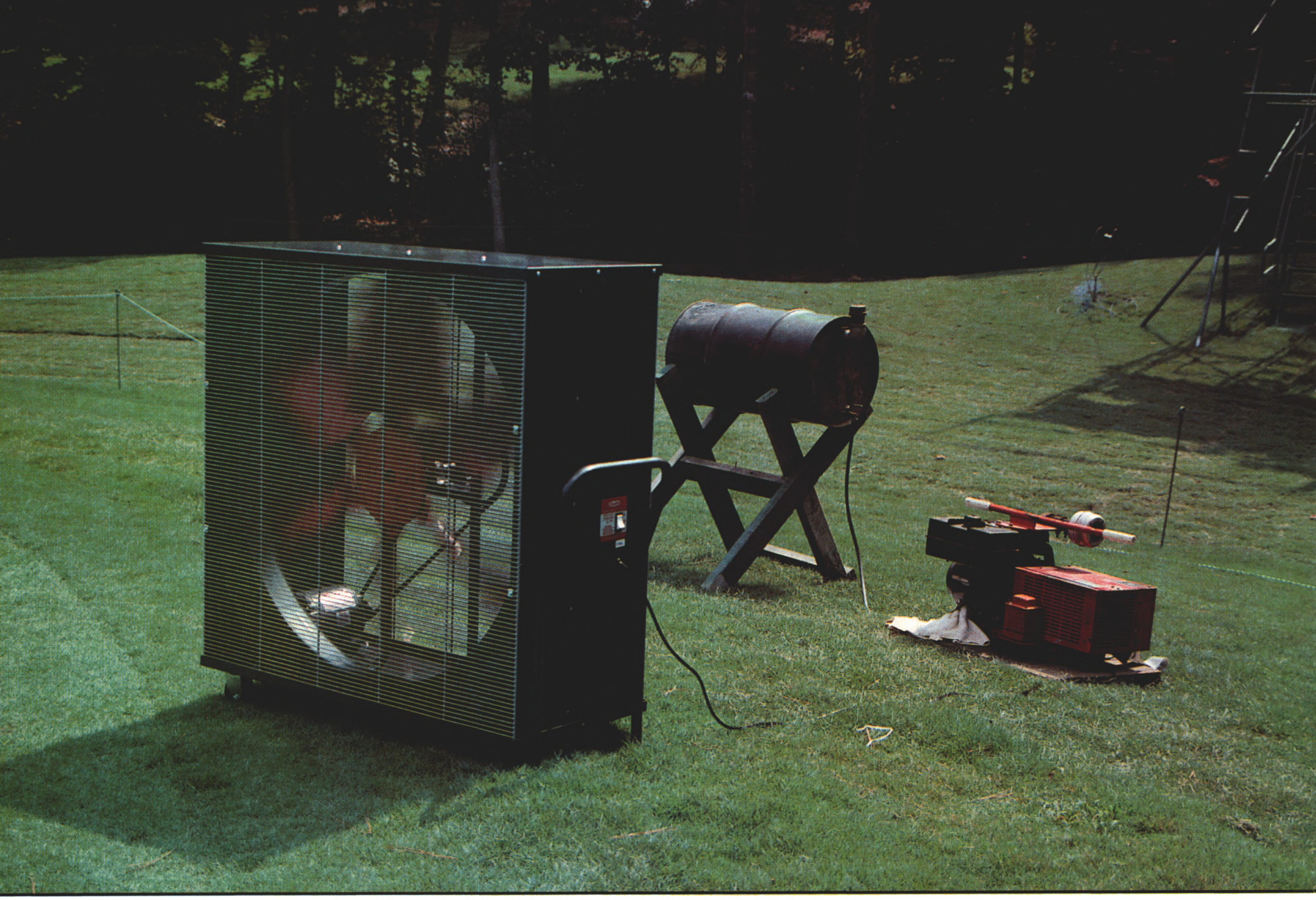
by PATRICK M. O'BRIEN

ALTHOUGH most people in the turf industry have seen electric or gas-powered fans used on the golf course, the rationale for their use often is misunderstood. As an agronomist for the USGA Green Section, I am frequently asked questions about the use of fans. To help those involved with this issue, a discussion of the benefits and liabilities of the use of fans is presented.

Affect on the Health of Bentgrass Putting Greens

Years of experience have shown that golf superintendents have the most trouble growing bentgrass or *Poa annua* greens during the summer at a site surrounded by trees or other barriers that allow almost no air movement. A USGA-type green provides a very effective base for growing putting green turf, but it cannot compensate for the lack of air circulation. In this environment, disease and higher rootzone moisture associated with these areas cause turfgrass plants to decline. Fans help improve air flow across greens, and the survival of bentgrass has been shown by Taylor to improve at sites with the increased air movement provided by fans.[1] The positive effects of fans drying out the soil and increasing evapotranspiration are the two major benefits influencing the bentgrass. Fans offer little cooling benefit to the turfgrass, which is contrary to most popular opinion.

Fans are sometimes mounted in trees instead of using poles.



Gas-powered fans can be used as a last resort in sites not located in close proximity to an electrical source, but they require intensive labor to operate.

Which Greens Need Fans?

Fans should be specifically used to help improve turf quality at problem green sites. By far the most popular use of fans is at *boxed* or *pocketed* sites surrounded by trees or other features that restrict air movement. In the past, these sites have been more prone to summer decline caused by disease, excess moisture, and surface algae. Green sites with wet rootzones also benefit from a fan program. Even small problem areas at *open* sites can benefit from the use of fans directed to the specific problem area.

Placement of the Fans

Most superintendents place two stationary fans at the 10 and 2 o'clock positions at the rear of the green, approximately 15 to 30 feet from the edge of the green. Fan height above the green surface normally is 10 feet or less with these stationary fans. Most fan companies sell poles that are usually seven feet tall, since OSHA requires finger guards on any fans positioned at lower heights. Finger guards can restrict air flow distance by up to 12%. Hand guards, which restrict air flow less than finger guards, are required for fans on poles taller than 7 feet. Trees are sometimes used instead of a poles, if available.

The key is to position the fan as close to a green and as low to the ground as possible to generate maximum air flow across the green surface. The main goal is to achieve a 3- to 4-mph wind speed over the turfgrass canopy. If fans are too far away or elevated too high, wind speed power will be lost by deflection off the grass itself, or by natural friction loss. A Turbometer, which costs about $120, is an effective instrument to help determine fan placement at each site. The Turbometer should be set on the green surface during measurements, and with the fans running, check various areas around the green for the 3- to 4-mph wind speed.

Another popular method to help determine fan location is the use of engineering flags. On a calm morning, place engineering flags over the green surface at 3- to 5-foot intervals with the flag height at approximately 3 inches above the ground. Clipping the metal pole on the engineering flags to a 3-inch length will speed this step. Turn the fans on and adjust the fan position until most of the flags are waving. Other superintendents check fan position by igniting smoke bombs at several sites on a green to detect air movement.

When to Operate

Golf superintendents need to pay attention to fan schedules, since each site may have different requirements. Fans usually run 24 hours per day at green sites that hold soil moisture and at pocketed areas. Running fans from early to mid morning to the early evening is advised at the small problem sites on certain greens. Other sites may require fan usage only during the early morning to mid morning when dew and surface moisture are greatest. In the Southeastern Region, surface moisture also can come out of the rootzone during the daylight hours, even at times of very high humidity. Fan use seldom will be required at open-air sites on sunny days with low humidity.

Fan Types

Nearly all fan types commonly seen have done a good job when positioned and run properly. Caged, oscillating, or turbo fans are the most common types observed. Oscillating fans are by far the most popular at golf courses. In the past, fan oscillating motors have caused problems, but today oscillating motors have improved power, similar to the other fan motors. Fan diameters can range from 22 to 48 inches. Because most fans are stationary to poles elevated above the greens, fan diameter size has been increasing with the demand for additional air movement from these products. Many fans now can throw a column of air more than 200 feet. With the improved power of many fans, some air movement can occur even at areas where the fan is not directed. Stationary fans do have the potential to dry the turf, since wind speeds can be much higher than 3 to 4 mph next to the fan. Extra irrigation may be needed for the turf in some situations when these fans are used.

Portable or *floating* fans are also popular, and most courses have at least two available. Most portable fans are the 48-inch cage types. A combination of both permanent and portable fans is a plus at some problem greens. Portable fans are used to treat special areas that require extra air circulation, such as a wet soil condition. Many superintendents move these floating fans to problem sites late in the evening and allow them to run all night. The fans can be positioned right next to the green during the night to provide an extra "blast" of air without affecting golfers. The portable fans can be repositioned and moved further away from the green the next morning, especially taking into consideration the hole location for that day. The additional air movement and mixing from this fan, especially when combined with the prevailing wind and the permanent fans, promotes faster drying. Portable fans can also be used at the maintenance building to help cool the mechanic's working area on hot days.

Tips on Installation

Setting up the electrical system for the fans on an existing golf course is very difficult, so a certified electrician should do all electrical work. Unfortunately, the electrical wire at the irrigation control boxes is too small for the high current requirements of electric fan motors, so alternative power supplies are needed. Usually, water coolers, irrigation pump houses, lift pumps, bathrooms, maintenance buildings, and clubhouses are sources of electrical power. Often, sites with fans are not close to any of these sources, and new meter service then is the only option. Gas generators are a last resort, with the inconvenience of refilling the generator with gas, transportation requirements, and the extra noise. New golf courses should initially install larger wire coming into the irrigation control boxes so that if electricity is required later for fans, the larger wire can handle the additional amperage for a fan motor.

Most fans used today have single-phase motors, although three-phase motors are preferred because of their higher power efficiency. Smaller wire

Extension cords and above-ground wiring should be avoided wherever possible.

can be used for three-phase motors, resulting in a lower initial installation cost. Many water coolers, irrigation and lift stations, and clubhouses have three-phase power for fans near these sites. Sometimes step-down transformers are needed, especially for the oscillating motor, which is always single-phase power, and luckily these transformers usually cost just $30.

All new electrical equipment and service must meet the local codes. Tables are available to calculate the wire size needed based on the distance from the power sources to the fan and the resistance loss in the wire. Direct burial cable wire (usually #4 or #6 cable) normally is pulled into the ground with a vibratory plow on a ditch-witch trencher with minimal disturbance to the surface, although occasionally small trenches are made to insert the wire. Wire depths vary according to the local codes, but most installations require an 18- to 24-inch depth. Wire is sometimes placed in a plastic conduit (depending on the local codes) under cart paths and service roads and across bridges for additional protection. Avoid the use of junction boxes whenever possible, as they could become sources of problems later.

At the green installation site, the wires, switches, timers, and plugs usually are placed in a sealed irrigation valve box with drainage. Avoid wiring the fan directly, as removing the fan later with this type of connection system is more difficult. Installing an extra plug to power a portable fan that may be needed later is always a plus, but a larger size wire will be needed initially to handle this extra power requirement. Timers also can be installed in the valve box to vary the operation of the fans. At The Honors Club, course superintendent David Stone has even connected his fans to the irrigation radio controllers. A switch to turn the fan off and on is another plus. It is always a good idea to install a ground fault interrupter at the plug to act as circuit breaker to enhance the safety of maintenance workers and golfers. Circuit breakers at the meter also help to avoid electrocution concerns. Afterwards, have an inspector check all electrical work to insure that all local codes are met.

Costs

Fans are used most during the months of May through September in the southern portion of the United States. Obviously, operation time will vary depending on the location of the golf course and the weather each summer. Most utility companies offer seasonal or full-time service for these meters. Flexible programs depending on the projected power consumption and usage are offered by many power companies, and consultants can detail your options. Most superintendents report typical electrical power costs for running two fans at a green site average between $75 and $100 per month.

The Turbometer is one tool that can be used to help determine fan locations around a green.

Fan Maintenance

Fans have required very little preventive maintenance so far on golf courses. Rust spots and scratches will occur over time just from being outside. A few fan distributors even offer annual maintenance services to wax and paint fans, but so far very few customers have taken advantage of this service. Most superintendents bring the fans inside the maintenance building or into a pole barn for the winter months. In any case, the structure must be tall enough so the fans can be stored in an erect position so moisture cannot enter the fan motor. Pole fans are easily disconnected by unscrewing the poles from their stands. The outside electrical components are protected by capping the plastic storage box. Some superintendents prefer to leave the fans at their permanent sites, especially if not enough storage space is available at the maintenance area. Heavy-duty fan covers that will not tear or blow away are now available from most distributors.

Noise

The auditory effects of fans are also a consideration. Most courses have home sites near some of their greens today, and some residents may be close enough to hear the fan motor noise. Educating your neighbors about the importance of the fans is essential for the superintendent. Letters sent to these homeowners each spring discussing the agronomic value and fan operational hours may help reduce complaints.

Effects on the Rules of Golf

Fans do have an impact on the Rules of Golf, depending on whether they are permanently or temporarily installed. Any time fans are installed in a permanent base, the golfer can assume the fan won't be moved. Permanently positioned fans are considered immovable obstructions according to the Rules of Golf. If the fan interferes with the lie of the golf ball or the swing or stance of the golfer, relief is provided under Rule 24-2. Sometimes the fan may be found between the golf ball and the hole location. Under this Rule, line-of-sight relief is not provided for with permanently installed fans, and the ball must be played as it lies.

Fans that have been set up on a temporary basis are treated as temporary immovable obstructions. Intervention on the golfer's line of play would warrant relief.

If a golf ball deflects off a fan, it is a *rub of the green* and the golfer plays the ball where it lies. If a fan deflects a golf ball out-of-bounds, the golf ball is still considered out-of-bounds.

Conclusion

Fans have made a major impact on many golf courses by helping the turf survive where it previously had died each summer. Many golfers also enjoy the additional comfort of a cool breeze while putting. However, sometimes fans are a nuisance to golfers because of the extra noise and their impact on the Rules of Golf. These negative factors must be weighed against the gain of improved health and playability of putting green turf.

[1]Gene Rupert Taylor II. 1995. The Effects of Mechanically Induced Air Movement on the Temperature, Water Potential and Soil Moisture Percentage of Creeping Bentgrass (*Agrostis stolinifera* L.) Golf Greens. MS Thesis, North Carolina University.

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Physiological Management of *Bipolaris sorokiniana* Leaf Spot Symptom Expression by Kentucky Bluegrass

A unique approach to disease management that involves suppression of visual symptoms.

by DR. CLINTON F. HODGES

BIPOLARIS SOROKINIANA infects grasses throughout the temperate regions of the world. Among the grass species used for turf, *B. sorokiniana* is best known for causing a leaf spot of Kentucky bluegrass (7, 24). It also can damage creeping bentgrass, perennial rye, and red fescue. In addition to causing leaf spot, *B. sorokiniana* can infect crowns, rhizomes, stolons, roots, and inflorescences of turfgrass plants.

The leaf spot disease caused by *B. sorokiniana* is often referred to as *spring leaf spot* in turf disease textbooks (24). Leaf spot is commonly observed in the spring, but damage to leaves can be more extensive in the fall, especially with wet, moderately cool, overcast conditions (19, 20, 21, 23). The spots produced on the leaves of Kentucky bluegrass are initially dark brown, to deep purple, to almost black in coloration. Spots occur individually or are scattered over the surface of infected leaf blades. As the individual spots enlarge, their centers typically become tan-colored and they often are surrounded by a chlorotic halo. If large numbers of spots occur on a single leaf, they often coalesce and cause rapid blighting of the leaf. Fewer spots on a leaf results in a progressive yellowing of the entire leaf blade. Yellowing of infected leaves occurs in the early spring, but it is the dominant symptom in fall and early winter.

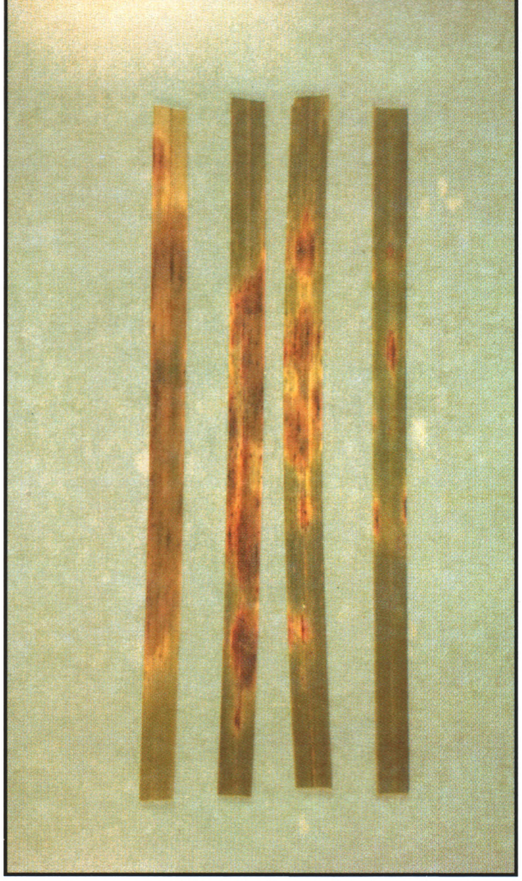
Control of leaf spot (and the other diseases caused by this pathogen) can be difficult. The resistance shown by Kentucky bluegrass cultivars is not very reliable and generally breaks down under cultural and environmental stresses (12, 23, 24). Several fungicides are effective against *B. sorokiniana* (24), but to be most effective they must be on or in the plants before infections are initiated. Once leaf spot has been initiated (and other organs of the plant also are infected), chemical control often is ineffective due to the inaccessibility of the fungicides to infected crowns, rhizomes, and roots (23). Hence, when Kentucky bluegrass is severely leaf-spotted, very large areas of turf become yellowed and the quality of the grass becomes aesthetically unacceptable. If the condition persists throughout the growing season, or from season to season, the turf will progressively thin and large areas can be completely lost.

Developmental Physiology of Leaf Spot

Control of leaf spot by means of cultural practices, host plant resistance, and fungicides is difficult and expensive under the best of circumstances. Because of the difficulty of controlling leaf spot and the prevalence of the disease in the north central states, studies on the developmental physiology of leaf spot of Kentucky bluegrass have been an ongoing part of the turf disease program at Iowa State University for a number of years. The ultimate purpose of this research has been to determine the physiology of disease development and to develop new approaches to the control and/or management of the disease.

The most damaging developmental characteristic of leaf spot is the yellowing of infected leaves that decreases the aesthetic value of the turf. Research conducted in our laboratory has shown that the yellowing of infected leaves is related to light, senescence processes, hormone action, and a phytotoxin produced by the pathogen. The yellowing of infected leaves can also be enhanced by postemergence herbicides.

Light and Senescence: The severity of yellowing by leaf-spot infected leaves typically increases with the aging of the individual leaves. This developmental characteristic of leaf spot is substantially influenced by photoperiod. As daylength increases from 10 to 14 hours, the size of the leaf spots and the yellowing of infected leaves decreases (18, 21). Infected leaves subjected to continuous dark for 96 hours will have up to 70% of the leaf tissue turn yellow; infected leaves subjected to continuous light show yellowing of only 9% of the leaf tissue. These observations explain in part why leaf spot becomes less severe from spring to summer as daylength increases. It also



Development of Bipolaris sorokiniana *on Kentucky bluegrass leaves results in yellowing 96 hours after inoculation.*

provides part of the evidence for why this disease is potentially more important in the fall (with progressively shorter daylengths) than in the spring.

Daylength also interacts with the natural senescence processes of leaves to further enhance yellowing of infected leaves. When progressively older infected leaves are subjected to a natural light spectrum with a daylength of 14 hours, there is little difference in the yellowing of leaves of different ages. When the infected leaves of different ages are subjected to 10- or 14-hour daylengths, yellowing of the two youngest leaves does not differ, but the two oldest infected leaves subjected to the 10-hour daylength show substantial yellowing (20). These responses imply an interaction between photoperiod and leaf senescence that influences severity of leaf spot development and subsequent yellowing of infected leaves. Long daylengths (14 hours or more) delay senescence and the yellowing of infected leaves. Short daylengths (10 hours or less) promote leaf senescence, especially among older leaves, and this condition is exploited by the pathogen to increase the severity of yellowing.

This light phenomenon is further illustrated by increasing the amount of far-red light in the light spectrum. Far-red light is known to promote senescence processes, and it will increase the severity of yellowing by infected leaves irrespective of daylength (20). The older leaves of the shoot that are beginning to senesce are especially sensitive to far-red light. As light passes through the upper, younger leaves of the shoot, the proportion of far-red light striking older undercover leaves increases and further enhances the yellowing associated with infected leaves. The effect of far-red light combined with the senescence-promoting effect of short daylength in the fall further predisposes infected leaves to accelerated yellowing.

Hormones: The interaction between photoperiod, light quality, and senescence implies that hormones are involved in the yellowing of infected leaves. The first evidence of this came from studies on the effect of postemergence herbicides on leaf spot development. Applications of 2,4-D, MCPP, or dicamba to Kentucky bluegrass were found to substantially increase the yellowing of leaf-spot-infected leaves (8). It was further observed that the herbicides increased the severity of yellowing on each older infected leaf (9, 10). These postemergence herbicides are auxin-type growth regulators. One of the side effects of auxin-type herbicides in perennial grasses and other plant species is that they elicit the production of the hormone ethylene by the plant, and the increase in ethylene can enhance the rate of senescence in mature tissues (1). This enhanced senescence caused by the herbicide-generated ethylene is exploited by the pathogen, and the yellowing of older infected leaves is further enhanced.

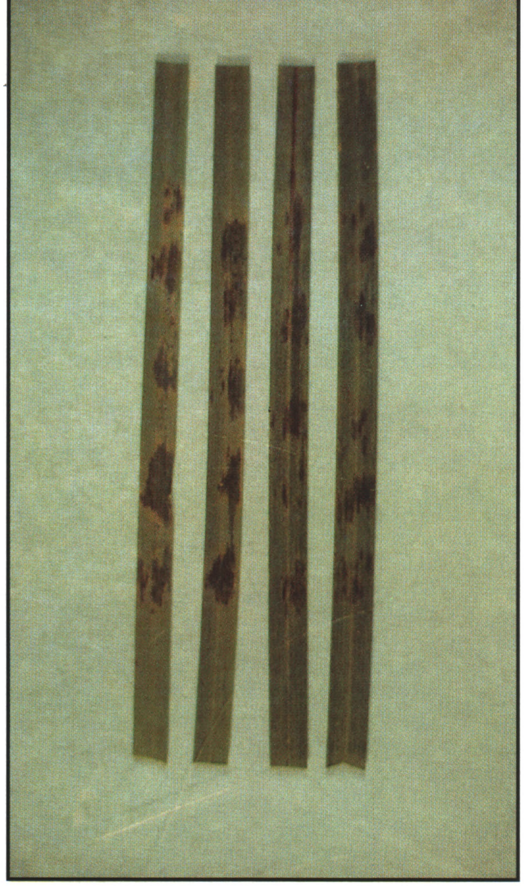
The potential involvement of ethylene in the yellowing of leaf-spot-infected leaves of Kentucky bluegrass provided the first critical information on the physiology of the disease that could be tested experimentally. During the infection of Kentucky bluegrass leaves by *B. sorokiniana*, studies revealed that substantial quantities of ethylene were produced in the leaves and that the increase in ethylene was correlated with the yellowing of infected leaves (15, 18). Natural levels of ethylene in leaves of Kentucky bluegrass range from about 250 to 350 ppb. The ethylene content of leaves infected by *B. sorokiniana* increases to 2,400 ppb or higher within 48 to 72 hours after infection and then progressively declines as the disease progresses. Visible yellowing of infected leaves can be seen within 24 hours of peak ethylene production. The severity of the yellowing increases on each older infected leaf, illustrating the link between the ethylene surge and leaf senescence (11).

Although a good cause-and-effect correlation was developed between the rise in ethylene and the subsequent yellowing of infected leaves, proof that the ethylene was responsible for the yellowing of infected leaves was still needed. Ethylene, as a plant hormone, is unique because it is a gaseous substance. This characteristic permits the ethylene to be evacuated from the leaf tissue during the infection process by placing the leaves of intact plants under a vacuum. When ethylene is evacuated from infected leaves, the leaf spots develop normally, but about 80% of the chlorophyll is retained by the infected leaves and they remain visibly green (15). In other studies in which plants were treated with norbornadiene (NBD), a substance known to block the mode of action of ethylene, infected leaves retained over 90% of their chlorophyll while the leaf spots developed normally (11). These studies clearly established ethylene as the primary cause of yellowing of leaf-spot-infected leaves.

Phytotoxins: When ethylene is evacuated from infected leaves, or its mode of action is interrupted by NBD, there is still a 10% to 20% loss of chlorophyll from the leaves. This loss seems to be associated with the chlorotic halo surrounding individual leaf spots on the leaves. Development of chlorotic halos is not prevented by the control of ethylene action. It is believed that the halos are the result of direct injury by a nonspecific phytotoxin (helminthosporal or prehelminthosporol) produced by *B. sorokiniana* during the infection process (4, 25, 26). The phytotoxin functions by disruption of cell membranes.

The Potential for Management of Symptom Expression

The establishment of ethylene as a primary cause of yellowing of leaf-spot-infected leaves provided an opportunity to develop a new approach to the management of this disease. The traditional approaches to disease control are development of plant resistance and/or prevention of infection by means of fungicides. Both approaches have substantial limitations for the control of



Leaves treated with canaline (CAN) to prevent the biosynthesis of ethylene by the plant during infection affects the development of Bipolaris sorokiniana.

diseases induced by *B. sorokiniana*. However, with increasing knowledge of the physiology of leaf spot development, it may be possible to prevent the yellowing of infected leaves without preventing infection. If the yellowing of leaf-spot-infected leaves could be prevented, the presence of small leaf spots would be of little consequence to the aesthetic value of the turf, and the diseased leaves would be periodically mowed off. Development of a system for management of symptom expression (specifically the yellowing of infected leaves) could provide a new approach to leaf spot management that could compliment, or replace, present systems that rely solely on prevention of infection.

There are two possible approaches to how management of symptom expression by leaf-spot-infected leaves might be accomplished. One approach involves the chemical inhibition of ethylene biosynthesis, or its mode of action, during the infection of the leaves. The second approach involves the regulation of ethylene biosynthesis during infection by means of genetic modification of the plant. To understand the work we have conducted to date on these approaches, it is necessary to return to ethylene and its biosynthesis during the infection process.

Potential for Chemical Management of Symptom Expression

Studies were initiated in 1991 to determine if ethylene biosynthesis could be reduced or prevented in leaves infected by *B. sorokiniana*, and thereby prevent a substantial portion of the yellowing of infected leaves. The ethylene generated during infection is produced primarily by the host plant in response to the infection (22), with relatively small amounts coming from the pathogen (5, 6). The biosynthesis of ethylene in infected leaves is as follows: methionine (Met) ➛ *S*-adenosyl-L-methionine (AdoMet) ➛ 1-aminocyclopropane-1-carboxylic acid (ACC) ➛ ethylene (27). The conversion of AdoMet to ACC is mediated by the enzyme ACC synthase (2). This enzyme can be inhibited by a number of compounds that prevent the biosynthesis of ethylene (3, 17), but prior to our studies, none of the substances had been evaluated for their ability to prevent ethylene biosynthesis in a host-pathogen interaction.

Our initial studies evaluated two known enzyme inhibitors (aminooxy)-acetic acid (AOA) and canaline (CAN) by applying them to the soil in which Kentucky bluegrass plants were growing (13). Infection of leaves on treated and nontreated plants did not differ, but infected leaves of nontreated plants produced 1,476 ppb ethylene within 48 hours. The leaves of plants treated with AOA or CAN produced 700 and 950 ppb of ethylene in response to infection, respectively. The infected leaves of AOA-treated plants retained 80% of their chlorophyll and the CAN-treated plants 74%. These values represent substantial increases in chlorophyll retention (and prevention of yellowing) compared to the 43% chlorophyll retention in the nontreated, infected leaves.

More recent studies with CAN applied directly to the leaves of Kentucky bluegrass held the ethylene surge to about 850 ppb without interfering with infection, and the infected leaves retained 90% of their chlorophyll (14). A 90% retention of chlorophyll during disease development keeps the infected leaves green with only the brown lesions present. These studies demonstrated that the yellowing of leaf-spotted leaves could be physiologically managed without preventing infection and leaf-spot development on the leaves.

Several questions still remain unanswered relative to management of the yellowing of leaf-spotted leaves. It is still unclear as to how effective chemical treatments will be on senescing leaves. Studies are in progress to determine the ability of CAN (and other substances) to slow or prevent yellowing on the oldest infected leaves of the shoot. Also, the compounds worked with to date (CAN, AOA) would not be effective for field use because of toxicological problems, but other substances and treatment techniques are still under study. Development of a practical field control technology is not out of the realm of possibility. Overall, the control of yellowing of leaf-spot-infected leaves with CAN and AOA has been effective and suggests that physiological management of the yellowing symptom is possible.

Management of ethylene biosynthesis might also have some unforeseen benefits in addition to controlling the yellowing of leaf-spotted leaves. Since ethylene is a known promoter of senescence, reducing the levels of ethylene in the plant might prolong the life of aging leaves. By slowing the aging of leaves, the yellowing of infected leaves might be further reduced and infection by secondary pathogens and saprophytes also decreased. Controlling symptom expression, as opposed to infection, might also slow the natural selection processes of the pathogen. If the pathogen is permitted to infect and develop normally, the need for it to change genetically in order to overcome a fungicide or plant resistance would be greatly diminished.

Potential for Genetic Management of Symptom Expression

Blockage of ethylene biosynthesis by means of exogenous application of chemical inhibitors to leaf-spot-infected leaves of Kentucky bluegrass can substantially decrease the yellowing of infected leaves. Continued research on this approach could result in a practical chemical treatment for control of symptom expression; however, development of a safe chemical treatment system could be a long process. A nonchemical solution to the control of symptom expression would be environmentally more acceptable and is within the realm of possibility.

Discovery of the gene for the enzyme ACC deaminase (16), which regulates the availability of ACC for ethylene biosynthesis, may provide the most expedient approach to genetic control of ethylene biosynthesis by infected leaves. The enzyme degrades ACC and prevents it from forming ethylene. The by-products of ACC degradation are metabolized to amino acids commonly found in higher plants. The ACC deaminase gene has been introduced into tomatoes, where it effectively decreases ethylene biosynthesis, but the gene has not been established in a perennial grass.

Research is in progress to determine whether the deaminase gene can be established in Kentucky bluegrass. The process of establishing the gene in Kentucky bluegrass first necessitates establishing cells of the plant in callus culture. This process has been achieved and whole plants have been successfully regenerated from the callus. It now remains to be determined if the ACC deaminase gene, which originates from a *Pseudomonas* bacterium, can be established in the Kentucky bluegrass callus, and if the gene will be incorporated into the cells of plants regenerated from the callus cells. Lastly, if the gene is incorporated into the regenerated plants, will it control the ethylene surge during infection and decrease the yellowing of the leaves?

The outlook for sucessfully establishing the ACC deaminase gene in Kentucky bluegrass is guardedly optimistic. It has been determined that like infected leaves, Kentucky bluegrass callus cultures inoculated with *B. sorokiniana* generate ethylene. If the gene can be incorporated into the callus cells, a callus bioassay system could be developed for determining the effectiveness of the gene for controlling ethylene prior to regenerating whole plants. Work is presently in progress for introducing the ACC deaminase gene into Kentucky bluegrass callus. A DNA vector is being constructed that will include the ACC deaminase gene, and the vector will be attached to another gene that is specific for expression in grasses. The vector will then be introduced to the callus cells by means of a particle gun.

The research conducted over many years on the physiology of leaf spot symptom expression by Kentucky bluegrass has provided information that will be effectively used in development of new disease management strategies. The knowledge gained relative to photoperiod, light quality, hormones, phytotoxins, and postemergence herbicides has provided the foundation for exploration of radically different approaches to the management of *B. sorokiniana* leaf spot (and perhaps some other leaf-infecting pathogens). Prevention of ethylene biosynthesis and yellowing of Kentucky bluegrass leaves in response to infection by *B. sorokiniana* by means of chemical treatment or genetic alteration is feasible. Whether this approach succeeds or fails, the knowledge gained on how the symptoms are produced has opened the door to an unlimited number of possibilities that will ultimately alter how we approach the management of many turfgrass diseases.

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HAND WATERING GREENS

There is a correct way.

by PAT GROSS

Hand watering greens may seem easy, but improper technique may actually cause more harm than good.

SUMMER IS HERE, and there is nothing an overheated maintenance staff member would rather do than hand water greens on a hot afternoon. After all, it's an easy job — grab a hose, hook it up to a quick coupler, and soak the grass. Right? Think again. That employee may be doing more harm than good if he or she is not familiar with the proper way to hand water greens.

A 1992 survey of the Green Section staff indicated that over-irrigation of greens was one of the top 10 maintenance pitfalls. Over-watering contributes to disease development and inconsistent playing conditions. Even the best-designed irrigation system cannot produce a green with perfectly uniform moisture content throughout. Occasional hand watering is necessary, therefore, to compensate for localized dry spots or to cool the turfgrass canopy, and to maintain consistent playing conditions.

A couple of basic tools are necessary to do the job right — a soil probe and a hose-end nozzle that applies water in a gentle showering fashion. If regular soil probes cannot be purchased, effective probes can be made by cutting down a broken golf club shaft and cutting out a view port using a bench grinder. Staff members should be trained to check the greens with the soil probe to determine soil moisture levels before applying any water. Many disease and insect problems display symptoms similar to localized dry spots. Watering these areas will often make the situation worse. If the turf is wilting and adequate moisture is present, staff members should report this condition to the superintendent immediately.

Hand watering the wrong way can do as much damage to the playing surface as no watering at all. Puddles on the surface of the green can promote the development of pythium or a condition known as "wet wilt." If the soil is dry, water should be applied gradually, in a showering manner, so that puddling or runoff is avoided. The goal should be to match the water application rate with the infiltration rate of the soil. It may take several minutes and several light applications of water to wet the soil. For hydrophobic areas, spiking the area first can improve water penetration. Spot applications of wetting agents also have been successful in treating localized dry spots; however, don't overuse these products to compensate for excessive thatch accumulation, compaction, or poor irrigation system coverage. In many cases, an aerifier will do a better job than a barrel of wetting agent.

Putting surfaces may wilt during the summer due to high temperatures, high winds, and hours of intense sunlight. In these cases, syringing the greens with a light application of water can help revive the plant. The idea is to reduce the moisture stress of the leaf tissue and allow the plant to continue a balanced transpiration rate. Syringing is a very misunderstood operation. It is important to remember that you are only trying to sustain the grass plant with a very light application of water, not wet the soil.

Hand watering greens should not be forgotten on weekends. A superintendent's worst nightmare is to return from a well-deserved weekend off only to find the greens scorched due to lack of water. (Actually, this is only one of several nightmares that superintendents have!) It is a good idea to schedule one or two people to come in on Saturday and Sunday afternoon to check the greens and hand water as necessary.

As a final note, check into the reason for the localized dry spots. These areas could be the result of poor sprinkler head coverage, worn nozzles, tree root encroachment, compaction, or excessive thatch accumulation. Be sure to treat the cause and not just the symptoms.

PAT GROSS *is an agronomist in the USGA Green Section's Western Region.*

THIRSTY TURF

A short course in water conservation.

by RON DODSON

IT'S A beautiful spring morning. Water cascades across green fairways and putting greens. To some, this is a beautiful sight indicative of the best efforts to ensure an enjoyable game of golf on the very best-kept turf. To other observers, it is the most visible evidence of environmental irresponsibility — spraying water over roughly 100 in-play acres on every golf course all across the country so that a few people can chase a little white ball. They consider it a waste of a critical natural resource that is needed for drinking, growing food, and providing one of the most basic elements of life on this planet.

Of all the environmental issues facing golf, water is very near the top of the list in most places around the country because *it is* a basic requirement of life. Every living thing — plants, humans, wildlife — needs its fair share in order to survive. Even though water often is considered a *renewable* resource, its use on golf courses is viewed by many as unnecessary and wasteful.

The fact of the matter is that many of us do waste water. How many times have you seen sprinkler systems running while it's raining? How about irrigation systems shooting water onto roadways, cart paths, or into water features? To people who are concerned about golf and its effect on the environment, these sights send cold chills down the spine. This apparent disregard for the responsible use of water clearly does not project a positive image for golf, but nonetheless, I see these and other equally wasteful practices frequently. On the other hand, I have also seen many golf courses that use water very efficiently and also use

By using part-circle *heads around lake banks, only turf areas are watered. Irrigating only in-play areas of the golf course and not water features or naturalized areas can greatly reduce water use at a course.*

Establishing native vegetation in out-of-play areas conserves water and reduces pesticide use.

recycled water. These courses serve as buffers against other types of land use activities that might negatively impact the quality of water. So what can you do? How can a golf course demonstrate its commitment to responsible water use and establish a more active role in water conservation efforts?

From a golf course perspective, using water effectively and efficiently can be approached from two angles: **Plant Selection and Management** and **Building Infrastructure**.

Plant Selection and Management

It should be obvious to anyone that the game of golf is played on living plants. From an environmental perspective it is extremely important that appropriate plants be chosen and then planted in the correct locations. To minimize water use, it's important for golf course land managers to judiciously integrate low-water-use native vegetation — ground covers, grasses, and other plants — into the landscape. The challenge for the land manager is how to strike a balance between playing the game in a reasonable amount of time and not losing an unreasonable number of golf balls in tall grasses, roughs, and other non-play areas. The best approach is to target and carefully assess specific areas for naturalizing, and work slowly over a period of time to integrate native vegetation where it is most natural.

Also think about high-stress areas — steep slopes where golfers have a tendency to walk all of the time and wear out the turf, and areas where people tend to drive golf carts over and over again. These activities wear out the turf, calling for re-establishment and increased water use. Proper plant selection and traffic control play critical roles in managing these high-stress areas.

Selecting the appropriate type of turfgrass for the ecological region in which the course is located is also a critical decision. If you attempt to grow a warm-season grass in a cool-season zone or grow any kind of turfgrass in an area that really wants to be a forest floor, you will have to create an artificial environment that will require all kinds of work, and yes, extra water. When in doubt, the USGA's Turf Advisory Service is a great resource for help in selecting low-maintenance, disease-resistant turfgrasses that ultimately will require less water to maintain.

Once you've started to naturalize the course and have selected the most appropriate turfgrasses for the ecological region, it's time to really focus on the irrigation system. It should be putting water where you need it, when you need it, and in the amount and rate that the targeted plants require. No more, no less. Check to make sure your irrigation system is really focusing on watering only those limited areas that really require watering. Remember, too, that irrigation is one of the most visible activities to the surrounding community. Be careful not to reinforce their perception that golf courses waste extraordinary amounts of water.

Building Infrastructure

Water can also be efficiently utilized around and inside the buildings associated with the course. Around the buildings, use appropriate, native landscaping materials that not only benefit butterflies and hummingbirds, but require less water to maintain than some of the showy, heat-intolerant selections. Set an example for your members by installing low-flow toilets and water-restricter shower and sink heads in the clubhouse and the maintenance facility. Let your members know that you've made a commitment to the environment by using water responsibly.

Do yourself, the environment, and the game of golf a favor by doing your own simple water conservation audit. It's not that hard and it doesn't take that much time. Find out how much water you're using and how much you're paying for it now. Then, look around the course, do a tour of your buildings, and see if you can find ways of reducing water use without impacting the business or the game. After a year goes by, check your water bills again and compare them. Many courses have done this and are amazed at the savings. Finally, don't forget to publicize your good efforts — the financial savings, the maintenance savings, the human resource savings, and most important of all, the benefit to the environment!

In the Spotlight

Olde Florida Club: A Fully Certified Audubon Cooperative Sanctuary. A private course located in Naples, Florida, the Olde Florida Club has worked hard to conserve water both on and off the course. A state-of-the-art irrigation system is just the beginning. As Darren Davis, superintendent of the Olde Florida Club, states, the irrigation system is "only pieces of hardware that can be seen from the surface. Also important are the design, proper placement, and maintenance of components under the surface." Focusing on proper pipe sizes and irrigation heads is critical to an efficient irrigation system. The irrigation pipes at the Olde Florida Club are laid in a loop system that allows all areas of the course to be watered from two directions, furthering irrigation efficiency and turf health.

At Olde Florida, the irrigation system is hooked into a weather station that provides temperature, humidity, wind speed and direction, and solar radiation, which are used to calculate evapotranspiration (ET) rates. Golf Link, a satellite/computer Doppler Weather Radar System, is also used to determine when storms will be in the area, with an accuracy of plus or minus 15 minutes. Watering at less than 100% of the ET rate further maintains turf health and reduces water used at the course.

Other measures that have been used to help reduce water use include converting some areas of bermudagrass to the more drought-tolerant cordgrass, using compressed air at the wash pit to lessen water used during the cleaning of equipment, installing water-saving toilets, not irrigating native areas or water features, and using mulch and native plants for landscaping.

Allowing natural vegetation, including tall grasses, shrubs, and trees to flourish in out-of-play areas along the number four fairway of Egypt Valley's Ridge Course reduces the amount of turf that needs to be irrigated.

Egypt Valley Country Club: A Fully Certified Audubon Cooperative Sanctuary. Located in Ada, Michigan, Egypt Valley Country Club has done an incredible job of conserving water, with a yearly reduction of about nine million gallons. By keeping careful watch over course watering needs using weather data, a soil probe, and turf color, the different areas of the course are only watered on an as-needed basis. Water is further conserved by the use of drought-tolerant turf species and watering at less than 100% the ET rate. Jeffrey Holmes, Egypt Valley's superintendent, and Craig Hoffman, the assistant superintendent, have also reduced irrigated turf by naturalizing areas, using mulch produced on-site around landscaping, hand watering during high-evaporation periods, and irrigating at night when evaporation is at its lowest.

Village Links of Glen Ellyn: A Fully Certified Audubon Cooperative Sanctuary. This public course provides a wonderful example of an integrated water conservation plan. Located in Glen Ellyn, Illinois, this 235-acre course has successfully demonstrated a 32% reduction in water use. One factor in this reduction is the extensive naturalizing that has been done at the course. Fairway coverage was reduced from 62 to 42 acres, and more than 40 acres of the course were restored to native grassland and prairie habitat. Timothy Kelly, Village Links of Glen Ellyn's superintendent, and Chris Pekarek, assistant superintendent, have been maintaining water usage and rainfall records since 1977. The golf course itself is a designated flood detention area, and storm water runoff collected in course ponds is often used for irrigation. A system of valves allows transfer of water between ponds. Recently they adjusted the lake overflow structure to reduce well use and increase the use of recaptured and recycled water. In addition, testing sprinklers and repairing them in a timely manner, prioritizing water areas and hand watering during drought, and mulching and using drip irrigation in landscaped areas have all contributed to the Village Links of Glen Ellyn's successful water conservation program.

RON DODSON *is president of Audubon International, based in Selkirk, N.Y. He directs environmental activities for golf courses, schools, corporate properties, and homeowners' backyards.*

LABORATORY ACCREDITATION PROGRAM ANNOUNCED FOR PUTTING GREEN MATERIALS TESTING

In cooperation with the USGA, the American Association for Laboratory Accreditation (A2LA) has formulated a program for accrediting laboratories that test putting green materials. This initiative will provide a service to golf by maintaining a list of dependable laboratories available for analyzing components specified in the *USGA Recommendations for Putting Green Construction.*

A2LA, headquartered in Gaithersburg, Maryland, is a nonprofit, nongovernmental, public service, membership organization organized primarily for the purpose of formally recognizing the competence of testing laboratories that meet stringent international criteria and have been found competent to perform specific tests or types of tests. It has accredited over 800 laboratories in fields as varied as biology, chemistry, construction materials, geotechnical, environmental, mechanical, and thermal testing.

"We are pleased to work with the United States Golf Association in the development of a program specifically to support the competence of testing in the putting green materials industry," Roxanne Robinson, vice president of A2LA, said.

One of the major objectives of this program is to provide golf course superintendents, officials, architects, builders, and suppliers who need putting green testing services with a list of physical soil testing laboratories whose competence is regularly evaluated and documented.

The accreditation process applicable to the special putting green laboratory accreditation program was designed to meet the requirements of the USGA and of golf courses that build greens to USGA recommendations. It requires meeting general and specific criteria. In order to be accredited in this program, a testing laboratory must be competent to perform, at a minimum, the following tests:

1. Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants;

2. Particle-Size Analysis of Soil;

3. Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils;

4. Standard Test Method for Saturated Hydraulic Conductivity, Water Retention, Porosity, Particle Density and Bulk Density of Putting Green and Sports Turf Root Zones;

5. Standard Test Method for Particle-Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Root Zone Mixes;

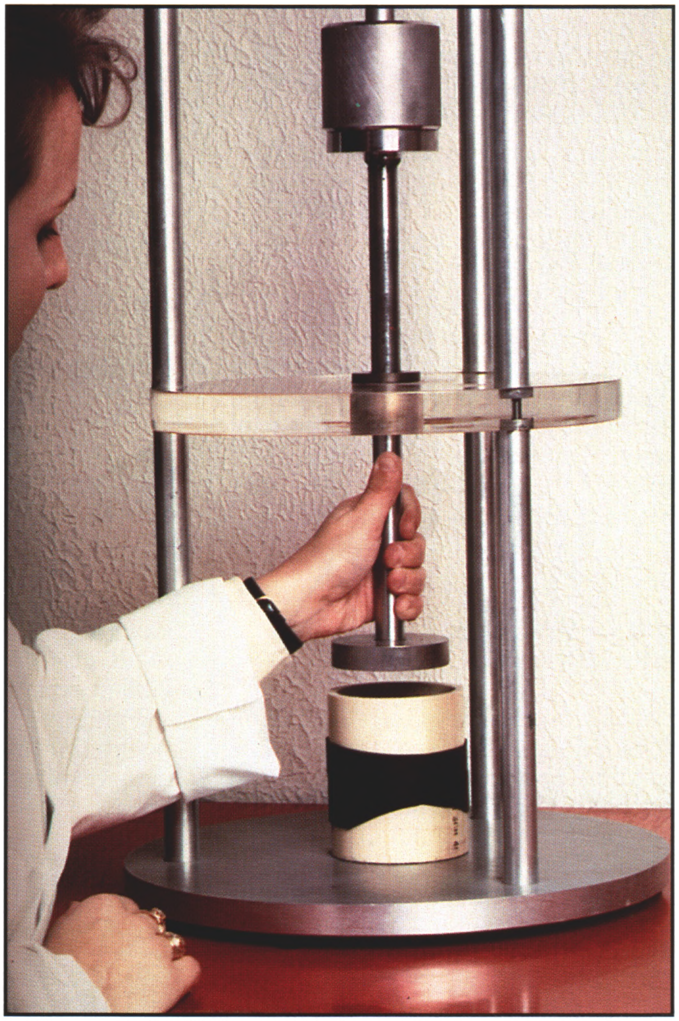
6. Standard Test Method for Organic Matter Content of Putting Green and Sports Turf Root Zone Mixes.

Additional turf tests can be added to a laboratory's scope as desired.

Laboratories seeking accreditation must allocate approximately $4,000 every two years, which includes a three-day, on-site inspection and review. This on-site review is conducted by one of several A2LA assessors chosen on the basis of their testing or calibration expertise. Currently, the members of this assessment team include three retired professors: Dr. Don Waddington from Pennsylvania State University, Dr. Bill Dest from the University of Connecticut, and Dr. Coleman Ward from Auburn University. Each laboratory's accreditation lasts for two years, at which time they must undergo reexamination.

Another requirement of accreditation is participation in the Western States Proficiency Testing Program conducted by Dr. Robert O. Miller of the University of California at Davis and Dr. Janice Kotuby-Amacher of Utah State University. It will involve a quarterly exchange of golf-green soil materials on which each laboratory performs physical analysis. Each laboratory will receive a quarterly report reviewing its work, plus notification of all values exceeding the program warning limits. Annually, each laboratory and the USGA will receive a report of the entire program with individual performance scores.

The *Green Section Record* regularly will publish a list of laboratories accredited by A2LA. This list will also appear on the USGA's Internet site. Only laboratories that have passed this rigorous testing process will appear, and the USGA recommends that only A2LA-accredited laboratories be used to test materials for building greens according to USGA recommendations. At this time, two laboratories have



A2LA-accredited laboratories have met rigorous competency standards for testing materials used in the construction of USGA greens.

passed muster with A2LA. These facilities are:

Brookside Laboratories, Inc.
308 S. Main Street
New Knoxville, OH 45871
Attn: Mark A. Flock
(419) 753-2448
FAX (419) 753-2949

Thomas Turf Services, Inc.
1501 FM 2818, Suite 302
College Station, TX 77840-5247
Attn: Bob Yzaguirre/Jim Thomas
(409) 764-2050
FAX (409) 764-2152

Questions about the accreditation process should be directed to The American Association for Laboratory Accreditation, 656 Quince Orchard Road, Gaithersburg, MD 20878; (301) 670-1377 or FAX (301) 869-1495. Attn: Roxanne Robinson or Ron Bell.

WILDLIFE LINKS GRANTS ANNOUNCED

The United States Golf Association (USGA) has awarded three grants totaling approximately $100,000 to initiate Wildlife Links, golf's first comprehensive program to investigate its relationship with wildlife and its habitat. The program is coordinated by the National Fish and Wildlife Foundation (NFWF), based in Washington, D.C.

The Colorado Bird Observatory, headquartered in Brighton, Colo., received the first grant. It will be used to create a manual that will provide golf course architects and superintendents with practical information about how to enhance golf course habitat for bird species. The working title of the publication is *Golf Courses and Bird Conservation: A Management Manual*, and it will appear next spring.

Donald F. Harker and Gary W. Libby, environmental researchers located in Frankfort, Ky., were awarded a grant to underwrite production of a publication with the tentative title *Wetlands Management Manual for Golf Courses* that is expected to appear in early 1997. This illustrated booklet will contain narrative, drawings, case studies, and key restoration techniques to help golf course superintendents understand wetlands and create programs to create, conserve, and manage them.

The final grant has been given to Audubon International, headquartered in Selkirk, N.Y. It will be used to help computerize Audubon International's substantial database of statistical information about golf courses that it has gathered through its involvement over the past six years in managing the Audubon Cooperative Sanctuary Program for Golf Courses.

Complete information about each of these grants may be obtained by contacting either Dr. Peter Stangel, NFWF, 1120 Connecticut Avenue N.W., Suite 900, Washington, DC, (202) 857-5676; or Dr. Kimberly Erusha or Marty Parkes of the USGA Green Section, P.O. Box 708, Far Hills, NJ 07931, (908) 234-2300.

PINE NEEDLES NOW A SAFE HARBOR

"This program is not about regulations. It's about partnerships. It's not about mandates. It's about incentives; architects, developers, golfers, and wildlife experts working together."

With these words, U.S. Secretary of the Interior Bruce Babbitt summarized an agreement, known as the Safe Harbor Program, signed by the U.S. Fish & Wildlife Service and the Pine Needles Lodge & Golf Club during the recent U.S. Women's Open held at the facility. This initiative, officially known as the Sandhills Conservation Plan, guarantees that private landowners such as golf courses will not be subject to restrictions under the Endangered Species Act after they succeed in attracting threatened species to their land and later decide to convert the property to alternative uses.

The federally endangered species in question in the Sandhills of North Carolina, where Pine Needles is located, is a bird called the Red-Cockaded Woodpecker (RCW). This seven-inch-long bird excavates nesting cavities in live pine trees usually more than a century old. RCWs thrive in a golf-course environment because they prefer the open pines often found on golf courses throughout the area compared to dense forests with significant underbrush. More than a dozen of the approximately 40 golf courses in the Pinehurst area have enrolled to date, with the Pinehurst Resort leading the way by enrolling last year (*Green Section Record*, July/August 1995). In

U.S. Secretary of the Interior Bruce Babbitt (far right) confers with Mark Cantrell of the U.S. Fish and Wildlife Service about the Safe Harbor Program operating in the Pinehurst region.

Secretary Babbitt with USGA President Judy Bell during the signing ceremony at the 1996 U.S. Women's Open.

excess of 20,000 acres of privately owned land, much of it golf-course acreage, now fall under the Safe Harbor Program.

"What I'd like to do is talk about two of my favorite subjects, woodpeckers and golfers, and the very happy conjunction of the two and the partnership that is now emerging between the owners and managers of golf courses and the surrounding natural values of the land," Babbitt said during the signing ceremony.

"Golf courses, at their best, are very closely designed and related to the natural environment and the landscape. And indeed the extraordinary draw of the golf course is a function both of its challenge to the player and the way that it reveals and relates to the landscape," Babbitt continued. "And what we have found here in the Sandhills of North Carolina means that good golf courses are also excellent woodpecker habitat. It ought to be possible to design and operate golf courses in a way that actually enhances wildlife values. That's an important lesson that I think every person who's interested in the game of golf can take all over this United States of America is that the presence of golf courses can actually increase the amount of wildlife."

ENVIRONMENTAL PRINCIPLES ADOPTED

Consider this scenario: Delegates from various entities throughout the nation meet periodically in extended discussions, attempting to forge a compromise among seemingly disparate interests and goals. These gatherings extend over 12 months and involve countless written revisions. Finally, a document is endorsed that articulates the much-thought-out principles.

The reference in this case is not the Continental Congress and its activities leading to ratification of the Declaration of Independence. Instead, it represents more recent activities of a myriad of golf and environmental interests, and an innovative document called *Environmental Principles for Golf Courses in the United States*. Unveiled during the second Golf and The Environment Conference, held in Pinehurst, N.C., in mid-March, it offers a framework under which environmental excellence is stressed in all aspects of golf course planning and siting, design, construction, maintenance, and facility operations.

The principles are envisioned as a tool for national use while keeping in mind that any assessment of the environmental compatibility of an individual course site is a decision that must be made by local communities. The principles are voluntary and are not intended for use in making judgments about socio-economic issues. They assume that regulatory compliance has been achieved and are designed to provide opportunities for those involved in the golf industry to go beyond minimum standards required by law.

The document appears in its entirety on the USGA's Internet site on the World Wide Web at http://www.usga.-org. Copies may also be obtained through the USGA Green Section at (908) 234-2300.

USGA RESEARCH SUMMARIES AVAILABLE

The 1995 Turfgrass and Environmental Research Summary is now available from the USGA.

The Turfgrass and Environmental Research Program, sponsored by the USGA, has three primary goals: develop turfgrasses for golf courses that substantially reduce water use, pesticide applications, and maintenance costs; develop management practices for new and established turfs that protect the environment while providing quality playing surfaces for the game of golf; and encourage young scientists to become leaders in turfgrass research. The accomplishments of the 41 current research projects funded through the USGA Turfgrass and Environmental Research Program are summarized in the 1995 research summary.

Also included in the document is a list of the ten research projects to be conducted on the construction and maintenance of greens. The goal of this research is to identify the best combinations of construction, grow-in procedures, and post-construction maintenance practices that prevent long-term problems, reduce environmental impacts, and produce high-quality playing surfaces. Beginning in 1996, this is a five-year research effort.

The 84-page research summary is available free of charge by leaving your postal mailing address on the USGA Internet site (http://www.usga.org), contacting Mary Jane Kymer at the USGA Green Section (908-234-2300), or by writing to the USGA Green Section, P.O. Box 708, Far Hills, NJ 07931. In the near future, the entire research summary will be available on the USGA Internet site.

SENSIBLE CHOICES

Making better choices of new bentgrass varieties.

by PAUL VERMEULEN

UNTIL THE EARLY 1990s, "Penncross" was the leading choice for seeding new greens in all but the bermudagrass regions. The choice was an easy one in those days, because there were no other varieties of equal quality. Today, there are 28 bentgrass varieties under review in the National Turfgrass Evaluation Program (NTEP), and the list grows longer each year.

How can someone evaluate his own circumstances and make a sensible choice when there are so many new varieties to choose from? Complicating matters further is the burgeoning desire to improve long-term stand performance by blending two or more varieties. This practice is based on the survival-of-the-fittest premise and is well established in the Kentucky bluegrass and perennial ryegrass markets.

Some people rely on testimonials from fellow turf managers or information published in popular trade journals to make varietal choices. Others remain loyal to their favorite breeder and plant only varieties developed by that individual. Although these selection methods can be used successfully in some cases, their reliance on subjective information is a cause for concern.

Let's evaluate the reliability of testimonials from fellow turf managers. This approach to selecting a variety simply tells you that someone else is satisfied with the choice they have made. But because a fellow turf manager is satisfied with a particular variety does not mean it is the best choice for your course.

Likewise, shopping for a creeping bentgrass variety from a single breeder can have serious drawbacks. The performance of a variety at a breeder's home base may or may not have a bearing on how well it will perform in another location under different climatic conditions or management practices. If a breeder uses germplasm without genetic tolerance to a specific pathogen or environmental extreme that is common in your region, their varieties may not perform as well as others that are available.

When selecting two or more varieties for a blend, it is important to consider several factors. Simply choosing something old, something new, something heat tolerant and something disease resistant based only on the survival-of-the-fittest premise is somewhat ludicrous. The best candidates for blending are those with similar NTEP rankings for overall quality, color, texture, spring greenup, and spring, summer, and fall density. If the components of a blend are not physically similar, their separation over time will erode the visual quality of a putting green. If compatible, blends should also include varieties that have disease resistance or stress tolerances that are pertinent to the course's location and environmental circumstances.

The most sensible method of choosing between varieties or blends is one that few courses employ because of either cost or inconvenience. Given the luxury of time, the performance characteristics for each variety/blend should be reviewed in on-site evaluation plots maintained using standard maintenance practices. An ideal location for the plots, albeit a possible inconvenience to a few players, is on the practice putting green. In this location the plots can be cared for using maintenance practices similar to those employed on the course, and the plots can be subjected to the wear and tear of pedestrian traffic. Also, to ensure that the evaluation is not tainted by the effects of traffic patterns, partial shading, inconsistent soil type, etc., the plots should be replicated and spaced randomly throughout the putting surface. The USGA, GCSAA, and NTEP will be establishing bentgrass trials on golf course practice greens at 15 locations throughout the country in 1997.

Choosing the best variety or blend for greens located in all corners of the globe requires sorting through the growing list of choices using sensible selection criteria and methods. If your course has time to plan ahead, there is no excuse for not evaluating potential varieties/blends using the establishment of evaluation plots located on the practice green or nursery.

One information source to ease the daunting task of selecting a variety for a new putting green can be found at on-site evaluation plots maintained with standard maintenance practices.

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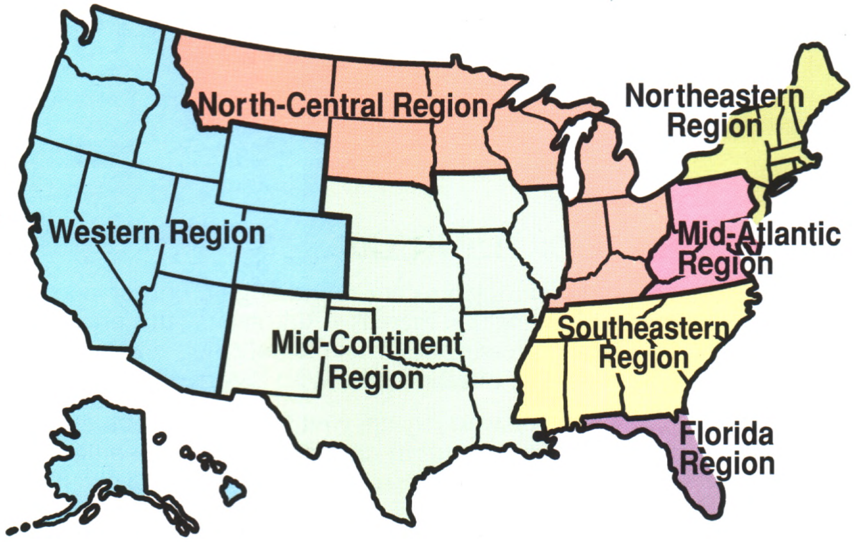

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TURF TWISTERS

KNOWLEDGE OF THE RULES

Question: During a recent round of golf, I observed a fellow-competitor pressing down a spike mark. Knowing that there is a Rule against this practice, I informed him of his misdeed. He said that he was pressing down an old hole plug, and because the spike mark was in the old hole plug that he was within the Rules. Who is correct? (Wyoming)

Answer: Pay up; your fellow-competitor was correct. Rule 16-1a permits touching the line of putt in repairing an old hole plug. If the spike mark had not been within the hole plug, the ruling would have been different. We offer another alternative. Encourage all players at your golf course to use the spikeless alternatives that have become increasingly popular during the past several years. The issue of spike marks will be eliminated, along with a few more strokes off your score due to the smoother putting surface.

FOR STATE-OF-THE-ART IRRIGATION

Question: The golf course I play at just purchased and installed a new state-of-the-art irrigation system. I don't understand why we continue to see employees pulling hoses and hand watering spots on greens, tees, and fairways. Can you help me understand why it is necessary to hand water when we have a well-designed and functioning irrigation system? (Kentucky)

Answer: A well-designed and functioning irrigation system is a tremendous asset and tool that many courses do not have. Nevertheless, the cardinal rule in golf turf management is to *maintain the grass as dry as possible.* This rule means programming the irrigation system conservatively, which may result in occasionally missing areas or running certain areas on the dry side. Hand watering is necessary to supplement irrigation on problem areas or spots that simply require a bit more irrigation. The labor investment to hand water occasionally is money well spent. Even the best of irrigation systems do not eliminate the need for occasional hand watering in the pursuit of good quality playing surfaces and healthy turf.

IMPROVES TURF QUALITY

Question: Our greens seem to become hard and unreceptive to golf shots, especially during the summer months when the golf course dries out. We encourage our superintendent to water more frequently to soften the surfaces, but he refuses, saying that heavy watering will only make the greens harder and hurt turf quality. Help! A Concerned Golfer. (Massachusetts)

Answer: The irrigation system should not be used to keep the greens soft, as this method will result in excessive water applications that can lead to further soil compaction, a reduction in surface quality, and conditions that favor weaker grass plants. A long-range program of aerification and topdressing with a good quality topdressing material is the best approach for creating a surface that will accept a properly hit golf shot. Dry, firm surfaces generally are the most desirable for maintaining high quality turf and good playing conditions.