USGA® GREEN SECTION

Record

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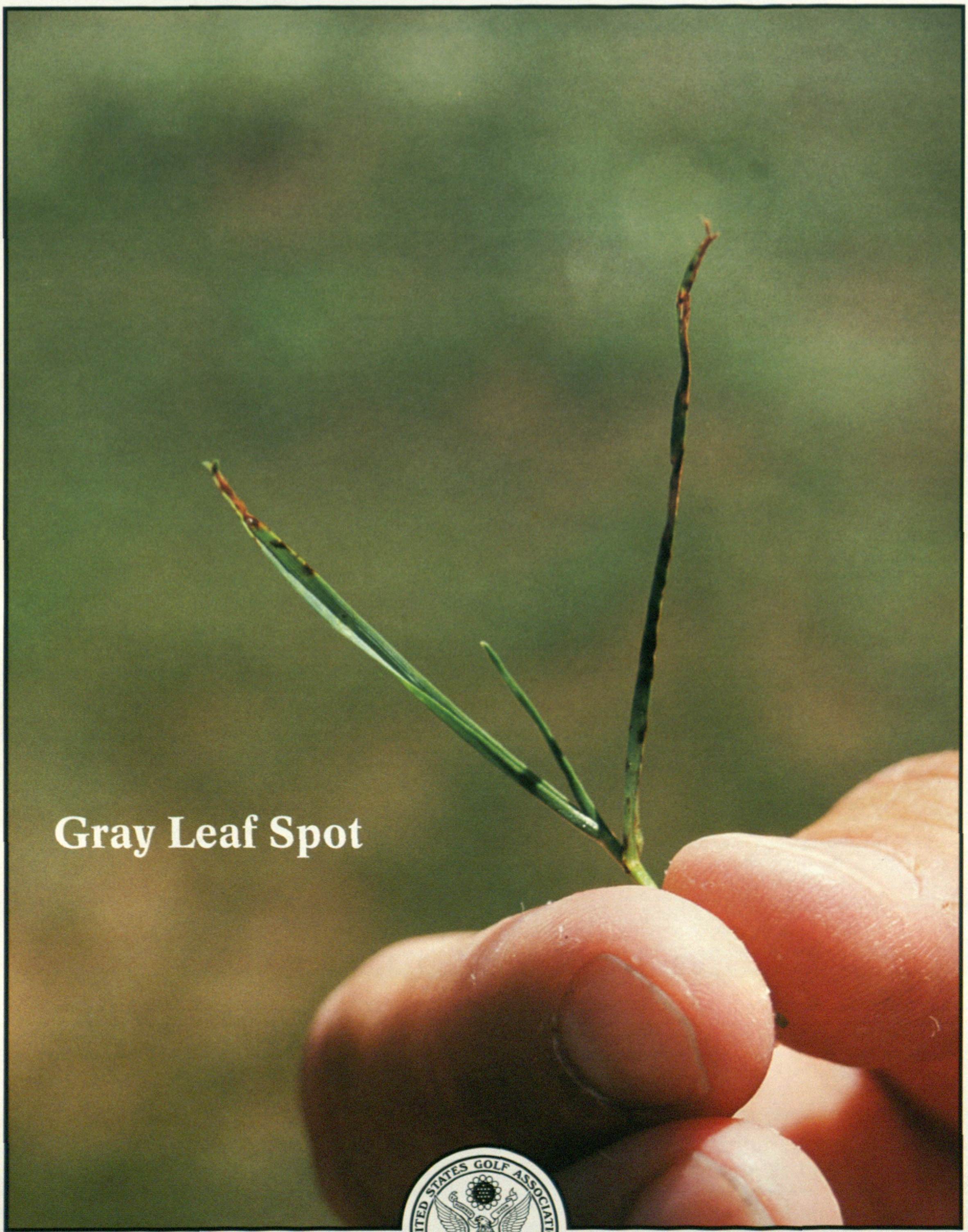

A PUBLICATION ON TURFGRASS MANAGEMENT BY THE UNITED STATES GOLF ASSOCIATION®

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Cover Photo:
The reddish-brown lesions of gray leaf spot can be seen on mature plants with the naked eye. It is always best to have a turfgrass pathologist confirm the diagnosis.

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The greens were originally built with native soil. Drainage was still very poor despite an aggressive aerification program, and the greens would not be able to withstand the use of effluent water. *See page 6.*

North Shore Country Club (Illinois) has actively incorporated the use of composts in its golf course management program. *See page 16.*

ACHILLES HEEL

Perennial ryegrass is struck by gray leaf spot.

by PAUL VERMEULEN

As evident in the foreground, gray leaf spot is extremely virulent and can cause turf losses of up to 90%. To protect the perennial ryegrass in the background, a fungicide treatment was made in late July and again in mid-August.

IN CELEBRATION of Achilles' birth, the Greek gods on Mount Olympus decreed that he would one day become a great warrior. This destiny came to fruition during the Trojan War when Achilles led his army to victory at the city of Troy. To ensure that he would always be invincible, his mother Thetis dipped him into the River Styx when he was a child, making his skin immortal. Tragically, she was later to discover that by holding her son's foot during his anointment he would be killed by a single arrow that struck his heel.

Much like the hero Achilles, perennial ryegrass exhibits many inherent strengths on the battlefields known to superintendents as fairways and rough. Among these strengths are its low establishment cost, excellent seedling vigor, good heat and drought tolerance, excellent wear tolerance, and superior playing characteristics over a wide range of cutting heights. Unfortunately, perennial ryegrass also has one true weakness that has caused superintendents to question its rightful position among the elite cool-season turf species.

Ever since improved varieties were first developed for golf course applications in the early 1970s, susceptibility to fungal attack has been considered the Achilles heel of perennial ryegrass. The primary concern has been *Pythium*, which can produce stand losses of 50 percent or more during periods of high heat and humidity.

In 1995 concern shifted away from *Pythium* and onto gray leaf spot. Known as *Pyricularia grisea* to the scientific community, this previously underestimated pathogen clearly demonstrated that it could slaughter perennial ryegrass with unimaginable efficiency. As made evident during recent epidemics, it can destroy 90 percent or more of a mature fairway or rough area if left unprotected by fungicide treatment.

History Lesson

The ancestral roots of gray leaf spot are found in the Southeast, where it has infected St. Augustinegrass and to a lesser extent bermudagrass for decades. These warm-season grasses, however, were not easy victims for the disease, as it was unable to cause extensive losses on anything other then newly sprigged, juvenile stands. Being an unsuccessful predator on warm-season grasses, it turned its attention to cool-season species. An early victim in this category was annual ryegrass when, in 1971, several thousand acres of pastureland were damaged in Louisiana and Mississippi.

Perennial ryegrass then became the next victim to fall prey to gray leaf spot in a growing chain of events. This evolutionary step was diagnosed by Dr. Peter Dernoeden of the University of Maryland in 1986, and it was later confirmed by Dr. Peter Landshoot of the Pennsylvania State University in 1991. Since it was first diagnosed, gray leaf spot has been responsible for two major epidemics. The first epidemic occurred in 1995 in the Mid-Atlantic and North-Central Regions, whereas in 1998 the epidemic occurred all across the Mid-Atlantic, North-Central, Northeast, and Mid-Continent Regions.

As of this writing, the growing list of susceptible victims includes tall fescue, creeping bentgrass, and Kentucky bluegrass. Of these three, only tall fescue has proven to be susceptible under normal field conditions, as made evident by a sole epidemic centered in North Carolina. The latter two (creeping bentgrass and Kentucky bluegrass) have only fallen prey under laboratory conditions where plants were subjected to unnatural climatic stress.

Since the first diagnosis of gray leaf spot in the Mid-Atlantic Region in 1986, the disease has seemingly moved westward at a phenomenal pace. By the end of the 1998 season, outbreaks had been diagnosed in 18 states stretching from the Atlantic coast to the eastern Colorado state line. The apparent migration of the disease is a subject of ongoing debate. Some of the prominent hypotheses include more accurate laboratory diagnosis, growing recognition among turfgrass pathologists of *Pyricularia grisea* as a primary pathogen, increased use of perennial ryegrass in the transition zone, and the birth and transport of new virulent races of *Pyricularia grisea* across the country. Whatever the reason, the disease seems to be capable of devastating new regions without much effort.

Symptom Development

The visual symptoms of gray leaf spot on perennial ryegrass begin as small black specks on the foliage resulting from the initial infection. Next, oblong lesions begin to develop along the margins of the leaf blades. These lesions have a grayish, reddish-brown boundary and in a limited number of cases can be surrounded by a yellow halo. The ⅛-inch or smaller lesions also can be accompanied by small masses of grayish fruiting bodies called conidiospores that can give the appearance of a velvety covering. As the lesions

Golfers in the Mid-Continent Region got their first serious look at gray leaf spot during 1998. This new disease is extremely virulent and can cause devastating losses on perennial ryegrass fairways and rough.

expand, they can cause the tips of the leaf blades to turn brown and twist or curl.

As the disease progresses, symptoms of gray leaf spot can be seen without close examination of individual leaf blades. From shoulder level, grayish or reddish-brown patches 3 to 5 inches in diameter develop rapidly. Over time, the patches tend to coalesce and they no longer have distinct boundaries. The symptoms of large infected areas can also mirror ordinary afternoon wilting under the right weather conditions. Unlike drought stress, though, the infected turf does not respond to short irrigation cycles and in the span of a few days will perish.

On seedling perennial ryegrass the symptoms are less obvious in the earlier stages of disease development, primarily because the leaf blades are very slender and the lesions are not easily seen with the naked eye. A distinct twisting of the leaf tip is probably the easiest way to identify seedlings infected with gray leaf spot. This twisting can cause individual plants to look like small fishhooks. Suffice it to say, the later stages of gray leaf spot on seedling perennial ryegrass are usually identified as complete crop failure.

The symptoms of gray leaf spot can be easily confused with brown patch or pythium on mature turf and damping-off on seedlings, even though they develop with an absence of conspicuous mycelium. When there is any doubt, the diagnosis should be *immediately* confirmed by sending a small turf sample to an experienced turfgrass pathologist. *Immediately* is the operative word, as the disease has the capacity to cause catastrophic damage to seedling turf in 48 to 72 hours and to mature fairways and rough in 3 to 5 days.

The rapid spread of gray leaf spot is attributed to its ability to produce an enormous number of spores in a short period of time. Once produced, these spores are easily transported from infected foliage to healthy host plants via air currents, water-splash, and equipment traffic. Once present on the leaf of a new host and given adequate moisture, the spores quickly germinate. Emerging fungal hyphae then penetrate the leaf blade and sheath of the new host and the spore production cycle rapidly continues.

Weather conditions that prompt the development of gray leaf spot occur during the summer months. In general, daytime temperatures above 85°F and nighttime temperatures above 70°F for prolonged periods of time can trigger an epidemic. During the summer of 1998, for example, a stretch of warm temperatures from late July through mid-September resulted in extensive losses of perennial ryegrass fairways in the Mid-Continent Region. During this particular epidemic the disease was said to be in a logarithmic phase whereby it reproduced and infected new plants at a horrifying pace.

Lesions caused by gray leaf spot can be accompanied by masses of grayish fruiting bodies that can give the appearance of a velvety covering.

Humidity seems to be less of a factor in the development of gray leaf spot, as the prevailing weather conditions during the 1995 and 1998 epidemics were punctuated by dry conditions in many areas. The moisture required for fungal development was likely supplied by irrigation. During prolonged periods of high temperatures and low rainfall, perennial ryegrass often requires both nightly irrigation and afternoon syringing to sustain high visual quality.

Once an outbreak of gray leaf spot occurs during warm summer weather, it will most likely continue to affect the perennial ryegrass stand until after the first two or three hard frosts in the fall. This means that the window of gray leaf spot activity can literally remain open from mid-June through late November in some regions of the country. The majority of severe infections, however, have actually occurred between mid-August and mid-October when the disease is capable of logarithmic reproduction under ideal weather conditions.

Controlling Outbreaks

Controlling the activity of gray leaf spot with fungicide applications is a mix of good and bad news. The good news is that the fungus can be effectively controlled with several fungicides available for use in the United States. According to trials conducted by Dr. Paul Vincelli of the University of Kentucky, azoxystrobin (Heritage), thiophanate methyl (Cleary's 3336), propiconazole (Banner MAXX), mancozeb (Fore), and chlorothalonil (Daconil Ultrex) show good activity on gray leaf spot. The efficacy of each product can vary depending on the rate and frequency of application. (Editor's note: As of this writing, only azoxystrobin, thiophanate methyl, propiconazole, and chlorothalonil are labeled for gray leaf spot control.)

The list of fungicidal controls will likely expand with the registration of new compounds. One example is the impending registration of trifloxystrobin (Compass). Furthermore, various combinations of fungicide treatments will be evaluated continually with the possibility of discovering synergistic responses.

When gray leaf spot initially infects turf and it becomes necessary to control it on a curative basis, events in the Mid-Atlantic Region indicate that both contact and systemic fugicides should be included in the spray solution for best results. Contact fungicides produce rapid results by disrupting the disease's ability to produce large numbers of spores on the surface of the leaf blades. Systemic fungicides generally produce slower responses but provide protection for two to three times as long.

After the first documented infection on a course, the optimal approach for controlling gray leaf spot during subsequent growing seasons is to apply preventive fungicide applications when prevailing weather conditions are conducive to fungal development. A preventive posture, even when early summertime temperatures are slightly below normal, can prove to be very advantageous by the end of the season because present knowledge is insufficient in predicting whether or not the logarithmic phase will occur during the latter half of the summer. A curative posture can lead to substantial losses, as rapid symptom development will leave superintendents precious few opportunities to treat large acreage.

The bad news on the issue of fungicidal treatment is that gray leaf spot control can be very expensive. The primary variables that determine the cost of control most often are (1) the seasonal duration of conducive weather conditions, (2) the number of treated acres, and (3) product pricing. Taking these variables into account, the cost of treating 50 acres of perennial ryegrass fairways and rough during an extended summer when the window of disease activity remains open for 120-plus days can exceed $60,000. This cost does not include fungicide treatments for other diseases that also may be problematic or the cost of manpower or equipment depreciation.

Controlling gray leaf spot using cultural management strategies is a topic of great interest. Unfortunately, the disease's rare occurrence on golf courses prior to the mid-1990s has provided few opportunities for the scientific community to conduct investigative studies. This aside, there are a few actions that warrant consideration based on limited evidence.

As gray leaf spot is known to be triggered by high temperatures and extended periods of wet foliage, improving cross ventilation throughout an entire course and irrigating during the daytime, when possible, may help prevent mild infections from worsening. Additionally, as the disease's spores are produced on the surface of the leaf blades, collecting the clippings during routine mowing and disposing of them into a managed composting facility can help prevent the spread of isolated infections.

To reduce perennial ryegrass's susceptibility to gray leaf spot, excessive nitrogen applications and the use of growth regulators during the heat of summer should be avoided on areas unprotected by fungicide treatment. Excessive summer growth resulting from high nitrogen applications will cause the foliage to become succulent and thus an easy target for the fungal hyphae that penetrate the leaf's surface during infection. Similarly, avoiding over-regulation of perennial ryegrass with growth-retarding compounds will improve recuperative potential if the turf is left unprotected by fungicidal treatments. During the fall, frequent nitrogen applications with urea at a dosage between 0.1 and 0.2 lbs./1,000 sq. ft. can help promote the recovery of damaged foliage.

Exploiting inherent resistance to gray leaf spot by planting select perennial ryegrass varieties is also a prudent cultural practice. While inherent resistance alone cannot eliminate the need for fungicidal treatments, choosing better varieties can result in faster recovery of blighted areas because the crown portion of semi-resistant plants is not as severely damaged. The National Turfgrass Evaluation Program (NTEP) publishes susceptibility ratings for many of the commercially available varieties on the World Wide Web at the following address: http://hort.unl.edu/netep.

The final cultural strategy available to superintendents is to decrease the cutting height. In studies conducted by Dr. Bruce Clarke, of Rutgers University, gray leaf spot infections became more severe as the cutting height was increased from 1 to 3 inches. This discovery is intriguing, as most diseases become more severe as cutting heights are lowered and the turf is placed under greater physiological stress.

The Need For More Research

Better management of courses infected with gray leaf spot will require additional research. Perhaps a good starting point is to develop a more in-depth understanding of the gray leaf spot organism. This information is needed to provide answers to some of the following questions:

- Will gray leaf spot continue to spread into new regions, such as the Southeast and Southwest, where perennial ryegrass is used extensively for winter overseeding?
- Does gray leaf spot have the capacity to further mutate and become a destructive pathogen on other economically important turfgrass species?
- Can other cultural management strategies be discovered that will reduce or partially eliminate the present need for fungicidal treatments?
- Can a better prediction model be developed to aid in scouting and reduce the number of treated acres?

In addition to continuing basic research, funding must also be sought to intensify the hunt for resistant genes. Dr. Andy Hamblin, of the University of Illinois, is currently screening the perennial ryegrass gene pool for inherent resistance. If this initial investigation fails to make a significant discovery, then researching the gene pools of closely related species should be undertaken. Once a resistant gene is discovered, the probability of importing it into the genetic coding of popular perennial ryegrass varieties using existing technology is thought to be very good.

Alternative Turfgrasses

Based on the enormous cost of protecting vulnerable areas of perennial ryegrass, it comes as no surprise that a growing number of course officials are beginning to ask whether or not it is worth maintaining in the long run. Depending on a number of mitigating factors, there are various responses to this inquiry. First, total acreage and historical performance must be considered. If a course has a small number of acres of perennial ryegrass and turf performance has not be problematic, then throwing the baby out with the bath water would not make a great deal of sense. If a course has a large number of acres and has experienced unacceptable losses that can only be prevented in the future with costly fungicide applications, then establishing an alternative turfgrass would be advisable.

Second, a course must consider the total cost of maintaining alternative species. Calculating this cost should include an assessment of the equipment inventory and irrigation system. Perennial ryegrass has established a good track record on many courses with small equipment inventories and older irrigation systems because it can be maintained over a wide range of cutting heights and has good heat and drought tolerance. To successfully convert 30 or more acres of perennial ryegrass to an alternative species, such as creeping bentgrass, can cost several hundred thousand dollars if the purchase of new equipment and a multi-row, computerized irrigation system is required. Besides, creeping bentgrass and other alternatives have disease problems of their own that require costly pesticide applications.

Third, the cost of establishing another turfgrass species must be considered. This cost consists of two components. The first component is the cost of establishing a new stand of turf from seed, sprig, or sod. This cost can vary from $1,200 per acre for seeding to $20,000 per acre for sodding. The second component is the hidden cost of complete or partial course closure during the establishment of an alternative species. This can include the loss of green fees, clubhouse revenues, special event revenue, and membership sales. In many cases, the loss of revenue from the various segments of course operations dwarfs the cost of turf establishment.

Fourth, courses must consider the attractiveness of alternative species to the golfing public. In some cases, the attractiveness of alternative species can be narrowed to pure economics. For example, a course located in southern Missouri may discover that zoysiagrass and bermudagrass are not attractive enough to entice golfers from North Dakota to go south for golf during March and April. As such, the loss of revenue from green fees could be greater than the cost of fungicidal treatments for gray leaf spot control on perennial ryegrass.

Attractiveness can also be a purely subjective issue. For example, golfers who have become accustomed to playing on perennial ryegrass may elect to continue paying for its adequate care as opposed to supporting the establishment of an alternative species with different playing characteristics. The irrational element of this argument is that most golfers can easily adapt to the different playing conditions offered by the major turfgrass species grown. The clearest evidence of golfers' innate adaptability to different turf types is the fact that they prefer to travel with their clubs on vacation from north to south and from east to west.

Conclusion

Gray leaf spot has proven to be a formidable opponent and has, in many respects, humbled a proud turfgrass industry. Only time will tell whether it proves to be the proverbial arrow that strikes the vulnerable immune system of perennial ryegrass.

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When gray leaf spot is suspected, it is important to take immediate action. To illustrate, this area was covered by a healthy crop of seedling perennial ryegrass just 72 hours before this photo was taken.

Part of the project involved preserving 1,200 mature trees on the golf course. The trees were incorporated into the new design and protected during construction.

Rebuilding a Municipal Golf Course — Is It Worth It?

With good planning and sharing of information, the answer is definitely YES!

by JAMES JARRETT and PATRICK GROSS

EXPECTATIONS of turf quality are generally low at a municipal golf course. The name of the game is to get as many golfers as possible on the course at an affordable price and gather revenue for the general fund to finance other programs in the city. Who cares if the tees are a bit thin or there are bare spots on the fairways? After all, this isn't the PGA Tour. If everything is humming along just fine, why in the world would anyone ever consider rebuilding a municipal golf course?

The City of Downey, California, faced several challenges with its municipal golf course, Rio Hondo Country Club, that forced a reevaluation of the standard municipal golf philosophy. The story provides an informative case study on the background and decisions that went into the successful renovation of Downey's municipal golf course.

Background

Rio Hondo Country Club was built in 1928. It was a very popular course, and approximately 110,000 rounds of golf were played annually by the late 1980s. With so much play, turf conditions suffered on the old push-up greens, especially during the summer. USGA Green Section Turf Advisory Service visit reports going back several years documented many problems, the most serious of which were poorly drained greens and a failing irrigation system. There were other mounting issues to consider, including the safety of people in nearby homes and the opportunity to bring effluent water onto the golf course that would require the construction of lakes for water storage. Conditions continued to get worse each year, and it was certain that the poorly drained greens would suffer even more with effluent water. Given the age of the course and the many

Safety issues were another factor driving the need for golf course renovation. The new design included more separation between fairways and rerouting in some areas to reduce safety risks.

problems, changes were necessary to stay competitive over the next 25, 30, or 50 years.

Rio Hondo competes with the average municipal golf course in Southern California, but there is a growing trend in the area for public golf courses that charge $75 to $100. Although there are many private courses available, there is nothing that fills the void in between, so a conscious decision was made to develop this municipal golf course to a higher standard and provide some of the amenities that one might find at a private course. The new philosophy was to reduce the amount of play by extending tee time intervals to nine or ten minutes, provide some amenities, and give the golfer a better golfing experience. Hopefully, this change would generate enough revenue to pay for all the great plans that were developed.

Doing the Homework and Selling the Plan

A team was assembled to research the feasibility of renovating the golf course and to investigate various plans and methods for accomplishing this task. Although the city staff had already done a feasibility study, it was important to have an independent third party provide an honest evaluation of the local golf market and finances. Bill Sherman from Golf Realty was hired, and he analyzed the situation to project revenues at various rates and amount of golf play. After the study was completed, the findings were shared with the golf community, Recreation Community Service Commission, and the city council. Essentially, all the studies indicated that not only was it feasible, but it was highly desirable to renovate the golf course in order to stay competitive over the next 20 to 30 years.

Next, golf course architect Gerald Pirkl was hired, and he began working with the city staff, representatives from the men's and women's golf clubs, the maintenance contractor, golf professional, and liaison from the Recreation Community Service Commission to develop a conceptual plan. Meetings were held with the city council, Recreation Community Services Commission, golfing groups, community groups, and anyone else who had a potential interest in the project. Models and conceptual drawings were made, information was posted on bulletin boards, newspaper articles were written, and tours of the golf course were organized to inform and publicize the project. Support for the project mounted as people became more informed about the issues. Specific design criteria included separation of fairways to improve safety, preservation of approximately 1,200 mature trees, incorporating lakes for the storage and use of effluent water, continuous cart paths, and providing a challenging course that a golfer could play in 4½ hours.

Then it was time to determine how to approach the project. One option was to pay as you go and renovate three or four holes a year, which would not really improve the overall facility. Furthermore, after renovating the course in bits and pieces over six or seven years, the golfers would not recognize the project as a *new course* and it would be difficult to charge more for green fees. The next option was to renovate nine holes each year over a period of two years. The third option was to close the entire course and get it all done at once. The various plans were discussed with the men's and women's golf clubs, and they offered strong support for closing the course

The decision was made to sod the tees, greens, and fairways. This was a controversial decision for the city, but sodding allowed the golf course to open five months early. The additional revenue that was generated by opening early easily offset the cost of the sod.

and getting it done at one time. Surprisingly, the least favorite option in their opinion was to renovate three or four holes each year.

Architectural plans and construction specifications were developed for the golf course in preparation for bid. During this time, the maintenance contractor, functioning as the clerk of the work/quality control specialist, began researching putting green construction materials. Samples of gravel, sand, and organic matter were collected and sent to a physical soils testing laboratory for analysis according to USGA Recommendations for Putting Green Construction. By testing and selecting the materials beforehand, it was possible to assure availability and make all the contractors bid on the same materials to avoid substitutions with inferior materials.

The overall cost of the project was estimated at $5 million. This included debt service on an existing bond and honoring the contracts for the golf professional and maintenance contractor during the renovation. The city was in a very good position because the golf course was operated on an enterprise funding system for several years and had about $3 million in reserves. A second bond was acquired to finance the project.

Then it was time to bid the project. A significant amount of time went into researching golf course builders and developing the bid specifications. For a municipality, it was preferred to have one general contractor responsible for the entire project instead of breaking the project down and having several subcontractors. The specifications were developed and advertised, with several builders solicited to bid on the project. Each company had to meet specific qualifications, and the city was obligated to take the lowest qualified bid. Each bid included unit costs so that change orders could be quickly and fairly calculated.

Ponds were incorporated into the new design of the golf course for the storage of effluent water.

Construction Begins

The course was closed near the end of September and work began. From the very start of construction, the guiding principle for the project was "do the right thing." Once the decision was made to go forward with the project, the city staff and project team were given the authority and latitude to make changes in the field to improve the project as they saw fit. One example was the decision to sod the golf course. After discussing the topic with the entire project team and running the numbers, it was determined that the cost of the sod would be offset by the revenues generated by opening the course five months early. The decision to sod was rather controversial at the time for a municipal golf project, but it was the right decision and enhanced the quality of the overall project.

Was It Worth It?

The project to rebuild Rio Hondo Country Club was completed five months earlier than projected. Given the fact that the cost of sodding the golf course was offset by the additional revenue, the project came in under budget. The success of the project came down to the good working relationship among the members of the project team. The maintenance contractor, Satsuma Landscape, supervised the construction with additional oversight provided by city staff. The contractor, Wadsworth Construction, also was flexible with change orders and often suggested ways to make the project better, which contributed to the overall quality of the project.

The basic municipal golf operating philosophy of putting the least amount into the course and taking the most out was challenged and replaced with a goal to provide a top-quality golf experience at Rio Hondo Country Club. The results were overwhelmingly successful. Various factors contributed to this success:

- A good project team that worked well together and had the same goal.
- The city staff did its homework and gathered as much information as possible over several years, which supported the decision to rebuild the golf course.
- The city worked with community groups to provide as much information about the project as possible and get their input and ideas.
- No one tried to force the project. If the community had not supported the project, it would not have been done.

Was it worth it to rebuild a municipal golf course? For the City of Downey, the answer was yes!

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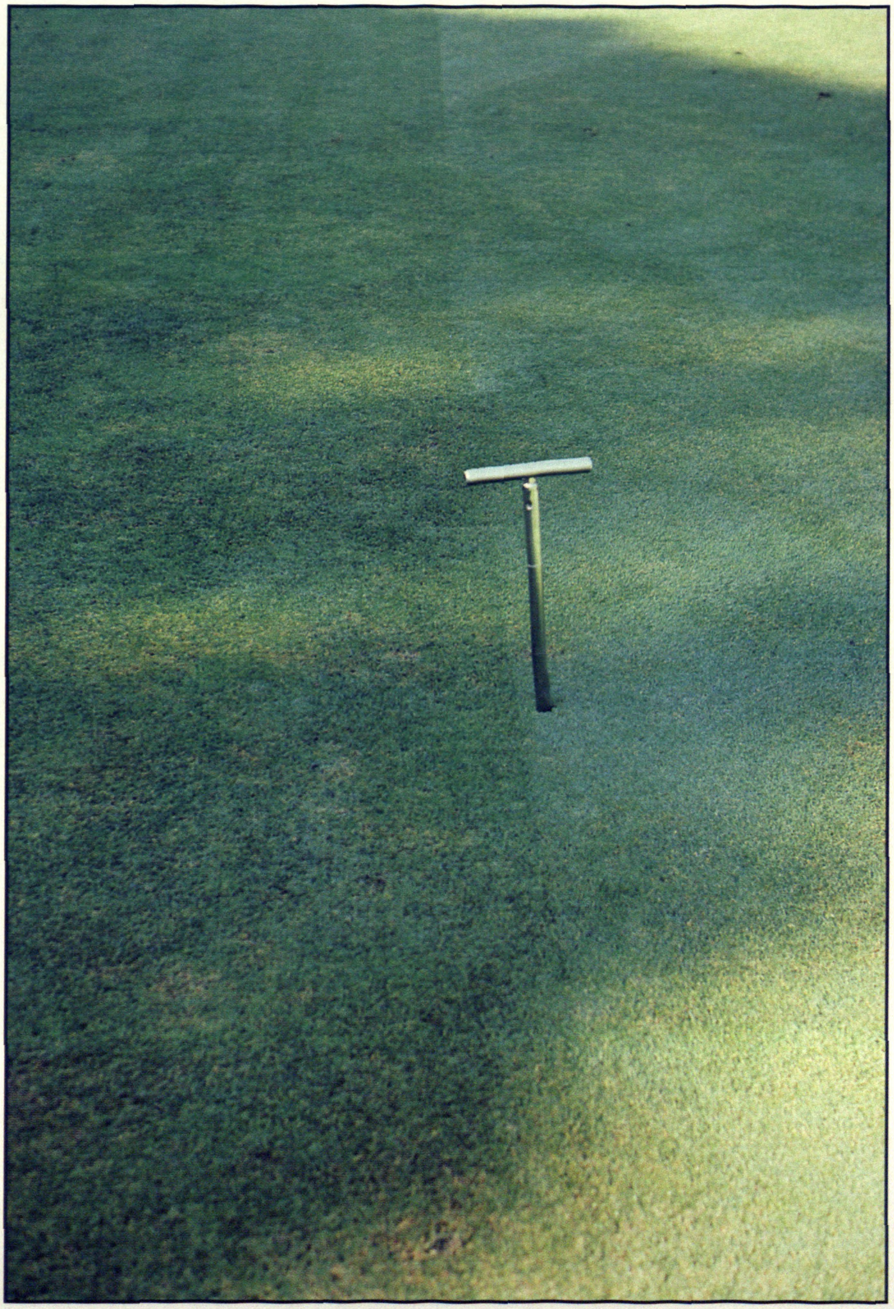
FIVE-PLEX RING

Triplex ring, once the scourge of putting greens, has been replaced by its first cousin. "Five-plex" ring has become a serious problem on fairways at many courses.

by DAVID A. OATIS



On this fairway, the difference in grass populations is striking. Poa annua *is the dominant species in the full width of the cleanup pass, while bentgrass is the dominant species just outside of it.*

IN THE November/December 1980 issue of the *Green Section Record*, USGA agronomist Jim Snow wrote an article entitled "The Triplex Ring." Nineteen years later only the location of the problem has changed. Today the "triplex ring" problem on putting greens and tees has been so well publicized and understood that it is fairly rare. However, a number of courses are experiencing a similar problem on fairways. It is called "Five-Plex Ring."

Historical Background

The 1970s was a decade of speed and efficiency in turfgrass management. Most of the new equipment used during that period was designed to be bigger, faster, and more efficient in terms of manpower. Triplex putting green mowers, large 7- to 9-gang hydraulic fairway mowers, and mechanical sand raking devices all were used on courses in the 1970s. Unfortunately, this labor-saving equipment caused a tremendous amount of damage to the turf, and in the 1980s, golfers and superintendents alike began paying more attention to turf quality.

The value of lightweight fairway mowing systems became obvious at many courses during the late 1970s and 1980s. But for most courses, using triplex putting green mowers to mow fairways was cost prohibitive since it entailed the use of as many as six to eight machines and the same number of equipment operators. Nonetheless, many courses initiated lightweight fairway mowing programs with triplex putting green mowers. The following are a few observations courses commonly made after doing so:

- The use of triplex putting green mowers on fairways led to improved turfgrass vigor, reduced disease incidence, and significant increases in creeping bentgrass populations at many transition- and northern-zone golf courses.
- The benefit derived from the smaller mowers was believed mainly to be a result of decreased compaction and clipping removal. Compacted tire ruts from the large mowers often were visible on the perimeter of fairways (in the cleanup pass), and this supported the theory that compaction was a big part of the problem. *Poa annua* was often very pronounced in these zones of compaction.
- The tire ruts usually disappeared after several years of triplex usage, and many fairways quickly developed increased levels of thatch. This demon-

Above: Grooming attachments can be beneficial in encouraging a more upright growth habit, but they add weight directly to the cutting unit and can increase wear injury. Below: Some superintendents have reduced five-plex ring problems by altering the cutting units. In this instance, the original front (Wiehle) and rear rollers have been replaced with lighter solid rollers from a putting green mower. A weight bar has also been removed.

strated the reduced injury caused by the smaller, lighter units. The increased accumulation of thatch also indicated the need for more effective cultivation programs.

Fortunately, the equipment manufacturers responded to the lightweight movement and introduced the first truly "lightweight" five-plex machines in the late 1980s. These new mowers were more efficient and put lightweight fairway mowing programs within the financial reach of many more courses. These lighter five-plexes performed admirably and collectively had a tremendous impact on fairway management programs. Clearly, the new five-plexes were not as light as the triplexes, but the benefits still were undeniable.

• The five-plexes provided an excellent quality of cut and their usage clearly favored creeping bentgrass.

• The five-plexes represented a substantial increase in efficiency over the putting green triplexes. Courses that once required six to eight triplexes found they could mow all of their fairways with just two or three five-plex machines. This also saved labor costs.

• Thatch development on fairways continued with five-plex mowers; however, the rate of accumulation was less when compared to triplexes.

The Problem

The compacted tire ruts caused by the 7-gang mowers did not reappear at courses that switched to five-plexes, and the improved efficiency over triplex units was a tremendous advantage. However, after several years of five-plex usage, courses that had been using triplexes began to experience a very gradual change in grass populations in the cleanup pass. Annual bluegrass populations became higher here than elsewhere in the fairways. This was understandable, since the mowing pattern of the cleanup pass really cannot be altered. This phenomenon became especially apparent in fairway perimeter areas where annual bluegrass was already favored, such as shady, wet, compacted, high-traffic areas. The five-plexes eventually began to cause turfgrass thinning and loss in these types of areas, a problem that was exacerbated by increased mowing frequency. Sharply contoured fairway perimeters and perimeters with severe topography also were affected. Five-plex ring was born!

Perhaps the most intriguing part of the five-plex ring phenomenon is that the damage virtually always appears in the full width of the machine rather than primarily in the tire print. In fact, the tire prints are rarely apparent in five-plex rings, and this suggests some interesting possibilities. Most importantly, compaction is not the primary culprit; if it were, the tire prints would be clearly visible in most cases. Therefore, it appears that the damage is primarily being caused by wear and abrasion injury. Clearly, there are other factors exacerbating the effects of five-plex ring. Some have already been mentioned, but there are others. The effects of tree shading and root competition play an important role that must be accounted for. Also, realize that new courses are especially susceptible to five-plex ring, since the turf is immature and the soil's structure often is severely damaged during construction.

In reviewing the history of five-plexes, it is quite apparent that the units have gotten progressively heavier in the years since their initial introduction. Innovations and superintendents' desires for more power, increased durability, and operator comfort prompted many of the design changes. The newest five-plexes have bigger engines, four-wheel drive, power steering, and other helpful features. Some have grooming attachments that add weight directly to the cutting unit. This can translate into more wear damage, even when they are not engaged. Finally, consider the rollers on the newest machines. In some cases, the grooves in the Wiehle rollers are considerably farther apart than they were initially. This causes the weight of the cutting unit to be supported by less surface area. The damage attributable to Wiehle rollers is magnified when their edges are sharply cut.

The Cure

The first step in solving any problem is clearly identifying the causal agent. This is especially true in the case of five-plex ring. Examine the perimeters of your fairways and determine if there is any wear injury or if there is a difference in grass population of the cleanup pass. Assuming you have some degree of five-plex ring, consider one of the following options as a solution for the affected areas:

- Reduced mowing of the cleanup pass is a good place to start, especially for courses mowing fairways four to five times per week or more. For courses that mow fairways only three days per week to start with, reduced mowing frequency may result in unacceptable definition.
- Although your first inclination might be to go out and aerify the perimeters of your fairways, aerification alone likely will not cure the problem. Work on relieving soil compaction but try not to increase abrasion injury. Remember, five-plex ring is caused more by abrasion injury than compaction, and traditional core cultivation will increase the former.
- Prune tree roots in the rough areas and prune or remove trees to increase sunlight penetration.
- In the short term, increasing fertility in the cleanup pass will help with turfgrass wear recovery. One pass around the fairway perimeters with a walk-behind rotary spreader, once or twice annually, may be all that is required. Use a slow-release, non-burning nitrogen source and apply it at ⅓ to ½ lb. N per 1,000 sq. ft.
- Since the heavy, sharp-edged grooved rollers are a major contributor to wear injury, experiment with different front rollers on the five-plexes.
- A number of superintendents are now using solid or "smooth" rollers (both in the front and back) on the cutting units. Solid rollers cause less abrasion injury and encourage more lateral growth. Ultimately, solid rollers can help increase bentgrass populations; however, solid rollers increase the effective cutting height of the mower. Height adjustment may be necessary to compensate.
- Other options include obtaining alloy or nylon rollers, which are lighter and potentially less damaging.
- One superintendent has experienced success by replacing the factory-supplied five-plex rollers with solid rollers from a triplex putting green mower. The rollers from the triplex are considerably smaller in diameter and lighter in weight.
- Some superintendents have successfully modified the cutting units on their five-plex mowers, making them lighter and less damaging. Weight bars can be removed on some units, but be cautious not to remove safety devices or do anything that might invalidate the warranty or present greater risk to the operator or mechanic.
- Down pressure can be regulated on some five-plex machines, so experiment with reducing down pressure, where possible.
- Avoid using groomers and/or verticutters on the cleanup passs.
- Mow the cleanup pass around the fairways as a separate operation with a different machine. A triplex putting green mower is a good choice.
- Finally, be sure to shift the interface between the approach mowers and the five-plex machines. Failure to do so will lead to more wear injury and high populations of annual bluegrass in this critical area.

Conclusion

Fairways at many of the courses I visit have some degree of five-plex ring. The five-plex ring at your course may be so insignificant that no corrective action is warranted, and the only sign may be a faint difference in grass populations in the fairway perimeters. However, it makes good sense to thoroughly evaluate the fairway perimeters and mowing programs on your course and prevent five-plex ring from becoming a problem.

DAVID OATIS *is currently the Director of the USGA Green Section's Northeast Region.*

Five-plex ring will be the most severe on sharply contoured fairways and where the topography is severe.

Subsurface Drainage of Modern Putting Greens

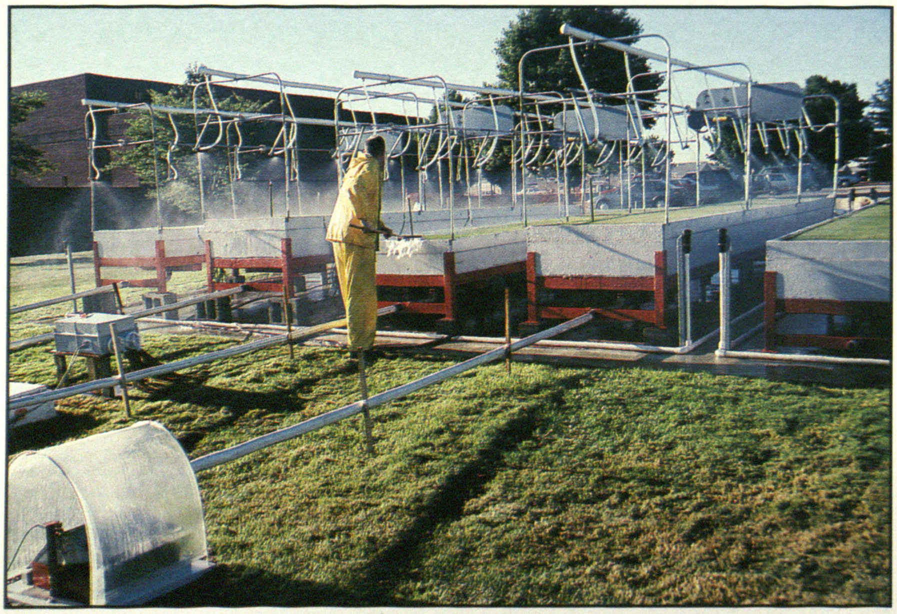
There's a lot going on below the surface.

by GUY PRETTYMAN and ED McCOY, Ph.D.

SUBSURFACE drainage involves both intensity and capacity attributes. Intensity of subsurface drainage refers to how rapidly a root zone drains. Capacity, on the other hand, refers to the extent of excess (gravitational) water removal from the root zone. Consequently, discussions of putting green drainage often become confused since the expression *improved drainage* can imply improved drainage intensity, improved drainage capacity, or both. This confusion most often occurs with modern, high sand content greens where subsurface drainage performance is emphasized.

The two most prevalent modern putting green construction methods are the California Method (Davis et al., 1990) and the USGA (USGA Green Section staff, 1993) green construction technique. The principal differences between these two construction methods are a higher recommended root zone permeability in a California (CA) green (relative to a USGA green) and the presence of a gravel blanket in a USGA green. With all other factors being equal, a higher root zone permeability should lead to higher drainage rates, and for most sandy root zones, a drier soil profile. Correspondingly, the gravel blanket should help drainage water move rapidly to drain pipes, but it also is shown to increase water retention in the root zone (reviewed by Hummel, 1993; Taylor, 1993). The key to comparing subsurface drainage in CA and USGA greens is understanding the interaction between root zone permeability and the presence of a gravel blanket.

Also, the natural contours or slopes that exist on putting greens may influence both the intensity and capacity of subsurface drainage. Even though these slopes are typically slight, they do represent a driving force for lateral, downslope water movement within the greens profile. The supposition here is that soil water retained in the profile after initial drainage may migrate downslope to yield spatially nonuniform soil moistures across a green. To our knowledge, however, no previously reported research on greens drainage has examined green slope effects.



The research greens are constructed from 4-foot by 24-foot wooden boxes. The support legs are blocked for slope adjustment, rain simulators are located overhead, and tipping bucket rain gauges are attached to the drainage outflow lines to allow for the measurement of water output.

This article reports research findings to address modern putting green drainage issues. The green construction methods under investigation are the USGA and California specifications. Other factors investigated include the effect of green slope on water drainage and redistribution.

The Research Approach

This study employed four green construction approaches consisting of:

1. A CA-style soil profile containing a 9:1 sand:sphagnum root zone.
2. A CA-style profile containing a 6:2:2 sand:biosolids compost:topsoil root zone.
3. A USGA layered profile (no intermediate layer) containing the 9:1 sand: sphagnum mix.
4. A USGA layered profile (no intermediate layer) containing the 6:2:2 sand:compost:topsoil mix.

Based upon independent testing by an accredited laboratory, both root zone mixes met the particle size and performance criteria for a USGA root zone. Additionally, the sand:sphagnum mix, although not entirely pure sand, met the recently proposed performance criteria of a CA root zone (Hummel, 1998). The sand:sphagnum root zone had a permeability of 20.8 in. $hr.^{-1}$ and is referred to as the high-permeability mix, while the sand:compost:topsoil blend had a permeability of 12.6 in. $hr.^{-1}$ and is referred to as the low-permeability mix. Gravel selection for the drainage blanket of the USGA profiles and for the drain line trenches of the CA profiles were based on the particle sizes of the respective root zones corresponding to USGA specifications for two-tier greens construction (USGA Green Section staff, 1993). The four treatments were replicated three times for a total of 12 experimental greens. At the time of the study, the greens contained a 15-month-old Penncross creeping bentgrass turf maintained at a mowing height of 3⁄16 inch.

The greens were built above ground in 4 ft. by 24 ft. wooden boxes supported by a legged, metal framework. Six-inch-wide by 8-inch-deep drain line trenches extended below the profiles, with each containing an outlet. The drain line trenches (perpendicular to the long axis) were constructed into each green at 2 ft., 12 ft., 17 ft., and 22 ft. from the downslope end. PVC pipes were connected to the outlet of each drain line trench, with each fitted with a valve for selective closure. The present study was conducted with only the 2 ft. and 17 ft. drain lines open, effectively yielding a drain spacing of 15 ft. The 12 research greens were placed in a randomized complete block design on an 80 ft. by 28 ft. concrete pad. This allowed adjustment of the green slope by jacking and blocking the metal legs. Green slopes used in this study were 0%, 2%, and 4%.

The root zones of each experimental green were instrumented with soil moisture probes at three depths (3 in., 6 in., and 9 in.) and five locations (2 ft., 7 ft., 12 ft., 17 ft., and 22 ft. from the downslope end of the green) for a total of 15 positions per green. The probes were connected to a measurement system that allowed frequent monitoring of soil moistures. Additionally, tipping bucket rain gauges were connected to the drainage outflow pipe of the furthest downslope drain line to monitor drainage outflow rate.

This experimental setup was used to monitor water drainage and redistribution within the root zone as influenced by green construction method, green slope, and rainfall rate. The overall study was conducted as a series of 18 experimental runs. During an experimental run, individual greens were configured to a predetermined slope of 0%, 2%, or 4%. Additionally, each green received rainfall from an overhead rain simulator set to deliver either a high (ca. 4.4 in. $hr.^{-1}$) or low (ca. 1.9 in. $hr.^{-1}$) rainfall rate. Rainfall was applied for 3 hours to ensure a constant drainage rate. At the end of the rainfall period, the rain device was turned off.

Drainage outflow was measured every 5 minutes for both the 3-hour rainfall period and for a 48-hour drainage period. Soil water contents were measured every 20 minutes for the 3-hour rainfall period and for the first 24 hours of the drainage period. Soil moisture levels were measured hourly for the remaining 24 hours. This resulted in about 44,000 total drainage outflow measurements and 113,000 total soil moisture measurements for the full 18 runs of the study. Data collection began on 6 August 1997 and ended on 30 October 1997.

Drainage rates between the two rootzone profiles differed significantly. The USGA profile greens (right) had a higher drainage rate than the California greens (left).

Results

Due to space limitations, only a portion of the data collected in the study will be presented in this article. Specifically, we will present only the high rainfall rate data since, after the first two hours of the drainage period, rainfall rate had little effect on the experimental results.

During rainfall, drainage rates from the research greens exhibited a significant interaction between profile design (either with or without a gravel blanket) and root zone permeability. The USGA profile greens, containing the gravel blanket, had higher drainage rates than the CA profile greens. Additionally, drainage rates from the USGA greens were essentially the same regardless of root zone permeability. This result differed from that of the CA greens, where the drainage rate during rainfall was substantially reduced for the low-permeability root zone compared to the high-permeability root zone. Finally, drainage rates in the USGA greens consistently increased with increasing green slope, while this was not the case for the CA greens.

Although drainage rates were much lower after 27 hours without rainfall, outflow was still observed from all research greens. The CA style greens had higher overall drainage rates than the USGA greens, due principally to differences between the high-permeability root zone treatments. Also, reversed from that observed during rainfall was the effect of green slope, where drainage rates of the CA greens exhibited a larger increase with increasing slope than the USGA greens.

Just as drainage rates showed an interaction between profile design and root zone permeability, the pattern of soil moistures through a cross-section of the root zone yielded a similar interaction. This pattern is illustrated by Figures 1 and 2, where isobands of soil moisture are shown as a function of distance upslope and root zone depth for each of the profile design:root zone permeability combinations. Also, the individual figures correspond to green slopes of 0%, 2%, and 4%.

After 48 hours drainage at 0% slope, both CA profiles showed an effect due to drain spacing. Lower soil moistures were observed over the drain lines at 2 ft. and 17 ft., and higher moistures were observed between the drains. This contrasts with the USGA profiles where soil water contents were more uniform laterally across the soil profile. As expected, root zone permeability yielded higher soil moisture levels for the low-permeability root zone for both profiles. It was interesting, however, that the levels of near-surface soil moistures were similar in the CA high-permeability and the USGA low-permeability greens.

All research greens exhibited increased water contents with root zone depth. In both permeability rates in the CA profiles, water contents increased by about 15% to 20% from the 2 in. to the 10 in. depths. The USGA low-permeability greens yielded about a 10% increase and, while not readily apparent from the figures, the USGA high-permeability greens had a 4% increase in water content with depth.

The patterns of soil moisture for greens sloped at 2% were somewhat similar to those observed at 0% slope. This small slope applied to the greens, however, generated some downslope accumulation of soil moisture for all systems. Consequently, the soil mois-

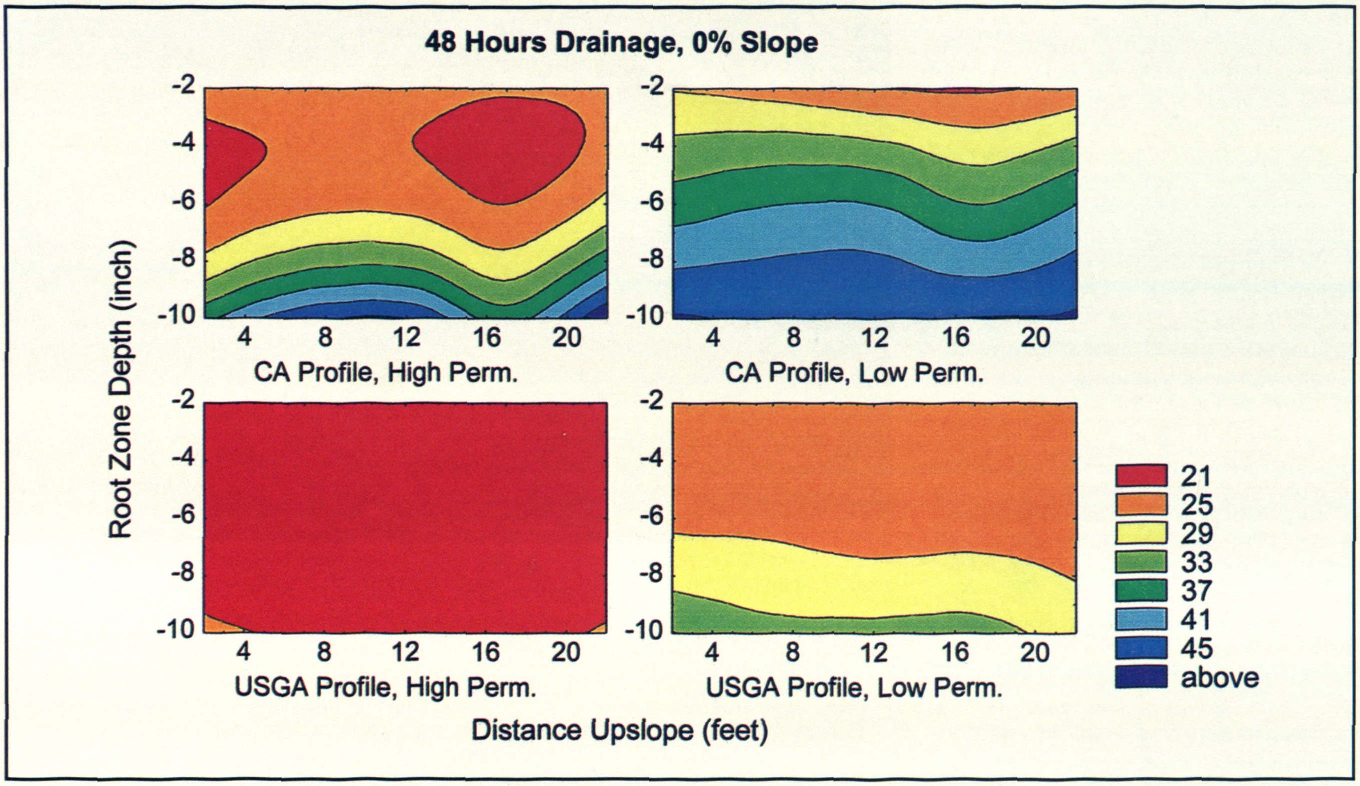


Figure 1. These contour plots demonstrate the soil moisture (% by volume) after 48 hours of drainage for research greens sloped at 0%. Individual plots show results for the California profile with a high permeability root zone, the California profile with a low permeability root zone, the USGA profile with a high permeability root zone, and the USGA profile with a low permeability root zone. Each plot shows moistures in a cross-section of the root zone with the horizontal axis given as distance upslope (feet) and the vertical axis given as root zone depth (inch). The plots are shown with the vertical axis expanded 16.7 times true scale.

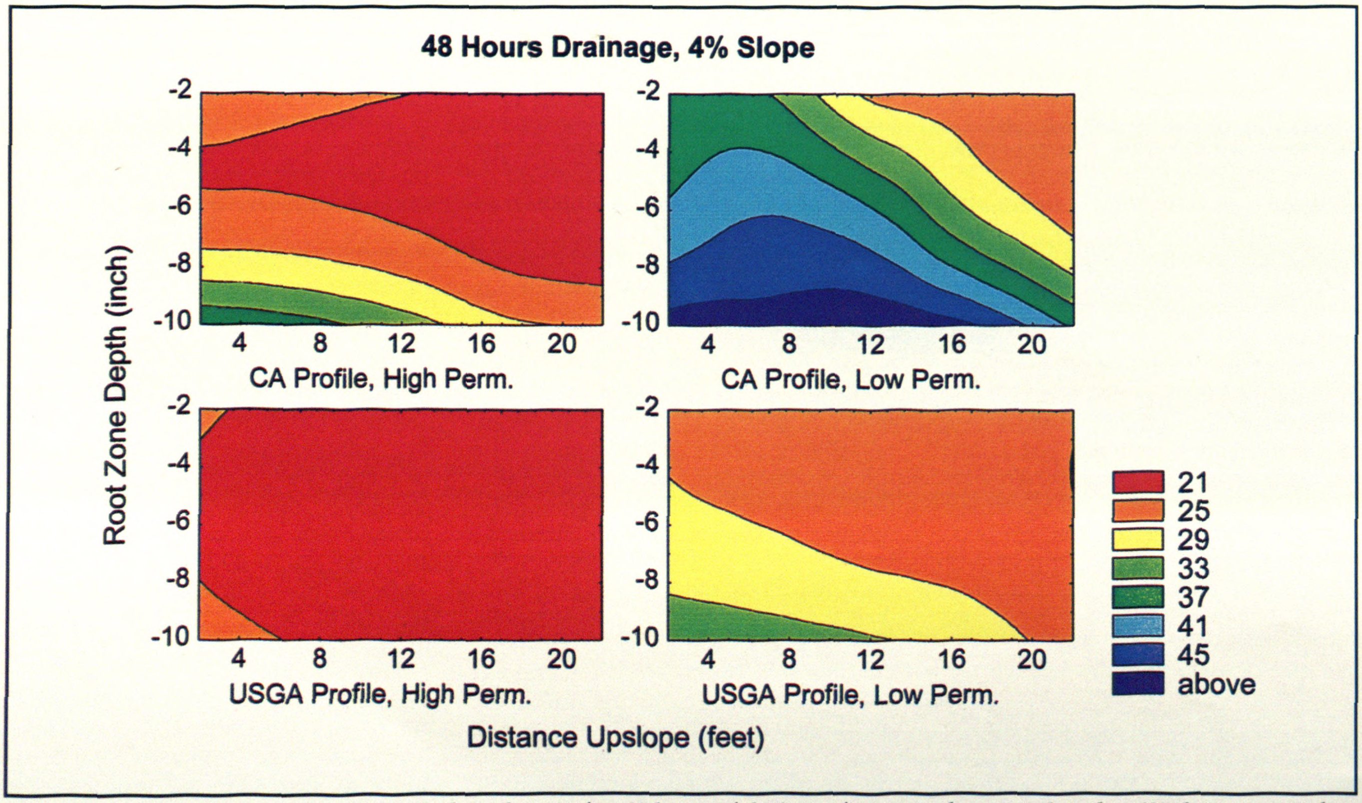


Figure 2. Contour plots of soil moisture (% by volume) after 48 hours of drainage for research greens sloped at 4% demonstrate the differences in drainage characteristics between California and USGA profile greens.

ture pattern due to drain spacing in the CA profile greens was skewed in the downslope direction, and downslope water accumulation, particularly at depth, was observed in the USGA greens. This downslope soil water accumulation was accentuated in all greens after 48 hours at 4% slope. Drain spacing effects disappeared for the CA greens and evidence of water perching in the USGA greens was absent near the upslope end. Finally, the 4% slope had the greatest influence on near-surface soil moistures in the CA low-permeability greens, where water contents ranged from 37% to 25% within a distance of about 18 ft.

It is important to point out that whereas results of Figures 1 and 2 are for 48 hours of drainage, similar soil moisture patterns were observed at earlier sampling times. The exception was that overall water contents were higher at earlier sampling times and slope effects did not become apparent until about 12 hours after rainfall stopped.

Table 1
Mean drainage rates during rainfall application and after 27-hour drainage for the experimental putting greens.

Green Profile	Root Zone Permeability	Green Slope	Drainage Rate During Rainfall	Drainage Rate 27 Hours
		%	gal. hr.$^{-1}$	gal. hr.$^{-1}$
California	High	0	59	0.22
		2	67	0.51
		4	52	0.52
	Low	0	10	0.08
		2	6	0.22
		4	3	0.46
USGA	High	0	82	0.13
		2	130	0.21
		4	140	0.24
	Low	0	81	0.17
		2	98	0.29
		4	146	0.30
LSD (0.05)			11	0.14

Implications

This research illustrates that when it comes to greens drainage, we need to go beyond considering just the root zone permeability or the profile design and consider the interaction of these two factors. Given equal root zone permeability, the USGA profile yielded more rapid drainage. Indeed, even rainfall rates of about 4.4 in. hr.$^{-1}$ failed to overwhelm drainage of the USGA profiles as evidenced by equivalent drainage rates for both the low- and high-permeability root zones. Consequently, it appears that CA profiles need a root zone permeability about 20 in. hr.$^{-1}$ greater than USGA profiles to yield similar drainage rates. Of course, greens built to CA specifications may be reasonably expected to have these higher permeabilities since the root zones frequently contain pure sand.

Drainage rate represents an intensity attribute. The capacity attribute of subsurface drainage, in the context of the present study, is the completeness of excess water removal from the respective root zones. Here, it is commonly thought that formation of a perched water table in a USGA green would result in a less completely drained root zone than a CA green. Our results show that for equal root zone permeabilities the experimental USGA greens are drier after 48 hours (interpreted as having an increased drainage capacity) than the experimental CA greens. Also, the CA greens exhibited higher soil moistures midway between the drain lines. Both of these soil moisture features result from the need for water to move laterally through the root zone in a CA green before reaching a drain line. This rather slow route for water to exit the root zone, as compared with flow into and through the gravel of a USGA green, resulted in wetter soil conditions even after 48 hours of drainage. Again, for more complete drainage, a CA green appears to need a higher root zone permeability than a USGA green.

This research also illustrates that we need to consider how a putting green, either a CA or USGA construction method, fits into the landscape; that is, the green slope and direction. Green slope clearly had an effect on water redistribution following rainfall, and did so for both putting green construction methods. Within each profile design, however, the lower permeability root zone yielded enhanced downslope accumulation simply because there was more moisture retained and accessible for migration in this root zone. Interestingly, increasing slope in the CA profiles resulted in higher drainage rates at 27 hours and slightly drier root zones after 48 hours. Thus, green slope may be beneficial for continued drainage of a CA green.

On the other hand, the slope-induced, lateral differences in soil moisture observed for both the CA and USGA greens appears to be analogous to spatially non-uniform soil moistures observed within greens on golf courses. This spatial non-uniformity may result in the formation of localized drying or "hot spots" at upslope locations and excessive soil wetness in downslope locations. Both green construction methods apparently face this dilemma.

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GUY PRETTYMAN *is a graduate student pursuing his master's degree in soil science.* DR. ED McCOY *is an associate professor of soil science at Ohio State University.* *The authors wish to acknowledge the USGA and the GCSAA for their support of this research project.*

USING COMPOSTS TO IMPROVE TURF ECOLOGY

We are just beginning to learn about all the benefits compost can offer.

by F. DAN DINELLI, CGCS

North Shore Country Club participated in a two-year study of composts. Observations included a strong suppression of dollar spot disease from some of the compost materials.

IT IS SAID that *if any of the billions of organisms inhabiting the soil had hands, the fate of the world would be in them.* Although the world of soil microbiology holds many mysteries, scientists are learning more each day about the amazing role of soil diversity and health.

As the superintendent at North Shore Country Club (Glenview, Illinois), I became interested in applying compost as a soil amendment after reading about research suggesting its many agricultural benefits. Dr. Michael Boehm, of Ohio State University, and Dr. Eric Nelson, of Cornell University, have conducted research about the effects of compost on turfgrass. Generally, researchers and practitioners recognize that incorporating high-quality compost does several things:

1. Adds food for nearly every kind of organism needed by healthy soil.
2. Adds diversity of organisms to the soil.
3. Encourages plant growth-promoting substances in soils. Compost can also have an effect on soil structure, nutrient cycling, disease suppression, nematodes, and other biological activity.

In fact, the use of composts on turf is not new. In a 1917 USGA-sponsored book given to me by my grandfather, Frank Dinelli (retired greenkeeper at Northmoor Country Club), *Turf For Golf Courses*, by Charles V. Piper and Russell A. Oakley, there is a chapter devoted to "Manures, Composts, and Other Humus Materials." Because compost is not widely used on golf courses, I wanted to participate in further research prior to investing in the process at North Shore Country Club.

Research plots were constructed on the fifth fairway at North Shore Country Club using various compost and organic materials.

The materials did not exhibit any suppression of snow mold (left), but earlier green-up was observed with the composted plots versus the control (right).

Phase I: Experimentation

In 1996, we got that opportunity by participating in a two-year study of various composts and organic materials under the direction of Dr. Michael Cole, of the University of Illinois, and GreenCycle, Inc., operator of several composting facilities based in Northfield, Illinois. The study was a replicated 10 ft. × 10 ft. plot design on our fifth fairway comprised of creeping bentgrass and *Poa annua* maintained at ½". Our main objective was to observe any disease symptom differences between the research plots.

Our first application was in the fall of 1996 to see if the compost produced snow mold suppression. None of the materials demonstrated any noticeable snow mold suppression; however, plots treated with compost had a notably earlier green-up and recovery rate versus the control plots. The applications were repeated in the late spring of 1997. Observations through the remaining growing season showed strong dollar spot suppression (up to 80% reduction), improved turf color and density, and increased earthworm castings. While the initial objective of snow mold suppression was not observed, the experiment to test organic products to improve overall turf ecology proved quite successful.

Phase II: Implementation

Based on favorable results after two seasons of field evaluation of compost topdressing, we implemented the strategy on all our fairways. During our normal coring of fairways, the process involves:

1. Coring with hollow tines.
2. Breaking up the soil cores with a vertical mower.
3. Topdressing with compost.
4. Mixing the soil with compost as it is matted into the surface with a section of chain-link fence.
5. Blowing the remaining tufts of turf and thatch into rough via a three-point-hitch blower.
6. Picking up debris in the rough with an out-front rotary mower fitted with a bagging attachment.
7. Irrigating the area.

We have been coring fairways this way for several years. Adding the extra step of compost topdressing has not significantly impacted the workload. The cleanup is about the same and we can still get our targeted 9 holes (15 acres) done in one day. Part of our IPM cultural program is poling, by dragging a chain over the fairways each morning to remove leaf moisture. This process also manages earthworm casting buildup.

Phase III: Results

To date, the results are much the same as in the test plots: improved turf density and color, rapid healing of cored turf, dollar spot suppression, increased earthworm castings, and thatch reduction. We continue to monitor the impacts of compost use on turf and maintain computerized spreadsheets to evaluate our results. With time and continued applications, we hope to document improved soil structure and suppression of other diseases.

Selecting Quality Compost is Key

Selecting quality compost is very important; you have to do your homework. Compost products are not standardized, so the challenge is in obtaining consistent, high-quality compost. The procedure we use to assure that the compost we obtain is optimal for our turf involves a series of tests. We

Compost is used in many areas throughout the golf course, including the fairway topdressing program, as well as in the soil and seed mix for divot repair.

Another use of the compost material is to brew a compost tea. The compost is placed in a bulk fertilizer bag and then placed in water. A compressor is used to circulate the water during a five-day period. The liquid is then applied to promote plant growth.

analyze chemical, physical, and biological activity of the compost material. The following factors are tested in each analysis.

Chemical Analysis

- Carbon:nitrogen ratio of <20:1, best at 15:1.
- pH at 6.5 - 8.5.
- None to trace amounts of sulfide, ammonium, and nitrite.
- Low concentrations of soluble salts, especially sodium.
- We strive towards elemental balance and recommended ratios favoring the high side of potassium and calcium.
- Biosolids need to meet US EPA's Part 503 technical rule for biosolids. All biosolids need to be tested for coliform and other diseases. Biosolids composted properly have been heated sufficiently to kill viruses, coliform, and other diseases. Metals in biosolids are often high and this should be considered.

Physical Analysis

- Fine texture < or = ⅛".
- Light, crumbly structure, parent material non-visible.
- Moisture at 30-40%.
- Dark brown to black in color.

Microbiological Analysis

Microbiological analysis should show high biological activity in all functional groups and high diversity. The following six functional groups tested are:

- Heterotrophic (aerobic) bacteria.
- Yeasts and molds (fungi).
- Nitrogen-fixing bacteria.
- Actinomycetes.
- Anaerobic bacteria.
- Pseudomonads.

In addition, compost needs to be free of contaminants, such as weed seeds, plant parts, pathogens, stones, plastic, glass, wood, nails, etc. Compost also needs to be *mature*, testing > 50% on the maturity index. *In house* maturity tests can be performed by planting grass seed in a pot, utilizing the intended compost as the growing medium, to observe seedling health and establishment. Another method is to fill a plastic bag with moist intended compost and allowing it to sit sealed in the sun for a few days. Upon opening the bag, the compost should have an earthy smell, not an offensive smell from ammonia or sulfur.

Following these procedures will help ensure favorable results. Adverse effects can result when utilizing poor-quality compost. Starting slowly and testing small areas first is always helpful. Developing a working relationship with local composters will help in understanding their product.

Additional Uses for Compost

In addition to our fairway compost topdressing program, we also use compost in our soil and seed mix for divot repair. Compost is used as topdressing while overseeding turf. In 1998, a 7,000 sq. ft. experimental putting green was constructed using 20 different root zone mixes. Each mix used sand meeting USGA guidelines in a USGA root zone profile with various organic and inorganic amendments. The 90/10 sand/compost plots out-performed the others in seedling establishment and development. We continue monitoring other effects as the putting green matures. Compost tea is made and applied as a protective biofilm and to deliver plant growth promoting substances.

The Bottom Line

To apply compost topdressing to fairways we purchased a TY-Crop MH-400 for $20,000. This material hauler/topdresser is used for other tasks as well, such as rapid refill of materials while topdressing greens and tees and applying sand in bunkers. The compost we currently use is a 50/50 mix of yard trimming compost and biosolids. Our cost for yard trimming compost is $14.00/cubic yard. For us now, biosolids are freely available (EPA permits are needed). The rate used is approximately 17 yards (7 tons)/acre = ⅛" layer. Total material cost is $119/acre. We offset some costs by reducing our other fertility inputs and decreasing fungicide treatments as part of our IPM program.

All Composts Are Not Created Equal

Understanding the chemistry, biology, and science of compost is complicated. Parent material used, how it's managed during composting, and storage can all have a huge effect on the finished product and results. Our efforts have certainly paid off. Results using composts have been positive, and the turf ecology is improving under our growing conditions.

DAN DINELLI, CGCS, *is the golf course superintendent at North Shore Country Club and an active member in the Audubon Cooperative Sanctuary Program for Golf Courses. He can be reached at 827-724-4963 or via e-mail at ddinelli@AOL.COM.*

NEWS NOTES

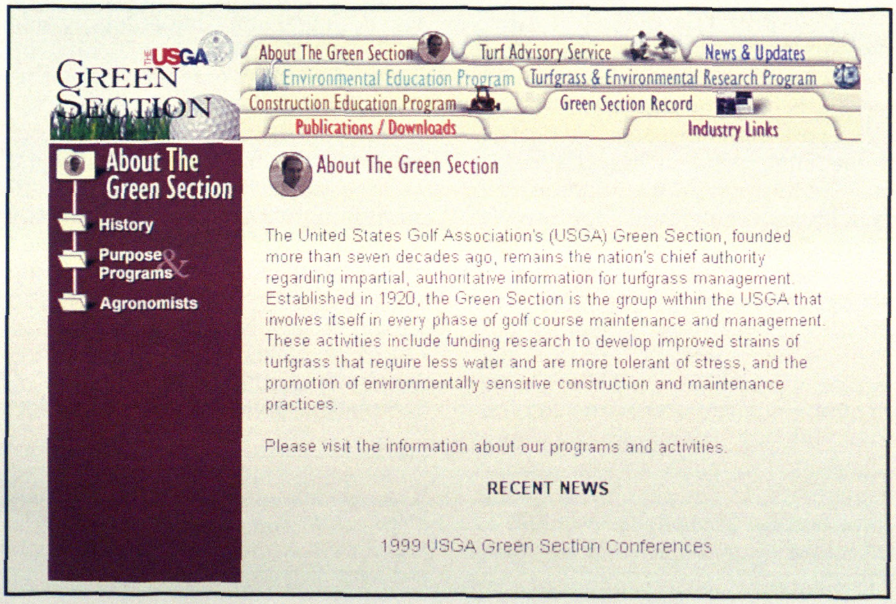
1999 USGA Green Section Internship Program

The USGA Green Section Internship Program provides selected students the opportunity to travel with Green Section staff members during Turf Advisory Service visits for one week between May and August 1999. The goal of the internship program is to provide students with a broad view of the golf course industry and the opportunity to learn about golf course maintenance through the perspective of the Green Section agronomists. Students participating in the program are junior or senior undergraduate or graduate students majoring in agronomy, horticulture, or a related field. The students have an interest in golf and turfgrass management. Each university may nominate one candidate for their program to participate in the final interview selection process. The following students have been selected to participate in the 1999 program.

Intern	School	Advisor
Robert Hertzing	California State Polytechnic University	Dr. Kent Kurtz
D. B. Todd Lowe	Clemson University	Dr. Ted Whitwell
Rick Welton	Colorado State University	Dr. Tony Koski
Aaron Patton	Iowa State University	Dr. Dave Minner
Ella Harrod	Mississippi State University	Dr. Michael Goatley, Jr.
Jason Lamb	Montana State University	Dr. Rob Golembiewski
David Cirata	Ohio State University	Dr. Karl Danneberger
E. Ryan Miller	Penn State University	Dr. Tom Watschke
Josh Honig	Rutgers University	Dr. Jim Murphy
Jason Gray	Texas A&M University	Dr. Richard White
Michael O'Bryant	University of Florida	Dr. Grady Miller
Thomas Grant	University of Rhode Island	Dr. Steven Alm
Jon Zalewski	Virginia Tech University	Dr. Dave Chalmers
Chris Kleene	Washington State University	Dr. Bill Johnston

USGA Green Section Regional Updates

Have you been looking for an easy way to keep up with the recent developments in your region? Look no further than the Green Section portion of the USGA web site. Throughout the year, the USGA Green Section agronomists will be writing regular updates for the web site on the latest agronomic activities occurring in their regions. The topics will be as diverse as the golf courses visited by the agronomists and might cover anything from aeration and anthracnose to zoysiagrass and zero-turning-radius mowers. Given the variety of places our agronomists visit, it's guaranteed there will be a few surprises included along the way. You will find the Green Section portion of the USGA web site at *http://www.usga.org/green*. The regional updates are found under the Turf Advisory Service tab. Visit regularly to find out what's happening within our world. You never know what kind of tips you might find.



Physical Soil Testing Laboratories*

The following laboratories are accredited by the American Association for Laboratory Accreditation (A2LA), having demonstrated ongoing competency in testing materials specified in the USGA's Recommendations for Putting Green Construction. The USGA recommends that only A2LA-accredited laboratories be used for testing and analyzing materials for building greens according to our guidelines.

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*Revised March 1999. Please contact the USGA Green Section (908-234-2300) for an updated list of accredited laboratories.

PLAY THE COURSE AS YOU FIND IT

Golf course setup is important for turfgrass management and the inherent challenge of the game.

by MATT NELSON

THOSE OF US who play golf realize that one of the most fascinating aspects of the game is the variability of conditions from day to day and golf course to golf course. Variability between golf courses is mostly attributed to design. Varying conditions at a particular golf course are due to changing weather, season of the year, grasses, and course setup.

Although golf course superintendents have no control over the weather, they do control setup of the golf course. Variety provides interest for the golfer, but it also allows the superintendent to manage wear on tees and greens. Many golfers understand the latter point until course setup causes difficulty with their game. Sometimes golfers are unhappy with a hole location, and equally common are golfers disgruntled with the location of the tee markers. Employees do choose inappropriate hole locations from time to time on steep or changing slopes, but demands for excessive green speed that does not conform with the architectural design of the putting greens often limits otherwise acceptable hole locations. When tee markers are located behind the yardage plaque or located on a side of a tee that forces players to hit shots they are not comfortable with, the Rules of Golf are often thrown out the window and the golf course superintendent is cursed as inept. Let's take a closer look at tee marker management.

Tee size should be determined by the following guideline: 100 sq. ft. of usable teeing area is necessary for every 1,000 rounds of golf played annually for par 4s and par 5s. Double this figure for par 3s, the 1st and 10th tees, and any other holes from which irons are regularly struck.

This guideline for area allows the golf course superintendent to rotate tee markers throughout the teeing area to effectively manage wear, meaning tee markers will be located both in front of and behind the yardage plaque from time to time. It is not the length of each hole, but the overall length of the golf course that should be maintained for handicapping purposes. Thus, tee markers should be set to balance forward, middle, and back placements. The overall length of the golf course has to vary by 22 yards to result in a change of 1/10 of one stroke in the course rating. Therefore, it is conceivable that a hole could play 35 yards longer than measured on a given day, as long as this additional length is compensated for on other holes.

Many golfers vaguely understand course rating and handicapping, especially when holes play longer or shorter than their official, measured length. There seems to be a group of adamant players at many golf courses who insist on playing from the permanent yardage plaque on the tee. Whatever game these people claim to be playing, it is not golf, and their so-called score cannot be posted for handicapping purposes. Rule 11-4 states that teeing off outside of the teeing ground (in front of, outside, or more than 2 club lengths behind the markers) results in a two-stroke penalty or disqualification in medal play, and a replay of the shot in match play. In my opinion, the penalty should be even more severe. These people who insist on playing from the permanent yardage plaque should be escorted off the golf course for their disrespect of the game of golf, their fellow members, and the golf course superintendent. These people do not understand the true fascinations, intrigue, variability, and unpredictability that make golf the greatest game of all. In addition, these people have no clue about what it entails to maintain the golf course to their expectations.

Lateral spacing of tee markers is another important component of effective tee management. Generally, a spacing of 5 to 7 paces provides ample teeing area with maximum rotation possibilities. This type of spacing also helps minimize inadvertent rule infractions. Simply placing the tee markers from one edge of the tee to the other and allowing golfers to play from anywhere between them will not evenly disperse wear, as players will tend to wear out the most favorable location. As stated previously, teeing off in front of, outside of, or more than two club lengths behind the tee markers results in a penalty. Moving tee markers to cater to your particular golf game is a violation of Rule 13-2 and should also result in removal from the golf course. If a tee marker location on the left side of a tee presents problems for your slice, tough luck! Go to the range and work on your slice. Hacking is no excuse to abandon the Rules of Golf. Furthermore, Rule 1-3 states that players shall not agree to exclude the operation of any Rule or to waive any penalty incurred. Rule 3-4 states that any competitor refusing to comply with a Rule affecting the rights of another competitor shall be disqualified.

Golf course setup is important not only for providing variety to the game we love, but is also an integral part of managing wear and maintaining premium playing conditions. Players who disrespectfully ignore course setup are not only cheaters, but are also compromising playing conditions for those people who play golf. Spread the word — play the game by the Rules, and play the golf course as you find it.

As an agronomist for the Green Section's Northeast Region, MATT NELSON *can be found, as is, visiting golf courses throughout New York and New Jersey.*

THE USGA

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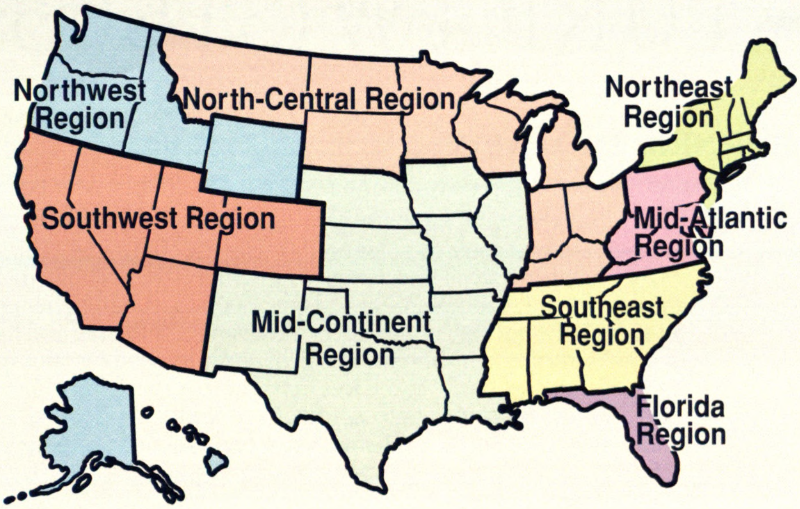

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TURF TWISTERS

OPENING TOO EARLY

Question: We are in the early planning stages of building a new golf course and are debating seeding rates for the greens. Do higher seeding rates result in quicker establishment and an earlier opening date? (New York)

Answer: Recent research at Cornell University compared various seeding rates (.5, 1, 2, 4 lb. per 1,000 sq. ft.) for establishing creeping bentgrass and found that establishment was not hastened by increasing seeding rates above the recommended 1 lb. per 1,000 sq. ft. rate. The higher seeding rates did provide more rapid cover initially, but cover differences between the 1 lb. rate and higher seeding rates were no longer evident six weeks after establishment. The 2 lb. and 4 lb. seeding rates resulted in more individual plants that had fewer tillers, more shallow and less fibrous root systems and higher disease incidence. The weaker, shallow-rooted plants are more likely to suffer from traffic injury once the greens are open to play. A seeding rate of 1 lb. per 1,000 sq. ft. is most effective and will not prolong establishment.

BY GOLFER DEMANDS

Question: What are the suggested heights of cut for hybrid bermudagrass fairways and roughs? The low-handicap golfers are always demanding closely cut fairways and at least 2-inch-high roughs like they see on TV. Yet the vast majority of our golfers have average to high handicaps, and they feel that this is a very penal course setup. (Florida)

Answer: First, for daily play, it is always best to try to maintain a course setup that accommodates the majority of the golfers. When it comes to bermudagrass fairways and roughs, during periods of active growth heights of cut of ½ inch and 1¼ to 1½ inches, respectively, would be suggested. Then, in the fall, as the growth rate of the bermuda begins to slow down, raising the height of cut to ⅝ to ¾ inch for the fairways and 1¾ inches for the rough areas is a standard practice at most courses. This slightly higher height of cut helps to increase the turf's wear tolerance and maintain a degree of definition between the fairway and rough cuts. These suggested heights of cut are not excessively penal for average- to high-handicap golfers.

RESULTS IN TRAUMA

Question: During the months of July and August I feel that it would be beneficial to aerify the putting greens, but I'm afraid to do so because of the physical trauma. Is there an alternative piece of equipment that can be used safely during the summer months to restore water movement through the soil profile? (Kansas)

Answer: One of the most popular methods of restoring water movement through the soil profile underneath putting greens during the summer months is to use a water injection aerifier. These aerifiers greatly reduce the physical trauma caused by aerification because they do not rely on the insertion of a tine that pulls the turf upward upon removal. For best results, water injection aerifiers are used in the "raised" position. The purpose of operating the aerifier in this mode is to produce a ¼-inch diameter passageway through the thatch layer that allows water and oxygen to move easily into the soil below. Since creating holes in the surface of a putting green can also allow soil moisture to escape quickly, water injection aerification should be performed in the early morning and the turf should be carefully monitored for drought symptoms for several days.