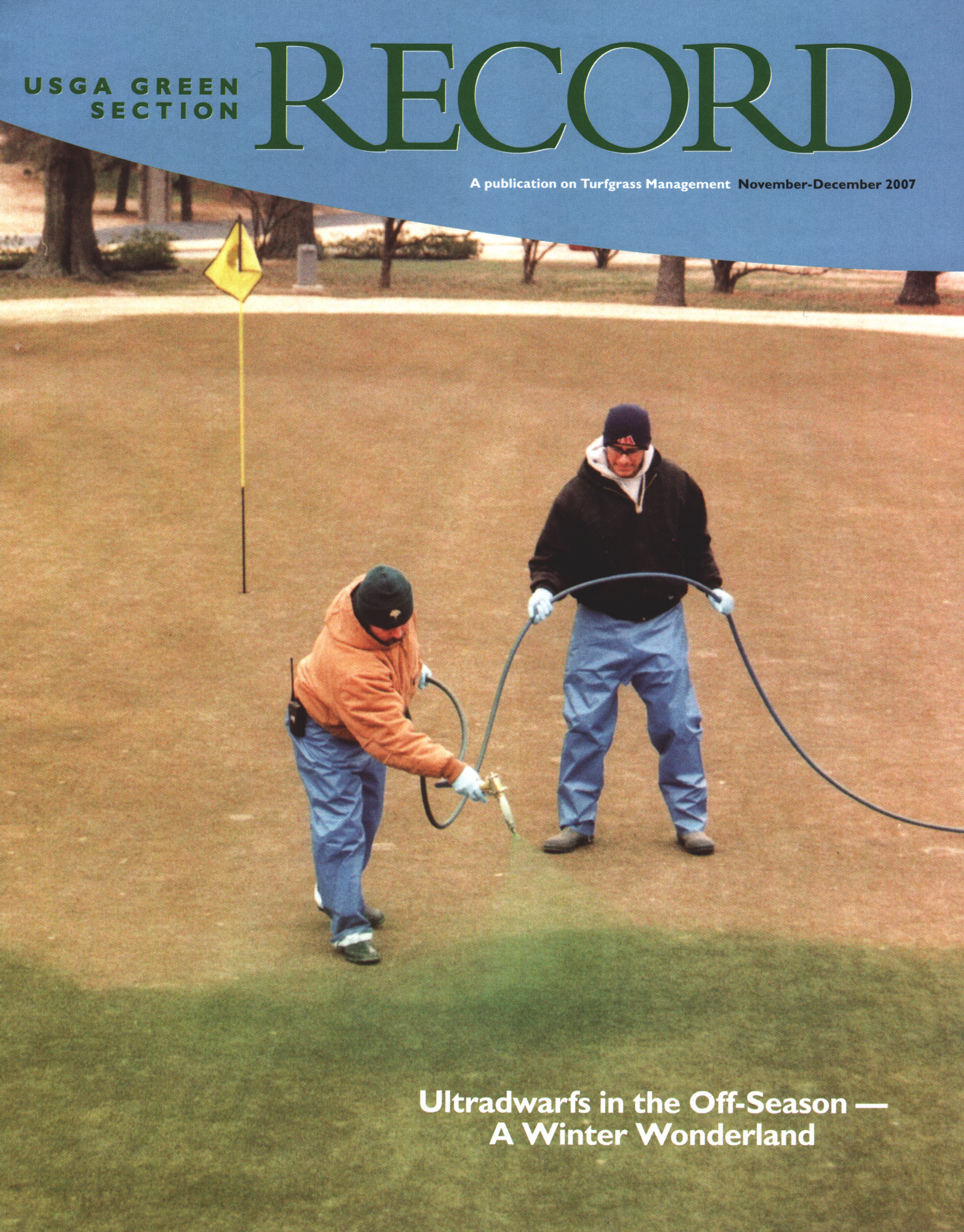
USGA GREEN SECTION

RECORD

A publication on Turfgrass Management November-December 2007



Ultradwarfs in the Off-Season — A Winter Wonderland

Contents

November-December 2007 Volume 45, Number 6

Cover Photo
Winter management of ultradwarf bermudagrass putting greens.

Ultradwarfs in the Off-Season – A Winter Wonderland

Winter may be the off-season, but with proper care, ultradwarf bermudagrass putting greens do not miss a beat.

BY PATRICK O'BRIEN
AND CHRIS HARTWIGER

The ultradwarf bermudagrass varieties have evolved from being labeled the next new thing to being considered the replacement for Tifdwarf bermudagrass. Their performance has been so strong that many golf courses with bentgrass putting greens are either considering or have replaced their bentgrass with an ultradwarf bermudagrass. A key component to having successful ultradwarf putting greens is managing them to a high standard in the winter months. This article will review how to prepare an ultradwarf for cooler months and what issues will need to be addressed. For the purposes of this article, the term *ultradwarf* refers to the varieties Champion, Miniverde, and TifEagle.

Nowhere is the art of greenkeeping more prevalent than in ultradwarf winter management programs. Beginning with their introduction almost ten years ago, superintendents with ultradwarf varieties adopted new philosophies and maintenance techniques in response to their unique characteristics. Because scientific research has been scarce or is just beginning in many of these areas, many of the ideas presented here are taken from superintendents who have extensive experience with ultradwarf varieties. We would like to thank Tim Etheridge, Dothan Country Club; Rodney Lingle, Memphis Country Club; Danny Malone, Berkeley Hall; and Ron Wright, Country Club of Mobile, for their contributions.

A painted ultradwarf bermudagrass putting green provides winter color without the negative attributes of overseeding.

Winter injury is no laughing matter. Covers must be used.

This article focuses on transition zone golf courses with ultradwarfs, but courses with 12-month growing seasons may find useful tips, too.

NO OVERSEEDING: A GOOD START

Winter management begins in the late summer, and the first item on the checklist is to not overseed the putting greens. In an era when most changes in the game of golf are making the game either more difficult, more expensive, or longer to play, there is a bright spot on the horizon. By not overseeding, superintendents with ultradwarf varieties are able to create more days of higher-quality putting surfaces. Bonuses with this approach include fewer inputs and lower costs.

The advantages of not overseeding can be summarized in the points below:

- **Elimination of Transition Periods** — Both the establishment of overseeding in the fall and its removal in the spring are influenced heavily by weather, are stressful to the bermudagrass base, and, most important, are highly disruptive to play. Not overseeding eliminates both transition periods.
- **Improved Putting Quality** — Golfers are not going to tolerate a no-overseeding program if putting quality is compromised. Regular observation of ultradwarf bermudagrass putting greens for the last ten years indicates that the best putting quality occurs approximately between April through early June and late September to late November. These are the periods when the bermudagrass is green and growing moderately, but temperatures are not in the optimum range for maximum growth. Winter putting quality is excellent, too. Maintaining excellent greens during these periods while avoiding competition from overseeding sets the stage for stronger greens in the spring and a better base to start the summer.
- **Organic Matter Dilution** — One of the secrets to successful putting greens over a long period of time is the dilution of organic matter in the upper rootzone with sand topdressing and core aeration. Overseeding adds more organic matter to the upper rootzone and therefore increases the amount of sand necessary to maintain a sand matrix in the upper rootzone. Putting greens that do not receive enough sand in aeration holes and surface topdressings are much more likely to experience secondary problems such as algae, scalping, poor drainage, disease, and bad transitions. Golf courses that do not overseed can lower their annual sand requirement.
- **Ease of Maintenance** — There is something to be said for the fact that with a no-overseeding program, the entire maintenance program can be set up around the needs of the bermudagrass. With an overseeding program, maintenance practices must be performed that are not ideal for the bermudagrass base. Contrast this with the fact that a non-overseeded green is able to take advantage of every day when temperatures and sunlight are adequate for growth.
- **Wear Tolerance** — A fear among those who are considering overseeding is high traffic in winter causing thin turf or areas of exposed soil on the putting greens. We do not see these problems occurring. The density and long growing season of the ultradwarfs allow turf to remain on the surface throughout the winter months even under high levels of play.

FALL MAINTENANCE

Fall is a time of year that brings a wide variation in temperatures. The management of an ultradwarf for the cooler fall and winter temperatures begins in early September. With these changes comes a shift in maintenance strategies.

MOWING HEIGHT MANAGEMENT

Cooler fall temperatures slow ultradwarf bermudagrass growth, and green speeds begin to increase at a given mowing height. For courses that do not overseed, excessive green speed in the winter months when growth has ceased is a real concern, but it can be prevented. Waiting until green speeds have exceeded a reasonable level is not the time to think about raising the mowers because no growth is occurring. The

solution is to begin raising mowing heights incrementally beginning in September. Temperatures can vary widely from week to week in the fall, and there is no absolute formula for how and when to raise mowing heights. Instead, we share with you the programs of three golf courses in different parts of the Southeast.

Ron Wright, The Country Club of Mobile, Mobile, Ala.: "I let member comments and the Stimpmeter tell me when to raise heights. Depending on the weather, we typically begin to raise heights from .130" to .140" during early October and then to .155" in late October to early November. Then we will alternate mowing and rolling in order to keep speeds in the 10-foot range."

Tim Etheridge, Dothan Country Club, Dothan, Ala.: "We slowly start raising the mowing height for winter in mid-September and try to get the height up to .150" by the end of October."

Rodney Lingle, Memphis Country Club: "In late summer we are usually mowing at around .125" and we are double-cutting every day. Around September 15, we start gradually moving our mowing height up to protect against winter kill and to give more rooting depth. As the weather gets cooler, it is not necessary to double-cut, because the grass is hardly growing. Our move upward in cutting height varies a little each year, but generally follows these guidelines: August — .125", September 20 — .135", October 20 — .157", November 20 — .190", December 20 through February — .220". You must remember that the more dormant bermuda greens get, the faster they get. We probably cut higher than other courses south of us, but we need the winter protection. The green speeds are still high (11-13 feet) when the greens become fully dormant."

SPRING DEAD SPOT PREVENTION

According to plant pathologists, all of the ultradwarf bermudagrasses are susceptible to spring dead spot. Treatment is made in late summer or early fall on golf courses with a history of spring dead spot or on those golf courses where a spring dead spot infection on putting greens will not be tolerated. Rubigan remains the most popular product to use for prevention of spring dead spot. With a no-overseeding program, timing of application is much easier because there is no need to worry about interference with seeding.

FERTILITY

With no overseeding, fall fertility is based upon the needs of the ultradwarf bermudagrass. Early September is a time to give the greens one last boost of nitrogen to provide the necessary energy for carbohydrate storage as the plant begins to harden off in the fall. A little extra nitrogen can also stimulate the growth necessary to move into higher mowing heights. As temperatures moderate in September and October, additional potassium applications are common. Iron and manganese applications can be helpful throughout the fall to maintain color. As always, allow soil test reports and your specific conditions to guide your fertility program.

Covering ultradwarf bermudagrass putting greens when conditions warrant is vital to protect against winter injury.

PLANT GROWTH REGULATORS (PGRs)

The PGR Primo is a staple in many ultradwarf bermudagrass putting green programs to reduce clipping production, provide a tighter surface, and maintain desired green speeds longer throughout the day. Most golf courses stop applying Primo after September 1. This is particularly important for those courses making a Rubigan application, as Rubigan has growth-regulating properties, too.

TOPDRESSING

Surface sand topdressing is a necessary and effective way to dilute the accumulation of organic matter. As the turfgrass growth slows during the fall, the quantity of sand that can be incorporated readily into the canopy diminishes.

However, we wondered how superintendents actually manage topdressing throughout the fall. The approaches below are quite informative. Note how frequency and the date of the last application changes as the location moves north.

Ron Wright, The Country Club of Mobile: "I don't topdress on Monday if I can still see sand from the previous application. But I continue to topdress the greens while they are dormant. It's a perfect time since you aren't mowing. It just takes one of those wonderful Mobile downpours to drive the sand into the rootzone."

Tim Etheridge, Dothan Country Club: "We try to match the amount of topdressing sand we put down to the growth rate of the greens. We normally are not topdressing much after mid-October, depending on the weather."

Rodney Lingle, Memphis Country Club: "We go from topdressing once a week during the summer, to every other week during September, and about once during the month of October. After October, we do not usually topdress again until the grass greens up in early March."

WINTER COLOR: PUTTING ON A COAT OF PAINT

The appearance of a golf course is part of the golf experience. While there is nothing wrong with having off-color or dormant ultradwarf putting greens, many golf courses use specialized turfgrass paints to provide green color at a reasonable cost. Painting techniques have become so good that, often, golfers visiting a course with painted greens will mistake the painted surface with actively growing grass.

Painting is an art, and many innovative methods to paint a putting green exist. In the field, we rarely see the same method used twice. Following the tips below is a good start, but feel free to modify these methods based upon your own circumstances.

TIMING

There are two schools of thought regarding the time of year to begin a painting program. Some golf course superintendents prefer to begin painting once the greens begin to go off color in mid to late fall. There is still some active growth occurring, but not much. Others prefer to wait until the putting greens are completely dormant before painting.

The primary difference between the two approaches is the number of times the greens will require painting. If the greens are actively growing, painted leaves will be mowed off over time and repainting will be needed. The rate at which this occurs depends on the growth rate of the grass. If the greens are not painted until they are completely dormant, the paint should last 8-12 weeks or until the grass breaks dormancy. Most golf courses following this approach can expect to paint one or two times per year at the most.

EQUIPMENT NEEDED

The most important component in the painting program is the sprayer. Turfgrass paint and water is far more viscous than herbicide, fungicide, or nutrient solutions. Some pumps are better able to handle paints than others. From the experience of superintendents, it seems piston or roller-type pumps seem to work best. Even with these types of pumps, the amount of wear on working parts of the pump will increase. The manufacturer of the sprayer pump is a good resource to discuss the suitability of the pump for painting.

Once a suitable sprayer has been obtained, a decision must be made whether to use a boom or a gun to apply the paint. The advantage of the boom is the speed and ease with which the paint is applied. No matter how well calibrated the nozzles are, though, there is going to be some streaking. Small "triangles" will be created on the collars or surrounds as the sprayer moves on and off the green.

Hand guns have the potential to apply the paint in a more uniform pattern with no "triangles" on the collars or surrounds. A hand gun allows the applicator to touch up light spots on the green immediately after painting. The quality of the painting is only as good as the talent or artistry of the applicator. Superintendents using hand guns advise that most applicators do a great job after an opportunity to practice on a portion of the nursery or practice putting green.

PROTECTING AGAINST WINTER INJURY

There are no ifs, ands, or buts about it. Cold temperatures can damage bermudagrass. History has shown that unprotected bermudagrass putting greens often are the first part of an all-bermudagrass golf course to succumb in cold

weather. Fortunately, a wide variety of turf covers that can dramatically decrease the chance for winter injury are available. Although there are many factors associated with winter injury, golf courses with ultradwarf putting greens in the transition zone need to have covers and must deploy them when conditions warrant.

The climate and temperature variation in the range of adaptation of ultradwarf bermudagrasses in the Southeast ranges from northwest Tennessee to the Florida Keys. If a location is one in which temperatures commonly fall below 25 degrees during the winter months, covers are not only recommended, they are considered mandatory. We have found that, in most years, the cover/no cover line extends from Jackson, Miss., to Montgomery, Ala., to Macon, Ga., and through southern South Carolina.

For courses that have covers, another question arises: "When should we cover our greens?" Dr. Mike Goatley conducted multiple research projects at Mississippi State University over the years regarding covers, and his general recommendation is to cover the greens any time the temperatures are predicted to fall below 25 degrees F. This is great advice to follow, and we have not seen any adverse effects when following it. Because some types of covers can be cumbersome to work with, these recommendations are stretched at times. For example, assume today's high is 57, tonight's predicted low is 24, and tomorrow's high is forecast for 62. Covers probably are not needed. Likewise, let's say tonight's low is scheduled for 26, tomorrow's high is going to be 39, and then the next night is forecast for 22 with a cooling trend to follow. It's probably a good idea to cover right away. The use of covers should be viewed as insurance, not a nuisance. If there is ever any doubt about whether to cover or not, go ahead and cover the greens.

A second use of covers is to protect an ultradwarf from premature dormancy by an early fall frost or protect a recently greened-up ultradwarf from a late spring frost. Both of these strategies can be used by superintendents to manipulate the growing environment and flatten out wide fluctuations in growth on the shoulders of the growing season.

An interesting fact from Dr. Mike Goatley's research on covers is that the type of cover material is not critical for winter injury protection. In other words, covers of all types of material performed equally as well at protecting bermudagrass putting greens from winter injury. Therefore, courses purchasing covers are advised to look at the weight and durability of the covers. Covers that are lighter weight and easier to install/uninstall are going to save labor hours and decrease the amount of time needed to cover/uncover greens.

Instant overseeding — turfgrass paint is mixed with water in a sprayer to produce excellent color.

WINTER MAINTENANCE ISSUES

Warm-season turfgrasses are not growing during the winter months in many locations, but golfers still enjoy playing golf, weather permitting. It is important to groom putting surfaces and provide

Hiding blemishes created by old hole locations is a challenge in late winter. Target hole liners are used in the winter to protect the edges of the hole so that the time between changing holes can be increased.

favorable playing conditions throughout the winter. Winter maintenance issues are reviewed below.

GREEN SPEED: WHEN FAST IS A PROBLEM

A familiar refrain heard from golfers throughout the region is, "We want faster green speeds." In the case of ultradwarf bermudagrass putting greens in the winter, be careful what you ask for. Preventing excessively fast speeds during the wintertime is an issue superintendents with non-overseeded ultradwarfs must manage for proactively. Developing such a program is not difficult, but it must be implemented before cold weather arrives. Nonetheless, sometimes superintendents are confronted with a situation during the winter when the green speeds are either above or below the desired range. Below are a few tips from superintendents on this issue.

Ron Wright, Country Club of Mobile: "Keep an eye on the long-range forecast. Let them slow down a bit if you are expecting cold, windy conditions in the near future. Let member comments and the Stimpmeter dictate your program. We measure green speed every day here. If the speed drops below 9.5 feet, we will roll the greens the following day if they are dormant. This will usually bring the speed up to 10.5 for a few days, depending on weather. Mow only when you have to."

Tim Etheridge, Dothan Country Club: "We mow the greens with walk mowers every day the weather permits. This mainly just rolls them since they are not growing, and it smoothes out scuff marks and picks up any small trash and debris that might be on them."

Rodney Lingle, Memphis Country Club: "The only time we seem to have a problem with slow greens is in the fall when we raise our mowing height, especially if the weather is abnormally warm for a week or so. If the greens slow down, we try to double-cut and roll to offset some of the slowness. I try to explain to

the members that the greens will speed up when the weather cools off again."

Danny Malone, Berkeley Hall: "We will roll if we need to increase speed. When speeds get too fast, we have brushed with push brooms to try to slow them down."

It is clear from the tips above that these superintendents pay attention to weather conditions and make adjustments as necessary. Therefore, it is not surprising that each of them has different frequencies of rolling and mowing during the winter months based upon weather conditions, which vary significantly by location.

CHANGING HOLE LOCATIONS AND BALL MARKS

When the growth of the grass slows or stops and mowing/rolling frequency decreases, blemishes to the surface such as ball marks and old hole plugs decrease smoothness and become more prominent. Expect the lowest level of turfgrass quality on an ultradwarf putting green to occur during the last few weeks prior to spring greenup.

Change holes as infrequently as possible based upon levels of play, the amount of cupping area, and deterioration of the hole. This typically equates to two to four times per week for most golf courses with ultradwarf putting greens in late winter. Some golf courses have used white hole target liners to preserve the edges of the hole and extend the time between changing holes.

Ball marks are an indication that people are playing the golf course, and this is good for business at every club. If ball marks become a distraction or an impediment to smoothness, topdressing and rolling are recommended. Many clubs have achieved positive results by topdressing individual ball marks with green sand. Although this practice is labor intensive, it will improve smoothness and appearance. Using a roller or running mowers over the putting green with the reels turned off are other excellent ways to improve smoothness.

WINTER WEEDS

Another program that becomes much simpler is winter weed control on non-overseeded ultradwarf putting greens. There are several new products, particularly in the sulfonyl urea class of herbicides, that provide excellent control of winter grassy weeds such as *Poa annua* or any winter broadleaf weeds. Use of non-selective herbicides is not recommended. Always apply herbicides according to the label.

WINTER IRRIGATION

An overlooked part of a winter management program is soil moisture. It is critical to maintain adequate soil moisture in ultradwarf bermudagrass putting greens, particularly those grown on high-sand-content rootzones. Although the plant may not be actively growing, desiccation or extreme drying is possible if rainfall is lacking and the putting greens are not watered.

One characteristic of most ultradwarf putting greens is that a majority of the growing or recovery points are near the surface. Should the top inch or so become dried out, two things can happen and both are difficult to see. First, the plant is under drought stress and there will be few visual symptoms present on a dormant or off-color ultradwarf bermudagrass putting green. Second, the temperature in the top inch will drop much faster toward the ambient temperature in a dried-out mat layer. This could prove lethal on cold nights.

There are no hard and fast rules regarding watering frequency and quantity. Check moisture first on slopes or mounds that are prone to drying out in the warmer months. Superintendents are advised to monitor soil moisture and add water as needed.

CONCLUSION

The real winners with ultradwarf putting greens are golfers. Golf is a 12-month game in the transition zone, weather permitting. Superintendents have taken the unique physical characteristics of these grasses and have developed a style of management that provides "in season" golf conditions in the cooler months of the year. Great grasses plus appropriate management makes a winning combination.

REFERENCES

Goatley, J. M., Jr.; Sneed, J. P.; Maddox, V. L.; Stewart, B. R.; Wells, D. W.; and Philley, H. W. 2007. Turf covers for winter protection of bermudagrass golf greens. Online. Applied Turfgrass Science doi:10.1094/ATS-2007-0423-01-RS.

PATRICK O'BRIEN *and* CHRIS HARTWIGER *have viewed many award-winning ultradwarf bermudagrass putting greens as Green Section agronomists in the USGA Green Section's Southeast Region.*

Cultural Management of Anthracnose Disease on Annual Bluegrass

Nitrogen fertility and growth regulators can have positive impacts on management of this potentially devastating disease.

BY JAMES A. MURPHY, JOHN C. INGUAGIATO, BRUCE B. CLARKE, BRAD S. PARK, AND T. J. LAWSON

Anthracnose is a disease on many turfgrass species throughout the world, but is particularly severe on weakened or senescent annual bluegrass (*Poa annua* L.) turf. Anthracnose is caused by the fungus *Colletotrichum cereale* (Manns, Crouch, Clarke, and Hillman), which persists in turf as a saprophyte in thatch or infected plant material. Typically, the fungus can become pathogenic and infect leaf, stem, or root tissue when an environment of high humidity or extended leaf wetness coincides with plant stress. Symptoms can be observed throughout the year, but they are most intense between June and September in temperate and transitional climatic zones.

Annual bluegrass grown on golf course putting greens is a weak perennial species that is known for its prolific production of seedheads, particularly between mid-April and June. Seedheads are unsightly, but more importantly, they also decrease the playability (smoothness and uniformity) of a putting green and deplete the carbohydrate (food) reserves of the plant by early summer. Consequently, carbohydrate-starved annual bluegrass plants are thought to be more susceptible to anthracnose once summer conditions become more stressful (e.g., hot, humid, and/or droughty weather).

The incidence and severity of anthracnose on annual bluegrass turf has increased in recent years throughout the United States, particularly along the East Coast and in Midwestern states. In many cases, epidemics were so severe that fungicides have been unable to effectively control the disease when used at label rates and application intervals, resulting in extensive turf damage and major disruption to play, especially on putting greens. It is thought that changes in fungicide use patterns as well as management practices commonly employed on golf courses may be predisposing turf to anthracnose.

It is probable that more than one or various combinations of management factors may be enhancing the severity of this disease and making it more difficult to control. Common management practices thought to affect anthracnose severity include N fertilization, mowing, rolling, chemical plant growth regulation, verticutting, topdressing, and irrigation. Our research program at Rutgers University has and is currently evaluating various aspects of these important cultural practices. The overall goal of our research is to develop a set of best management practices (BMPs) for the control of anthracnose disease on annual bluegrass putting green turf. This article summarizes findings from a trial that evaluated the impact of N fertilization, two chemical growth regulators, verticutting, and the potential interactions of these factors on anthracnose of an annual bluegrass putting green.

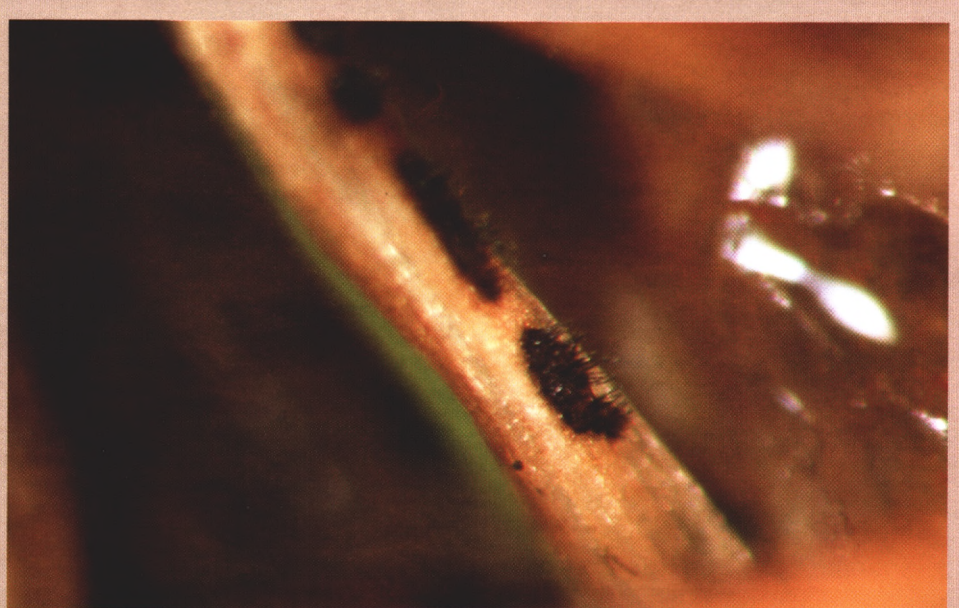
GENERAL RESEARCH METHODS

The trial was conducted on annual bluegrass turf grown on a Nixon sandy loam and maintained as a putting green. Plots were mowed 10 to 14 times per week with a triplex mower bench-set at 0.125 in. Turf was topdressed lightly with medium sand every 14 days and brushed with a cocoa mat. Water was applied uniformly to the plot area by hand-held hose or sprinkler irrigation to avoid severe drought, yet maintain firm, dry surface conditions consistent with industry playing standards. Preventative disease control (fungicides) that did not affect anthracnose was applied for dollar spot and brown patch diseases.

NITROGEN FERTILIZATION

Of the 17 essential nutrients required for plant growth, nitrogen (N) is often the fertilizer nutrient that can be most effectively used by a turf manager to impact plant vigor and health. Plant

Anthracnose Up Close and Personal



Anthracnose first appears on annual bluegrass as ¼- to ½-inch-diameter spots of yellow to orange-brown turf (top photo), which can progress to large, irregularly shaped areas on infected putting greens, tees, or fairways. Infection often first occurs on older or senescing leaves of plants, causing yellow leaf lesions (middle photo). "Basal stem rot" refers to the stage when the pathogen attacks leaf sheaths, stems, and the crown. Lesions on these plant parts initially appear water-soaked, but quickly turn black as tissue is destroyed. At this point, damaged shoots are easily pulled from the infected crown and the entire plant may die. Upon close examination with a magnifying glass or 10x hand lens, affected foliage and stems are often covered with small, black reproductive structures called *acervuli* (diagnostic feature). As acervuli mature, long black spines (setae) are produced (bottom photo). Each acervulus contains dozens of one-celled, crescent-shaped, asexual spores called *conidia*. The conidia are readily moved by wind, water, or other mechanical means to uninfected turf and cause infection.

growth and maintenance require relatively large amounts of N, and N deficiency can inhibit growth and reduce tolerance to environmental stress (Orcutt and Nilsen, 2000). In the Northeast, N is commonly applied at less than 3 lbs. per 1,000 sq. ft. annually on putting greens to limit leaf growth and reduce the frictional resistance to ball roll (Radko, 1985; Zontek, 2004). This may result in N deficiency during the growing season since recommendations for N fertilization of annual bluegrass putting greens typically range from 2.7 to 6.3 lbs. per 1,000 sq. ft. per year (Beard et al., 1978; Vargas and Turgeon, 2004). Turf maintained below optimal N levels can enhance the severity of diseases such as dollar spot and red thread (Smiley et al., 2005). The practice of occasionally spoon feeding turf with N at 0.05 to 0.125 lb. per 1,000 sq. ft. when plants are low in vigor may not be sufficient to maintain a healthy, disease-free playing surface.

We evaluated soluble N applied at 0.1 lb. per 1,000 sq. ft. (as an NH_4NO_3 solution) every 7 or 28 days beginning in mid-May and through the summers of 2003, 2004, and 2005. Our findings clearly indicate that low-rate soluble N fertilization every 7 days had the greatest reduction in anthracnose severity throughout this study; increasing N by 0.3 lb. per 1,000 sq. ft. per month during the summer reduced damage 25% to 73% (Table 1). More research is needed to determine the optimum frequency of low-rate liquid N fertilization; that is, fertilization every 14 or 21 days may be as effective as every 7 days at reducing severity of anthracnose.

Superintendents have frequently asked about the potential role, if any, of late- and early-season granular N fertilization in suppressing anthracnose of annual bluegrass turf. Some superintendents have reduced or abandoned the practice of applying granular N (¾ to 1¼ lbs. per 1,000 sq. ft.) on greens in the fall or spring, thus further reducing the supply of this important nutrient. Previous research on annual bluegrass fairway turf has found greater disease when most N was applied during April and May rather than November; also, N applied at 6 lbs. per 1,000 sq. ft. per year increased anthracnose foliar blight compared to 3 lbs. per 1,000 sq. ft. per year (Danneberger et al., 1983). Similar research is needed to define the possible role of late- or early-season granular N fertilization on anthracnose of putting green turf. Furthermore, the influence of the seasonal effect of granular N fertilization on the optimum frequency of low-rate liquid N fertilization during the growing season needs to be determined. Such research would provide insight into the feasibility of using foliar (liquid) fertilization to reduce and possibly eliminate higher-rate granular N fertilization with respect to disease management.

Table 1
Anthracnose disease response to N fertilization of annual bluegrass turf mowed at 0.125 in. in North Brunswick, N.J., during 2003. Data are representative of disease response in 2004 and 2005.

	Turf Area Infested			
	18 June	30 June	25 July	22 August
	%			
Nitrogen (N) †				
28-d	14.2a‡	36.8a	49.9a	39.8a
7-d	5.7b	12.8b	31.4b	35.9a

† Nitrogen was applied as an NH_4NO_3 solution containing 0.1 lb. per 1,000 sq. ft. of N from 12 May to 22 September 2003.

‡ Numbers in columns followed by a different letter are statistically different based on an *F*-test at the 0.05 probability level.

CHEMICAL GROWTH REGULATION

Chemical plant growth regulation has become an integral component of putting green management on many golf courses (Dernoeden, 2002; Danneberger, 2003). We evaluated two plant growth regulators (PGRs) for possible effects on anthracnose severity. Mefluidide (Embark® 0.2L) is applied to suppress seedhead formation in annual bluegrass putting green turf, which improves uniformity and smoothness of the playing surface. Trinexapac-ethyl (Primo MAXX™ 1ME) can also improve the vigor and playability of putting greens by reducing vertical shoot growth and increasing stand density and uniformity (McCullough et al., 2005). The Embark levels studied were either none or a split application of Embark at 0.69 fl. oz. per 1,000 sq. ft. two weeks apart in April 2003, 2004, and 2005. The levels of Primo studied were either none or Primo applied at 0.125 fl. oz. per 1,000 sq. ft. every 14 days starting at the same time Embark was applied, except on plots treated with Embark when Primo treatments were initiated on the last date of Embark treatment.

Our findings indicate that chemical growth regulation generally improved turfgrass quality, but the greatest benefits (i.e., reduced seedheads, better turf quality and reduced anthracnose) occurred when Embark and Primo were used sequentially. Disease reduction from growth regulation was not as consistent and generally not as dramatic as that observed with 7-day soluble N fertilization. The effect of either growth regulator used alone was inconsistent, but neither product greatly aggravated disease symptoms. At later stages of disease outbreaks, the greatest reduction in anthracnose occurred on

Table 2
Anthracnose disease response to N fertilization, Embark (mefluidide), and Primo (trinexapac-ethyl) application on annual bluegrass turf mowed at 0.125 in. during later stages of disease progression in 2004 and 2005.

			Turf Area Infested	
			2004	2005
Nitrogen†	Embark‡	Primo§	30 August	30 July
Interval (d)	fl. oz. per 1,000 sq. ft.		%	
28	0	0	65.0	84.9
28	0	0.125	51.3	86.5
28	0.69	0	57.4	82.0
28	0.69	0.125	50.3	85.3
7	0	0	48.9	66.6
7	0	0.125	43.0	67.6
7	0.69	0	50.0	69.0
7	0.69	0.125	25.1	45.9
	LSD		*6.8*	*9.4*

† Nitrogen was applied as an NH_4NO_3 solution containing 0.1 lb. per 1,000 sq. ft. of N from 7 May to 9 October 2004 and 21 May to 3 August 2005.

‡ Embark 0.2L was applied as a split application of 0.69 fl. oz. per 1,000 sq. ft. on 7 and 21 April 2004 and 6 and 20 April 2005.

§ Primo MAXX 1ME was applied every 14-d from 7 April to 22 September 2004 and 6 April to 10 August 2005. Initial Primo application was delayed on turf previously treated with Embark until 21 April in 2004 and 20 April on 2005.

plots treated with Embark and sequential applications of Primo under the 7-day N fertilization schedule (Table 2).

The combination of these PGRs presumably improved physiological and morphological characteristics of the turf, thereby reducing susceptibility to anthracnose, a disease that is known to be more severe on stressed turf (Smiley et al., 2005). Embark reduces seedhead production of annual bluegrass, and several studies have reported that regulation with Embark reallocates photosynthate away from shoots and seedheads to root and crown tissues (Cooper et al., 1987; Cooper et al., 1988; Hanson and Branham, 1987). Stress tolerance of turf improves with increased rooting; thus the reallocation of photosynthate to roots and crowns probably improved the vigor of annual bluegrass turf. Additionally, Primo applications can improve physiological characteristics (Ervin and Koski, 2001b; Zhang and Schmidt, 2000; McCann and Huang, 2007) as well as reduce internode elongation of turfgrass (Ervin and Koski, 1998; Ervin and Koski, 2001a). A slower growing, more compact turf would increase the proportion of the leaf blade remaining after mowing. Since leaf blades have greater photosynthetic efficiency than sheaths (Thorne, 1959), stress associated with routine low mowing would be reduced with the use of Primo.

Because plant growth regulation has become so prevalent, a better understanding of the impact of these materials on anthracnose is needed before more comprehensive BMPs can be developed to combat this devastating disease. Our current research is evaluating chemical regulation strategies that reduce seedhead formation in the spring, suppress vegetative growth throughout the season, or combine both forms of suppression. Various application timings, rates, and frequencies of Primo, Embark, and ethephon (Proxy®) are being studied for their effects on anthracnose.

VERTICUTTING

Anthracnose is reputed to be enhanced by wounding of host plant tissue. Verticutting is commonly used to reduce irregular shoot growth, puffiness, excessive thatch, and non-uniform shoot density of putting green turf with the goal of improving turfgrass quality and increasing ball roll distance. An initial report indicated that verticutting to a 0.2 in. depth increased the severity of anthracnose on a mixed annual bluegrass-creeping bentgrass turf compared to a 0.12 in. depth or no verticutting (Uddin and Soika, 2003).

We have evaluated verticutting to a 0.12 in. depth with 0.04 in. wide blades spaced 0.5 in. apart every 14 days from May to August 2003, 2004, and 2005. Contrary to expectations, verticutting to a shallow depth (0.12 in.) did not have a substantial effect on anthracnose. Verticutting in our study only cut leaf blades and did not remove organic matter from the thatch layer. Thus, verticutting at depths great enough to cut crowns and stolons or remove thatch may enhance plant stress and increase anthracnose, whereas verticutting to groom the leaf canopy does not appear to affect disease.

SUMMARY

Management of annual bluegrass putting green turf with soluble N applied every 7 days at a low rate (0.1 lb. per 1,000 sq. ft.) from late spring through summer provided the most consistent reduction in anthracnose severity. The growth regulators Embark and Primo used in sequence to suppress seedheads and vegetative growth also reduced anthracnose severity but not as consistently as weekly low-rate N fertilization. At advanced stages of disease, the combination of 7-day N fertilization and Embark and Primo applications provided the greatest reduction in disease severity. Use of Embark or Primo alone had infrequent and inconsistent effects on anthracnose but should not greatly aggravate disease severity.

Rutgers graduate student John Inguagiato discusses his anthracnose management research at Field Day.

Shallow verticutting of the upper leaf canopy (grooming) every two weeks during the growing season had little effect on anthracnose severity.

ACKNOWLEDGMENTS

The authors thank Dr. Hiranthi Samaranayake for assistance with statistical analysis. This work was supported by the New Jersey Agricultural Experiment Station, Rutgers Center for Turfgrass Science, and grants from the Tri-State Turf Research Foundation, United States Golf Association, and New Jersey Turfgrass Foundation.

REFERENCES

Beard, J. B., P. E. Rieke, A. J. Turgeon, and J. M. Vargas, Jr. 1978. Annual bluegrass (*Poa annua* L.) description, adaptation, culture, and control. Res. Rep. 352. Michigan State Univ. Agric. Exp. Stn., East Lansing, Mich.

Cooper, R. J., P. R. Henderlong, J. R. Street, and K. J. Karnok. 1987. Root growth, seedhead production, and quality of annual bluegrass as affected by mefluidide and a wetting agent. Agron. J. 79:929-934.

Cooper, R. J., J. R. Street, P. R. Henderlong, and A. J. Koski. 1988. An analysis of the carbohydrate status of mefluidide-treated annual bluegrass. Agron. J. 80:410-414.

Danneberger, K. 2003. Nobody could have predicted how vital PGRs have become. Golfdom 59(4):94.

Danneberger, T. K., J. M. Vargas, P. E. Rieke, and J. R. Street. 1983. Anthracnose development on annual bluegrass in response to nitrogen carriers and fungicide application. Agron. J. 75:35-38.

Dernoeden, P. H. 2002. Creeping bentgrass management: summer stresses, weeds, and selected maladies. John Wiley & Sons, Inc., Hoboken, N.J.

Ervin, E. H., and A. J. Koski. 1998. Growth responses of *Lolium perenne* L. to trinexapac-ethyl. HortScience 33:1200-1202.

Ervin, E. H., and A. J. Koski. 2001a. Kentucky bluegrass growth responses to trinexapac-ethyl, traffic, and nitrogen. Crop Sci. 41:1871-1877.

Ervin, E. H., and A. J. Koski. 2001b. Trinexapac-ethyl increases Kentucky bluegrass leaf cell density and chlorophyll concentration. HortScience 36:787-789.

Disease activity typically starts first in high-stress areas such as the perimeter of greens that were recently expanded or within the mower cleanup pass.

Hanson, K. V., and B. E. Branham. 1987. Effects of four growth regulators on photosynthate partitioning in "Majestic" Kentucky bluegrass. Crop Sci. 27:1257-1260.

McCann, S. E., and B. Huang. 2007. Effects of trinexapac-ethyl on creeping bentgrass responses to combined drought and heat stress. Crop Sci. *In Press.*

McCullough, P. E., H. Liu, and L. B. McCarty. 2005. Mowing operations influence creeping bentgrass putting green ball roll following plant growth regulator applications. HortScience 40:471-474.

Orcutt, D. M., and E. T. Nilsen. 2000. Physiology of plants under stress: Soil and biotic factors. John Wiley & Sons, New York, N.Y.

Radko, A. 1985. Have we gone too far with low nitrogen on greens? United States Golf Association Green Section Record 23:26-28.

Smiley, R. W., P. H. Dernoeden, and B. B. Clarke. 2005. Compendium of turfgrass diseases. 3rd ed. The American Pathological Society, St. Paul, Minn.

Thorne, G. N. 1959. Photosynthesis of lamina and sheath of barley leaves. Ann. Bot. 23:365-370.

Uddin, W., and M. D. Soika. 2003. Effects of turfgrass cultural management practices on severity of anthracnose basal rot in mixed annual bluegrass and creeping bentgrass greens. Phytopathology 93:S86.

Vargas, J. M., Jr., and A. J. Turgeon. 2004. *Poa annua*: physiology, culture, and control of annual bluegrass. John Wiley & Sons, Inc., Hoboken, N.J.

Zhang, X., and R. E. Schmidt. 2000. Hormone-containing products impact on antioxidant status of tall fescue and creeping bentgrass subjected to drought. Crop Sci. 40:1344-1349.

Zontek, S. 2004. Have we gone too far? The grass is talking to you. Are you listening? United States Golf Association Green Section Record 42:28.

JIM MURPHY *and* BRUCE CLARKE *are extension specialists in turfgrass management and pathology, respectively;* JOHN INGUAGIATO *is a graduate student;* BRAD PARK *is a sports turf research and education coordinator; and* T. J. LAWSON *is a principal laboratory technician at Rutgers University, New Brunswick, N.J.*

Research *You Can Use*

Phosphorus Leaching from Sand-Based Putting Greens

Auburn University investigates sub-surface applied phosphorus to minimize leaching.

BY BETH GUERTAL

Even though phosphorus (P) is the nutrient needed in the third greatest amount for turfgrass growth and production, the amount of research that has been done on P fertilization of turf is rather limited. This is especially true when the larger amounts of potassium (K) and nitrogen (N) required for turfgrass growth and development are used as a reference point.

Lack of research about P nutrition for turfgrasses may be for several reasons. First, although P is needed in larger quantities than micronutrients (such as iron, manganese, copper, and zinc), the amount typically required is much smaller than amounts of N and K, so it is easy to develop a mindset that P is less important. Second, years of field-crop research have shown that P is less mobile than N, so it has been thought that P is less likely to be lost from the rootzone via leaching. Leaching of N from sand-based putting green mixes has been widely studied in turfgrass systems, but there is less evaluation of P leaching because it has not been thought to be a loss pathway of much environmental consequence. Loss of P via runoff, with subsequent possible pollution of surrounding surface water, has received far more study in turfgrass systems.

A third reason for limited P research in turf is that P fertilizer recommendations are made as a result of years of soil-test calibration and are not based on crop-response calibration curves.

The lysimeter research facility at the Auburn University Turfgrass Unit consists of four sets of 16 lysimeters each. Each lysimeter drains completely into a collection vessel. The collection vessels are housed under the valve boxes shown in the photo foreground, and the lysimeter is built above it.

Soil testing and fertilizer recommendation methods for P have long been evaluated for field and pasture crops. Because it tends to be a regional issue and related to factors such as crop, soil type, and soil extractant, there are only a few studies that have evaluated turf growth and response related to extractable soil P, especially in high-sand greens.

Turfgrass putting greens are unique because they use constructed rootzones, typically high in sand, and thus have very low cation exchange capacities. There is evidence that P will leach in sandy soils. In one recent turfgrass study, P leaching losses from a St. Augustinegrass residential landscape in a sandy Florida soil were measurable, and they were highest during lawn

establishment and immediately after heavy rain (3). Phosphorus leaching is especially likely when P accumulates in excess of that capable of being held by the soil. This accumulation at the soil surface can occur as a long-term effect of P application in no-till crop production systems.

Because a putting green cannot be inverted or tilled, in some respects a green can be viewed as in a no-till soil. Thus, many of the research findings from agronomic no-till research might be a starting point for P research in putting greens. For example, research in no-till corn has shown that band placement of P (in a narrow strip alongside the seed) can increase early growth of corn, compared to when that P was broadcast (2). This is because banded P is less prone to rapid fixation by soil clays because less P comes into contact with the soil. When broadcast applied, P may accumulate at the soil surface, resulting in stratification of P within the soil profile.

Phosphorus placement research has not yet been completed in putting greens, so we do not know if P will stratify (or move) in a sand-based putting green. We also do not know if banded P would be more available to a growing turfgrass plant than if the same P was broadcast applied. In turf production, "banded" P would actually be a vertical band, as P would be applied as a part of core aeration, with P fertilizer swept into holes left by the aeration procedure. Thus, for this research project, one objective of the research was to determine if deep placement of P in aeration holes (banded, or sub-surface applied) increased P uptake by turf. A second objective was to determine if P placement (sub-surface or broadcast) or P rate affected P leaching in a high-sand USGA-type putting green.

MATERIALS AND METHODS

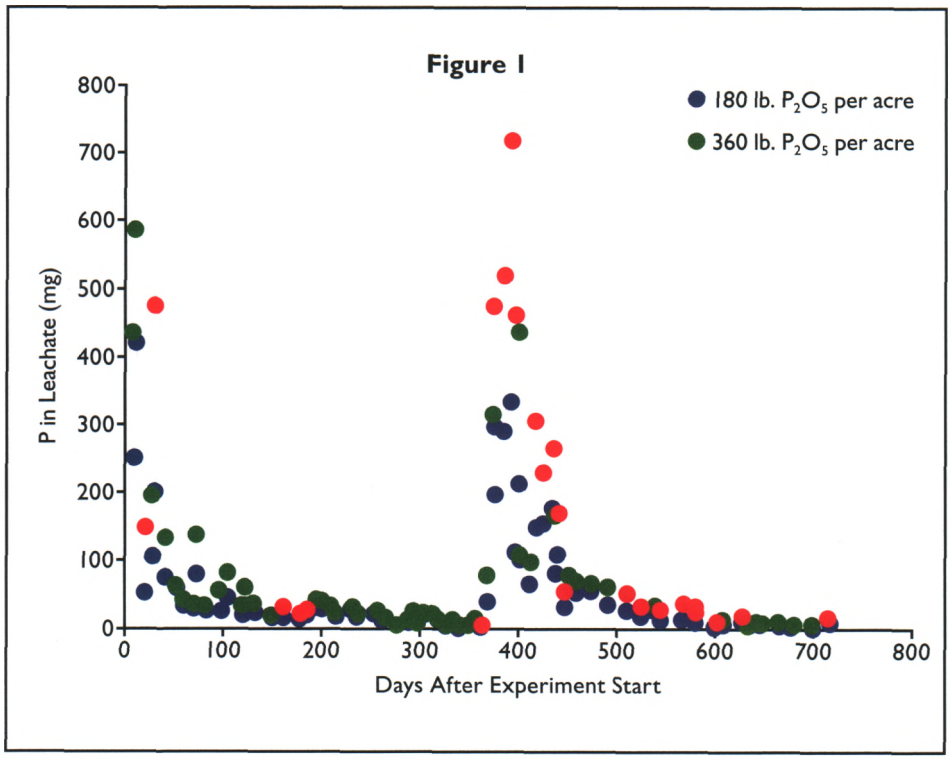
The two-year study was started in 2002 using 16 small individual putting greens at the Auburn University Turfgrass Research Unit, located in Auburn, Ala. Built in 2001, the putting greens consisted of 70-gallon plastic cattle watering tanks buried in the ground, with the edge of the tank even with the soil surface. Each green drained to a 5-gallon collection chamber, enabling leachate to be collected and measured. The greens were filled with an 80/20 (sand/peat) USGA-type greensmix, and in March 2002 each green was sprigged with Tifdwarf hybrid bermudagrass. One month after sprigging, P fertilizer treatments were initiated when each putting green was at 50% establishment.

An example of the first-generation lysimeters that were built prior to the switch to plastic cattle waterers. This top view shows four individual lysimeters, each of which drains into a collection vessel.

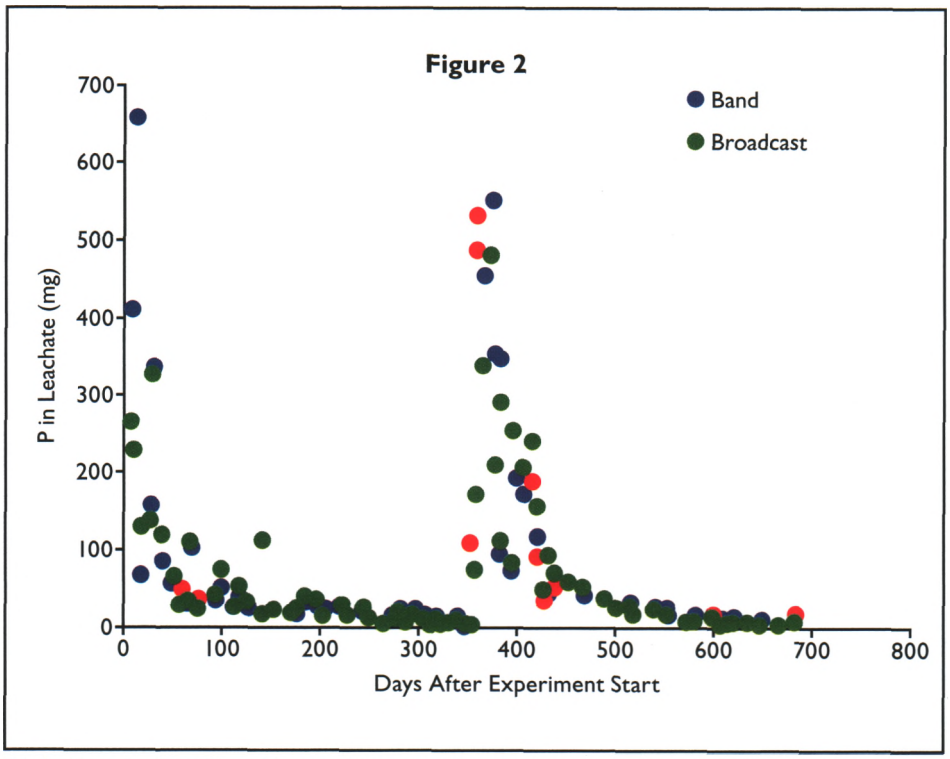
Phosphorous fertilizer treatments consisted of two rates of P fertilization (180 lb. P_2O_5 per acre and 360 lb. P_2O_5 per acre) and two types of P placement (band and broadcast). The P rates were based on the Alabama recommended rate (180 lb. P_2O_5 per acre) of fertilizer P for a bermudagrass putting green with an initial "very low" P soil test (average P soil test was 2 lbs. P_2O_5 per acre). The higher P rate was twice the recommended rate and was selected to represent a worse case scenario — a high rate of P applied to the soil surface.

Sub-surface treatments were applied by core aerating the green (⅜-inch diameter cores, 4 inches deep, 4-inch spacing), removing the cores, and sweeping the P fertilizer (triple superphosphate, 0-45-0) into the aeration holes, followed by sand topdressing. Broadcast P fertilizer treatments were applied by aerating the plots, removing the cores, sweeping topdressing sand into the aeration holes, and spreading P fertilizer across the entire plot surface. Phosphorus treatments were applied on April 18, 2002, and reapplied on April 16, 2003.

The research area received irrigation as needed to provide a total of one inch of rainfall/irrigation per week. Plots were mowed with a walk-behind greens mower to maintain a mowing height of 5⁄32 inch. In 2002, percent establishment was visually evaluated in each plot until 95% establishment was recorded. Each week, the total volume of leachate from each green was



P in leachate (mg) as affected by sampling time and P rate in a Tifdwarf hybrid bermudagrass putting green. Significant differences in leachate P are indicated when the data point for the 360 lb. P_2O_5 rate is colored red, indicating a significant difference at that sampling date compared to the 180 lb. P_2O_5 per acre fertilization rate.



P in leachate (mg) as affected by sampling time and method of P placement in a Tifdwarf hybrid bermudagrass putting green. Significant differences in leachate P are indicated when the data point for the sub-surface applied treatment is colored red, indicating a significant difference at that sampling date compared to the broadcast P fertilization method.

measured, and a subsample was taken for solution P analysis. At 3, 6, 9 (2003 only), and 12 weeks after P fertilization, soil samples were collected from each plot. Samples were taken at 2-inch increments to a depth of 10 inches, and P was extracted with Mehlich III for phosphorus determination. Each month clipping yield was measured and P content of the clippings was determined.

RESULTS

Figures 1 and 2 illustrate the results from two years of leachate collection. Results are shown as mg of collected P, determined by multiplying the volume of collected leachate (mL) and the concentration of P (micrograms/mL) in the collected subsample. Over the two years the study was conducted, there was rarely a significant P rate × P method interaction (6 times out of 79 leachate collections), indicating that differences in leached P were largely due to P rate or the method of applying the P, but not the combination of the two.

Over the 715 days that the study was conducted, leachate was collected and analyzed 79 times. Out of those collections, the rate of P fertilization significantly affected leachate P 26 times (33%), with the P in leachate always higher from plots that received the higher rate of P (Figure 1). The method of P application (sub-surface or broadcast) significantly affected leachate P 11 times (14%) (Figure 2). Most of these significant results occurred in the second year of the study, and they are partly reflected as a delay in P leaching from broadcast treatments, as compared to sub-surface. For example, in 2003, at 7, 13, and 14 days after the P fertilization (DAF) was applied, leachate P from plots in which the P fertilizer was swept into the aeration holes was greater than from plots in which the fertilizer had been broadcast. By 71, 75, 84, and 89 DAF, leachate P was greater from plots in which P was broadcast applied.

In this study, two years of leachate data indicates that, when applied at an agronomically recommended rate, P leaching was greatest in the first month after fertilizer application. The single application of P fertilizer (at a high rate of P) to a sandy putting green soil created a risk of P leaching. Others have shown similar results, with P leaching losses greatest in immature landscapes and when rainfall amounts were greatest (1).

When P fertilizer was applied at a recommended and 2× rate, the rate of bermudagrass establishment (Year 1) never increased by the addition of the extra phosphorus (2× rate). However, establishment was faster when the P was broadcast applied, rather than banded. For example, on June 20, plots receiving broadcast P were 88% established, while those receiving sub-surface applied P were 79% established, a significant difference. All plots had reached 95% establishment by July 12, after which clipping yield and P uptake data were collected.

There was never an agronomic benefit to applying P above the recommended rate of 180 lb. P_2O_5 per acre. Soil-test calibration is a continually evolving issue, as new extractants, methods of calibration, and soil-test devices are developed. Although outside of the objectives of this research, other work at Auburn is beginning to show that current Auburn soil-test recommendations for bermudagrass putting greens may need adjustment, as bermudagrass response may be maximized at a soil-test critical level below the current 180 lb. P_2O_5 per acre recommendation. Reevaluations of soil-test procedures are a constant research need and are always underway with different crops and nutrients.

In 2002, July, August, and September clipping yields were never affected by P rate. When P was broadcast applied, the July and August clipping yields were greater than when P was sub-surface applied. In 2003, clippings were collected in May (twice), June, and July. As in 2002, P rate did not affect clipping yield. The sub-surface application of P only increased clipping yield in the first May clipping harvest, with no significant difference in clipping yield due to method of P fertilization thereafter.

Over the two years of clipping harvests, P rate did not affect P uptake by the bermudagrass, but method of P fertilization did. In 7 of the 8 clipping harvests, P uptake was greater in bermudagrass from plots receiving broadcast P than in sub-surface applied plots. Tissue P content ranged from 1.1% to 6.6%. End of experiment (2004) shoot density was not affected by either P rate or method of P placement.

In summary, leaching of P may occur in sand-based putting greens. There were no agronomic or environmental benefits to band application of P fertilizer. Uptake of P and clipping yield were better when P was broadcast applied than when the P was band applied. Applying a 2× rate of P fertilizer never improved grass establishment, clipping yield, shoot yield, or P retention in the rootzone. Application of P at a 2× recommended rate makes no agronomic or environmental sense. When applying P fertilizer to a sand-based putting green, use smaller amounts applied at a more frequent interval, using your soil-test recommendations as a point of reference.

Upon closer inspection, the collection vessel is simply a 5-gallon gas can built into a wood-framed box. The plastic tube that drains into each gas can is attached to the drainage hole of each 70-gallon cattle waterer, which is buried to ground level. Each collection vessel is emptied once per week, unless sufficient rainfall occurs to require additional collection.

LITERATURE CITED

1. Erickson, J. E., J. L. Cisar, G. H. Snyder, and J. C. Volin. 2005. Phosphorus and potassium leaching under contrasting residential landscape models established on a sandy soil. *Crop Sci.* 45:546-552.

2. Mallarino, A. P., J. M. Bordoli, and R. Borges. 1999. Phosphorus and potassium placement effects on early growth and nutrient uptake of no-till corn and relationships with grain yield. *Agron. J.* 91:37-45.

EDITOR'S NOTE: An expanded version of this paper can be found online at *USGA Turfgrass and Environmental Research Online* (http://usgatero.msu.edu/v06/n16.pdf).

E. A. GUERTAL, PH.D., *professor, Turfgrass Management, Department of Agronomy and Soils, Auburn University, Auburn, Ala.*

CONNECTING THE DOTS

A Q&A with Dr. Beth Guertal, *Auburn University, about phosphorus management for golf courses.*

Q: *Ecologically, phosphorus is sometimes referred to as the "linchpin" nutrient regarding eutrophication of surface water. Please explain.*

A: Long-term application of phosphorus (P) to the soil surface can lead to accumulation of P at the surface. This P is prone to movement with surface runoff, either as P attached to soil particles or P dissolved in the runoff water. Once P leaves with runoff water, it ends up wherever the water does — in streams, rivers, or lakes. When bodies of water receive excess P, it helps create an environment that is favorable to algae growth (eutrophication), or "algae blooms." This flush in algae growth reduces water oxygen content and can lead to fish kills. Phosphorus is not the only factor in eutrophication, but it is involved, and there has been a great deal of research that focuses on non-point P pollution effects on water quality.

Q: *As environmental stewards, superintendents have to be cautious to minimize nutrient runoff and leaching from golf courses. Has phosphorus gotten the attention it deserves from the scientific community regarding its potential effect on surface water and groundwater quality?*

A: Next only to nitrogen, P has garnered its share of attention from the scientific community. A lot of focus has been placed on P runoff in cropping systems where there has been long-term application of animal wastes (especially poultry litter). Basically, animal waste contains P (usually more P than N), and that waste has to go somewhere. Usually, that "somewhere" is a pasture or production field, and long-term surface application of manure results. This often results in accumulated P, and that P may move in runoff to water.

The other area where we've seen a lot of research is in no-till crop production. Placement of P is an issue there, because in a no- or minimum-till system there is little disturbance of the soil, and P may be largely surface applied. If the field is continually no-tilled, the fertilizer P may accumulate and move to water with runoff. This research has some application to turfgrass, as the systems are similar in that there is no inversion tillage, and fertilizers are typically surface applied without incorporation.

Q: *Was applying sub-surface phosphorus (e.g., sweeping the applied phosphorus fertilizer into aeration holes) a way to minimize phosphorus runoff losses? Do you have data that support this rationale?*

A: The idea behind "band" application of P wasn't to reduce runoff losses, but rather to increase the availability of P for plant uptake. The idea was taken from row-crop production, where P is often applied in a horizontal band two inches from the planting row and two inches deep. This zone of concentrated P reduces soil:fertilizer contact, slowing the conversion of P into less-soluble forms (such as calcium phosphates or iron phosphates). These less-soluble forms of P are not immediately available for plant uptake and must be solubilized over time into plant-available P. A band of P slows that conversion, and roots from new seedlings can reach the P in the band, increasing uptake. Our idea was to take that banding concept and turn it vertically, placing the P in a concentrated zone at the bottom of a core aeration hole.

Q: *Why do you think P uptake and clipping yield were better when P was broadcast applied compared to sub-surface?*

A: In these newly establishing research plots, the surface-applied P was available for the new bermudagrass growth, which was largely on the surface through stolons and shallow rhizomes.

Q: *Do you think the results of your study on sand-based putting greens are applicable to potential P losses from other turfgrass sites such as sports fields and home lawns?*

A: The results represent an absolute worse-case scenario: sandy soils, turf initially in the establishment phase, and, in one treatment, an excessive rate of P application. It is important to remember that well-maintained and uniform turf is one of nature's best filters, and when P is correctly applied, runoff and leaching are often minimal. This is especially true in heavier soils that have higher silt and clay contents than used in our sand-based study — where P is far less prone to movement via leaching, for example.

The key is to avoid excessive application that results in a buildup of P at the surface. When I look at the soil tests that come through Auburn's laboratory, you can see the home lawns that have had long-term overapplication of materials such as 10-10-10 or 13-13-13. These tests often have P in the "very high" or "extremely high" category, and no additional P fertilizer is needed, probably for quite a while.

Q: *Phosphorus fertilizer is agronomically important for rapid turfgrass establishment. Is this when phosphorus is especially prone to leaching losses? What's the best advice for superintendents to minimize such P losses during establishment?*

A: There is actually very little published research that examines P leaching in turfgrass systems. A few runoff studies have shown a greater risk for P movement during the establishment phase (research on cool-season grasses), basically because there is more bare soil, which is prone to erosion. When the soil erodes, the P goes with it.

My best advice would be to: 1) apply P according to soil-test recommendations, and 2) do not overapply P in order to "build up" your soil P. Additionally, take soil tests frequently during grow-in. In some other P research we conducted on a loamy soil, additional P fertilizer was needed at approximately 3-month intervals, when the P was applied at the recommended rate.

Q: *Did you find your research results surprising, and do those results point to other needed research regarding P losses from sand-based rootzones?*

A: I thought that we would see positive results from the application of banded P, especially as the greens matured. We did not see that, and broadcast P was our best treatment. In some of our other research, on five-year-old TifEagle greens, we showed an increase in P uptake when the P was band applied compared to surface broadcast.

Also, P leaching, even from plots that had a 2× application rate, was less than anticipated, and dropped off quickly after each year's application. The next research would be to see how that changes when there is long-term application of P, and how the leaching of P might change in older, established greens.

Jeff Nus, Ph.D., *manager, Green Section Research.*

Communicating Without Saying a Word

Availability speaks louder than words, and playing golf can communicate more than a score.

BY THOMAS VOGEL

Before each round, teams are picked and then rotated every six holes to play three distinct matches. Superintendent Tom Vogel, CGCS (fourth from left), and professional Rod Johnston, MGP (third from left), tee off with two members — Dr. Richard Rea (second from left) and Dr. Kamienski (hitting). The benefits from their time together will extend well beyond the playing of 18 holes.

Most golf course superintendents would agree that we must communicate — to our memberships, customers/golfers, and guests — any concerns we may have about the golf courses we are responsible for maintaining. However, we also need to communicate when there are no concerns and all is going well. Newsletters, e-mails, Web sites, and meetings are the most used avenues to inform golfers of our efforts and intentions for the course, but another avenue that I believe is overlooked as a way of communicating is by playing golf.

Twenty-five years ago, Portage Country Club hired Rodney Johnston as its golf professional. Rod has a strong belief that the two most important persons at a club or course are the golf course superintendent and the golf professional. He opened a line of communication between the two of us by inviting me to play a round of golf with him. At first, I was not too excited about playing golf with the golf professional. At that time I was not that good of a player (I had a 22 handicap) and didn't want to expose my poor playing ability. Additionally, I felt it would be taking up valuable time I needed to maintain the golf course.

Rod suggested we play at least once a week to discuss the importance of conditioning and the scheduling of events and how they interact between the two departments. For the betterment of the golf course I agreed to play. Playing golf with friends is one thing, but when you play with the pros you see (and hear) things from a different perspective. There is a lot more to the game of golf than just hitting the ball and looking for it. As a 22-handicap player I didn't think about it too deeply — as long as the grass is cut and the greens are mowed, my job is done, right? I found out quickly I needed a new way of thinking.

A lot of finesse goes into playing golf at a higher level and I saw a new beginning to what I needed and wanted to set as a goal. It also made

A few times each summer, Rod Johnston and Tom Vogel invite or are invited to play with ladies. They are always interested in sharing time and hearing from both genders and all handicap levels.

me think of my golf game, and I discovered that I now wanted to play better golf. Rod took time and worked with me and, after a few lessons, lowered my handicap to 18 in just a few short weeks. As my handicap decreased, I had a better feel for the golf course and how much the little things counted in the game. Rod has continued to help me through the years and, although I am not a golf professional, I do maintain a 12 handicap, which I think is respectable in the golf world.

The gist of this article, though, is not about me and my now lowered handicap; it's about playing golf with the golf professional and the two of us becoming a team for a better golf experience for and with our members. What happened 25 years ago quickly grew into an 8:53 a.m. standing tee time on Sunday mornings. Once we realized the benefits of playing together, we invited members to play along. This action opened a line of communication that I never realized existed. Prior to this I would talk with members at green and golf committee meetings or over the shoulder at lunch, but never for four hours on the golf course.

Playing golf with our customers allows the formal atmosphere to vanish, and they become very curious about what, how, and why we do things the way we do. In every case, after the game is over they leave with a better understanding of, and more respect for, our professions. They appreciate the camaraderie that Rod and I have, knowing we're working together to make a better experience for them.

Now the 8:53 a.m. tee time has become so popular that our members actually ask to play with us. We try not to play with the same group every time, extending an open invitation to anyone who is interested in playing with us. We also do not pick who we play with by handicap or gender. We play with men, women, and mixed couples no matter what their handicaps. All too often women think they are passed over and feel left out. Including them is an excellent way of letting them know we want them to play and have a good time. We value interacting with the ladies as much as the men.

Another important group we try to invite is the new members. Sharing

Occasionally Tom Vogel and Rod Johnston spend time playing with a husband-and-wife team.

Golf professional Rod Johnston has helped superintendent Tom Vogel to lower his handicap. Their regular communication has made every member of the Portage Country Club a winner.

our golf time with them shows that we are accessible; they can ask us anything and feel comfortable doing so. It's not about how well we're playing — it's about sharing time and ideas and showing the members you care. In almost every case, when our round is over, I feel as though I've not only played golf with a member, but I also made a new friend. Their subsequent waves are stronger, the hellos are more meaningful, and that's very important to me. Sometimes when things are not as they should be, we need a friendly vote or understanding of our side, and playing golf with members and building relationships bring support on our behalf.

From listening to comments from other superintendents at local association lunch meetings or at national and regional conferences, a strong working relationship with the golf professional is very rare. My question is — why? There is nothing more important than these two departments interacting, both in operations and in the desire to meet a common goal. This doesn't mean that we agree on everything, but we do have the opportunity to talk things out and agree on a course of action. I do believe that egos can sometimes get in the way, and no one wants to give in to the other. But what must be considered is what is right, not who is right. Superintendents need to keep in mind that the golf course staff does not have as much opportunity to interact with the members/customers as the golf shop staff, and we need all the positive support we can get. Having the golf shop staff in sync with the golf course staff just makes sense. When everything is working on an even keel, it also helps reduce the "seven year switch." One of the last things we need is to have a new golf professional every few years, not to mention a new superintendent. We need to keep the staff we have, and sometimes that means standing up for the golf professional and supporting his/her operation.

I'm not suggesting that building a strong working relationship with the golf professional and members/golfers will always be easy. Sometimes it's work, sometimes you have to bite your tongue, and sometimes you have to do things you don't want to do. However, in the end, those rounds are time well spent and everybody wins. Nothing is better than a win/win combination. For me, the lower handicap has been a bonus.

THOMAS VOGEL, CGCS, *has been the golf course superintendent at Portage Country Club in Akron, Ohio, for 27 years.*

No Till in No Time

The advantages of ultradwarf bermudagrass putting greens are unlocked with a minimally invasive and effective conversion method.

BY CHRIS HARTWIGER

Doing your homework is vital to success in any subject. A class on the no-till method of ultradwarf bermudagrass putting green conversion is now open for registration. Any takers? In this class, students will learn what this term means, what types of golf courses are attempting it, which courses are good candidates, and what it takes to be successful. Last, but not least, any class would be incomplete without homework assignments, and this article will provide anyone interested in the no-till method with plenty.

WHAT IS NO-TILL PLANTING?

Golf course maintenance is under constant pressure to evolve. What is considered to be the standard today may be outdated by next year and proclaimed to be obsolete in 20 years. Nowhere is the force of change more apparent than on putting greens. There is a trend going on in the Southeast right now: removal of creeping bentgrass or Tifdwarf bermudagrass and replacement with an ultradwarf bermudagrass.

A technique called no-till or no-till planting is the method used to replace these grasses. Currently, the most popular ultradwarf bermudagrasses (Champion, MiniVerde, TifEagle) offer no-till planting. Although each producer will have its own protocol and specifications for no-till planting, the term *no-till planting* can be described as the replacement of the turfgrass on a putting green with minimal disruption to the underlying rootzone. No-till planting is popular because it lowers costs and requires less downtime compared to complete reconstruction.

THE NO-TILL PROCESS

There is more than one way to no-till plant a putting green, and several variations have been used in the region. Outlined below are factors that can determine how the no-till conversion is carried out.

Sprig preparation will vary among producers.

Kill Existing Turfgrass — Most no-till conversions involve killing the existing turfgrass, although some courses have no-till planted directly into the existing stand. Roundup is the most widely used product to kill the existing turfgrass.

Aggressive Aeration — The period between killing the existing turf and planting an ultradwarf is an ideal time to aggressively aerate, dethatch, and topdress putting greens. The extent to which golf courses complete these processes varies.

Turfgrass Removal — Some golf courses with unusually high levels of organic matter in the upper rootzone use conversion as an opportunity to remove this layer and replace it with a suitable rootzone mix.

Fumigation — To fumigate or not fumigate is a dilemma. If nematodes are present, most courses will fumigate. Higher-end clubs with bermudagrass putting greens are more likely to fumigate to minimize chances of the older bermudagrass contaminating the new ultradwarf putting greens. Courses with fewer resources or clubs with bentgrass putting greens are less likely to fumigate.

WHO IS USING THE NO-TILL METHOD?

At the present time, no-till conversions are being embraced by all market segments from the entry level to the high end. However, each market segment is using the no-till process for different reasons, and success stories have been written at all levels.

Those in the mid- to low-level market are looking for an improvement over their current circumstances. They are not seeking perfection. They believe providing better putting greens will allow them to attract more members or charge higher green fees. They understand that no-till planting only replaces the grass and will not wipe away any other problems affecting the putting greens. These clubs have performed the cost-benefit analysis and have determined that, given the costs of change, the anticipated improvements are worth the cost. They also understand that switching turfgrass varieties does not guarantee that other existing problems will disappear. These golf courses desire something better.

Those in the upper-end market are using no-till for different reasons. These are golf courses that generally have well-built greens, few problems with site conditions, and plenty of funds for state-of-the-art maintenance progams. They have gotten the most out of their current turfgrass variety and have pushed it to the edge of failure, yet those who play the course continue to ask for more. The upper-end courses believe that an ultradwarf bermudagrass will offer an improved level of performance. A good example

Boxes of sprigs are loaded onto refrigerated trucks at this producer's field.


The surface is prepared with minimal disruption. Sprigs are ready to be planted.

The sprigs are planted by hand to ensure excellent coverage.

is the high-end private club in the Southeast. These clubs are using the no-till method to replace creeping bentgrass putting greens because those who play the course are seeking firmer, faster putting conditions throughout the summer.

IS YOUR COURSE A GOOD CANDIDATE FOR NO-TILL?

Setting expectation levels for putting greens is the first step in determining if a golf course is a good candidate for a no-till bermudagrass conversion. Obviously, this assumes the golf course in question is in a region where an ultradwarf bermudagrass can be grown and managed successfully. Below are a series of questions to consider.

Is is possible to grown healthy turfgrass on putting greens if this was the only goal for the putting green maintenance program? Many golf courses with Tifdwarf or creeping bentgrass putting greens suffer in terms of quality because too much is asked of the grass in terms of playability. This places the grass under stress, causing turf health to decline and playability to suffer. All the ultradwarfs appear to be well adapted to heavier soils or soils with mature levels of organic matter in the upper rootzone.

Are sunlight levels adequate at all putting green locations to sustain an ultradwarf? Bermudagrass has the worst shade tolerance of any turfgrass used on golf courses in the world, and it has not earned the title without backing it up. If shade is limiting, grow-in will be slowed, thin turf will be a constant battle, and ultimately putting quality will be affected.

Are there issues with internal and/or surface drainage? Internal drainage relates not only to how fast the water moves into the soil, but how long the soil stays saturated. Chronically wet soils are not desirable. These are common in depressions with no surface drainage, areas with shallow mix, in rootzones with a clay layer that limits drainage, and on putting greens with no drainage pipe to carry water out of the rootzone.

Sometimes poor internal drainage can be aided by excellent surface drainage. If slopes carry water off a green rapidly, poor internal drainage may not be so problematic. If water flows from surrounds onto putting greens, even average to above-average internal drainage may not be enough to avoid soggy surface conditions.

Will there be adequate time, staff, and equipment to meet expectations upon completion of the no-till conversion? The time/staff/equipment matrix often limits what can be done to the putting surface. When clubs expect significant improvements, make sure these pieces are in place. Remember that a beat-up 20-year-old mower is still a 20-year-old mower regardless of the grass it mows. If it did not cut well on the old greens, it will not be any better on an ultradwarf.

Will increases in green speed exceed the architectural speed limit? This refers to slope in the putting greens. If an ultradwarf is desired because of the ability to increase green speed without unduly risking turf health, make sure all the greens are playable and have enough hole locations to handle the rounds of golf played.

Are there significant pest issues that impact turfgrass quality? Of all the pests that affect a putting

green, few are as frustrating or as hard to control as nematodes. None of the ultradwarf varieties has documented improved tolerance to nematodes, so this pest will still be present after no-till unless the rootzone is fumigated.

Does the club desire architectural changes to the putting greens? Many putting green renovation projects seek to not only improve the infrastructure, but also address strategic elements of the golf course by changing the design of the greens. Courses seeking different architecture are not good candidates for no-till planting, as this procedure is intended to produce minimal disturbance to the surface. Removing features such as steep slopes, ridges, etc., is not recommended with the no-till procedure because it can result in variable mix depth and the need to expand the renovation out into the surrounds and approaches to create the desired tie-in. The one exception is on golf courses seeking to recapture parts of putting greens lost due to encroachment.

Is cost savings in maintenance the main goal for the conversion? Cost savings should not be the primary goal for a no-till conversion. On courses with bentgrass considering a no-till conversion, it is likely that there will be less money spent on items such as hand watering, electricity for fans, and fungicide applications, but there may be other areas with higher costs. Examples include the need to hand water steep slopes because of ultradwarf density, more scheduled double

Adequate irrigation is a must during grow-in of a no-till conversion.

mowings, more scheduled rollings, and more time spent on mower sharpening. Great things are possible with a no-till conversion, but just don't bet the ranch on cost savings.

WHAT IT TAKES TO BE SUCCESSFUL

A successful no-till putting green renovation begins with planting an ultradwarf bermudagrass and establishing it over a period of six to ten weeks. It is complete when a product that meets expectations is produced. Before attempting a no-till renovation, review the factors below and make sure that once the grass is replaced, these components are in place to meet or exceed expectations.

Thriving nine years after no-till conversion, this putting green continues to meet or exceed expectations each year.

Expertise and Desire of Staff — The motivation to succeed is of paramount importance. Superintendent know-how is more important than budget. Superintendents who enjoy challenges and are excited about learning a new maintenance protocol will achieve better results.

Time/Budget/ Equipment Matrix — There is a common belief that ultradwarf varieties are maintenance-intensive grasses. There is an element of truth to this saying, but it needs clarification. Keeping an ultradwarf alive is not maintenance intensive, but maintenance intensity does increase as expectations for playability increase. Much, if not all, of this higher maintenance intensity is scheduled maintenance in the form of keeping sharp mowers, more frequent mowing, reel and bedknife maintenance after topdressing, the time to schedule light vertical mowing/grooming, etc. This type of maintenance is much different from bentgrass maintenance intensity, which is focused on plant health and summer survival.

HOMEWORK

Selecting the turfgrass variety requires homework. There are differences among the major ultradwarf producers in no-till planting experience, techniques, and grow-in. Every golf course is advised to perform appropriate due diligence before selecting a variety. This homework includes the following:

INTERVIEW AND/OR VISIT THE PRODUCER

Ask the producer the following questions:

How many no-till jobs have you completed?

What is the average grow-in time?

Where are the sprigs grown?

Is a nematode test available for the fields where the sprigs will be harvested?

How are they harvested?

How are they transported?

What is done to prevent excessive sprig heating?

How are the sprigs planted?

How long will the grow-in take?

VISIT OTHER COURSES

Visit a minimum of three courses for each no-till variety your golf course is considering. Try to schedule one of the visits during grow-in. Make sure the managers of the courses visited have expectations and budgets similar to yours. Ask about the conversion process. What went well? How could the process have been better? Ask the superintendent and others if they are satisfied with the no-till conversion.

CONCLUSION

No-till conversions from creeping bentgrass or Tifdwarf to an ultradwarf bermudagrass variety have been and will continue to be successful. Although no-till may be a quick way to improve putting greens, making a quick decision may not result in the best decision. Replacing the grass on putting greens is a decision that will affect golfing conditions for years, and therefore it requires some work before an informed decision can be made. For those seeking to earn an "A" in no-till, pay attention in class, do your homework, and ace the test at your golf course.

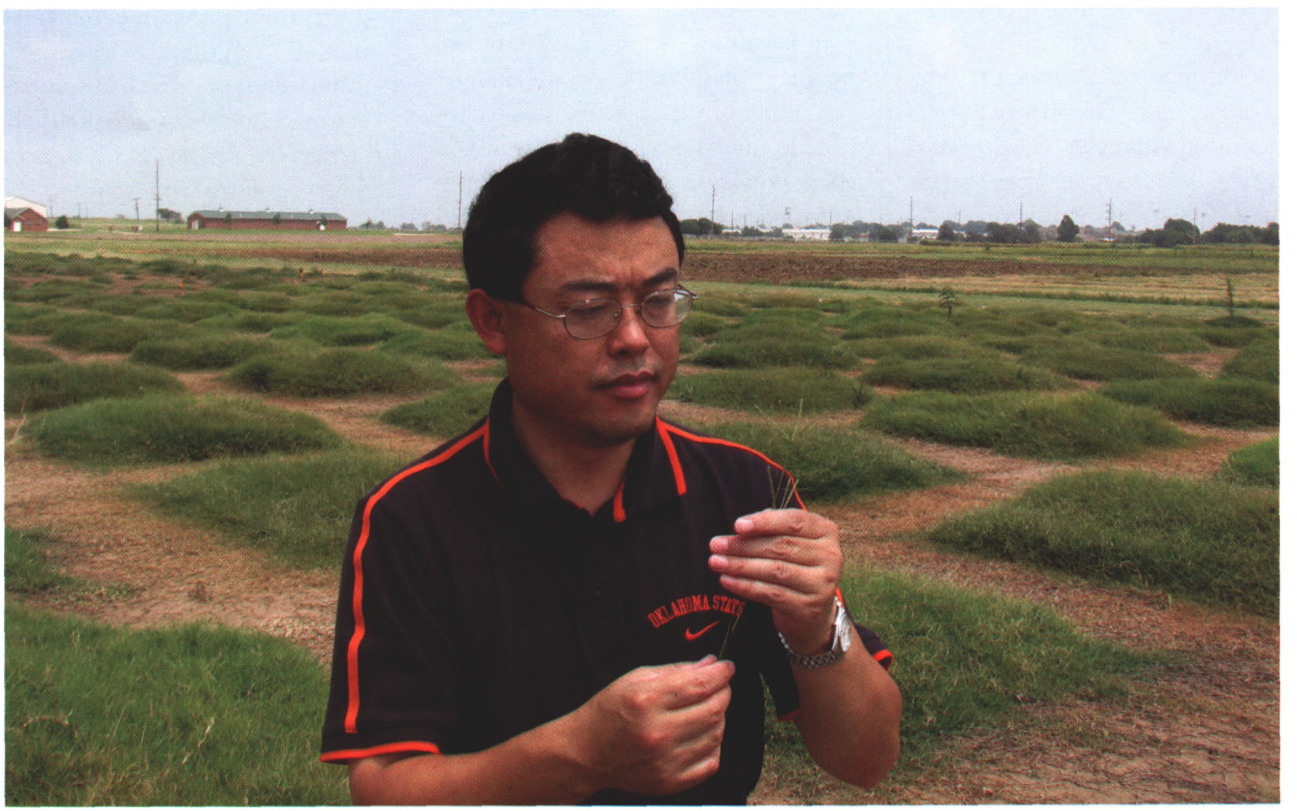
CHRIS HARTWIGER *is a senior agronomist working with golf courses in the USGA Green Section Southeast Region.*

Research *You Can Use*

Investment Yields Bermudagrass Cultivars with High Quality and Improved Cold-Hardiness

Oklahoma State University scientists continue to improve this crucial turfgrass for the golf course industry.

BY DENNIS L. MARTIN, YANQI WU, JEFF A. ANDERSON, MICHAEL P. ANDERSON, GREGORY E. BELL, AND NATHAN R. WALKER



Since its inception in 1986, the bermudagrass breeding and development program at Oklahoma State University has released five cultivars with improved quality and winter-hardiness. These cultivars have reduced the risk of winterkill when using bermudagrass in the transition zone. An extensive bermudagrass germplasm collection has been formed, breeding populations improved, and a steady stream of promising experimental lines has been developed. Dr. Yanqi Wu, turf/forage/biofuels breeder, examines flowers of experimental bermudagrass lines in a field space planting.

Bermudagrasses (*Cynodon spp.*) are the most widely used turfgrasses for golf courses, athletic fields, and lawns in the southern U.S. Tolerance to close mowing, as well as favorable heat, drought, and traffic tolerance and few serious pests makes bermudagrass an attractive choice in tropical and subtropical areas. Although widely adapted, its susceptibility to freeze injury has been a continuing threat in many areas of its use. Thus, there has been a long-term need for high-quality bermudagrasses that have reduced risk of winterkill.

Oklahoma State University (OSU) began a joint venture in 1986 with the USGA to improve the cold-hardiness,

Table 1

Turfgrass cultivars released by the Oklahoma State University bermudagrass development program.

Cultivar	Year Released	Propagation Method	Ploidy Level
Guymon	1982	Seed	Tetraploid
Midlawn*	1991	Vegetative	Triploid
Midfield*	1991	Vegetative	Triploid
Yukon	2000	Seed	Tetraploid
Riviera	2001	Seed	Tetraploid
Patriot	2002	Vegetative	Tetraploid

*Midlawn and Midfield were developed by the Kansas State University turf program and were jointly released with Oklahoma State University

as well as the visual and functional performance qualities, of seeded bermudagrasses. At that time, the only choices available for seeded bermudagrass cultivars were the less-winter-hardy Arizona Common (*C. dactylon* var. *dactylon*) or the more cold-hardy but coarse-textured Guymon (*C. dactylon* var. *dactylon*). The bermudagrass breeding effort at OSU eventually grew to encompass vegetatively propagated types, as well as seeded grasses. This article provides a brief overview of the OSU turf bermudagrass development effort.

HISTORY

Collection of *Cynodon* germplasm for culture and scientific use began around the start of the 20th century in South Africa and the United States. Bermudagrass germplasm collection and taxonomic characterization at OSU was underway in the 1950s and '60s with noted accomplishments by Drs. Jack Harlan, Johannes de Wet, and Wayne Huffine. Turf bermudagrass improvement began in earnest in 1986 under the direction of Dr. Charles Taliaferro. The initial broad objective was to develop finer-textured, seed-propagated, cold-tolerant bermudagrasses (*C. dactylon* var. *dactylon*) for the U.S. transition zone. The initial efforts involved collecting additional germplasm, characterizing appearance and performance, improving the fertility and texture of breeding populations that were known to be cold tolerant, and improving the cold-hardiness in populations known to be highly fertile.

By 1990, the effort at OSU was expanded to include the development of high-quality, cold-hardy, vegetatively-propagated materials for golf course fairways/tees and to examine the possibility of generating improved African bermudagrasses (*C. transvaalensis*) for use on putting greens. Field plantings of improved African bermudagrasses in tropical areas of the U.S. revealed the species performed well in fall, winter, and spring but declined substantially in the summer months in both tropical and the more southern subtropical planting sites. Many African bermudagrass selections also suffered substantially more nematode problems on the sandy gulf coastal plain compared with the interspecific hybrid Tifdwarf (*C. dactylon* X *C. transvaalensis*) and its derivatives. Although by early 1997 efforts to generate putting green types of African bermudagrass were discontinued, the breeding and selection effort in that species resulted in improved types that had value in generating improved interspecific hybrid crosses (*C. dactylon* X *C. transvaalensis*) for the golf turf industry.

Dr. Taliaferro led the turf and forage bermudagrass breeding and development effort from its inception until his retirement in January 2006. Guymon, Yukon, Riviera, and Patriot turf bermudagrasses (Table 1), as well as a number of promising experimental types (still under study) were developed under his leadership. Additionally, his familiarity with cultivar development helped facilitate cooperative releases of Midlawn and Midfield hybrid bermudagrasses between Kansas State University (KSU) and OSU in 1991 (Table 1). Midlawn and Midfield were developed by Dr. Ray Keen of KSU with field-testing assistance by Drs. John Pair, Jeff Nus, and others.

The successes of the OSU turf bermudagrass development program are not only due to USGA investment, but can also be attributed to the leadership of Dr. Charles Taliaferro in concert with a number of past and current faculty (Table 2), staff, graduate students, and cooperating industry scientists. Following the retirement of Dr. Taliaferro, an extensive search was conducted that resulted in the hiring

Table 2

The Oklahoma State University bermudagrass breeding and development team has expertise in several crucial areas. Current team members and their areas of expertise are listed below.

Faculty Working Group Member	Area of Expertise
Charles Taliaferro	Team Coordinator (retired), Breeding & Genetics
Yanqi Wu	New Coordinator, Breeding & Genetics
Dennis Martin	Cultural Management
Jeff Anderson	Physiology & Cold Tolerance
Mike Anderson	Molecular Biology & Genetics
Greg Bell	Cultural Management, Herbicide & Shade Tolerance
Nathan Walker	Plant Pathology, Entomology & Molecular Biology
Tom Royer	Entomology

Table 3

Mean turfgrass quality ratings of seeded bermudagrasses during 2006 from 9 transition-zone locations, 2002-2006 NTEP Bermudagrass Trial.*

Seeded Entry	Mean
Yukon	6.2
Riviera	5.8
Contessa	5.8
SWI-1046	5.7
SWI-1012	5.7
SWI-1044	5.6
CIS-CD6	5.4
Veracruz	5.4
SWI-1014	5.4
CIS-CD7	5.3
SWI-1003	5.2
Sunbird	5.1
SWI-1001	5.1
Princess 77	5.0
Tift No. 2	5.0
Transcontinental	5.0
CIS-CD5	4.9
Tift No. 1	4.8
SR 9554	4.8
Panama	4.7
LaPaloma	4.7
FMC-6	4.7
Arizona Common	4.7
Southern Star	4.7
NuMex Sahara	4.6
Mohawk	4.6
Sundevil II	4.5
Sunstar	4.5
B-14	4.5
LSD (0.05)	0.3
Coeff. of variation (%)	12.3

*Excerpted from Tables 3b, p. 14, of the 2006 NTEP Progress Report NTEP No. 07-6. Quality rated on a 1-9 scale, where 1 is poor and 9 is excellent.

of Dr. Yanqi Wu in July 2006 to head up the OSU bermudagrass breeding and development effort. Dr. Wu completed his Ph.D. under the tutelage of Dr. Taliaferro in 2004. A substantial portion of the newer bermudagrass germplasm in our program was collected by and is in an ongoing state of characterization by Dr. Wu.

BERMUDAGRASS CULTIVARS DEVELOPED AT OSU

In 1982, preceding the USGA-funded turf development effort at OSU, the forage/pasture effort resulted in the release of Guymon bermudagrass (*C. dactylon* var. *dactylon*) (Table 1). Guymon was arguably the first seeded bermudagrass with improved cold-hardiness over Arizona Common. Guymon found favor in soil erosion control areas, roadsides, rangeland, and pastures. With only the non-cold-hardy Arizona Common bermudagrass seed being available during the 1980s, the coarse-textured, but cold-hardy and vigorous Guymon was often used on lower-maintenance sports fields and lawns in the transition zone.

Yukon bermudagrass (*C. dactylon* var. *dactylon*), tested as OKS 91-11, was released in 2000. It was the first turf bermudagrass from OSU developed with grant funding from the USGA. Yukon is a high-quality seeded turf-type bermudagrass with improved cold-hardiness and improved spring dead spot disease tolerance.

Yukon found favor on some golf courses, sports fields, and in the lawn/landscape industry. It performs well at the 0.5-inch mowing height typical of bermudagrass fairways. The divot recovery rate of Yukon varies from intermediate to rapid. Although Yukon seed availability has been limited in recent years, increased availability of seed is anticipated in the near future. Yukon continues to provide excellent quality in transition-zone climates (Table 3).

Riviera bermudagrass (*C. dactylon* var. *dactylon*), tested as OKS 95-1, was released in 2001. Riviera is a high-quality (Table 4), medium-fine-textured seeded bermudagrass. Riviera seed production yields are typically higher than those of Yukon. Riviera has improved cold-hardiness and improved tolerance to spring dead spot. The Riviera divot recovery rate varies from intermediate to rapid. Riviera is now receiving increased use on fairways, tees, athletic fields, and lawns when a high-quality seeded bermudagrass with improved cold-hardiness is desired.

Patriot bermudagrass (*C. dactylon* X *C. transvaalensis*), tested as OKC 18-4, was released in 2002. Patriot is a vegetatively propagated hybrid characterized as having improved color, quality (Table 4), and cold-hardiness. Its divot recovery rate has been characterized as medium to rapid. Licensed producers have reported rapid sod production cycles from planting to harvest. Improved tolerance to spring dead spot disease is also a desirable characteristic of Patriot. We believe Patriot to be the first commercialized interspecific hybrid turf-type bermudagrass that is a tetraploid. It was created by a cross of the hexaploid Tifton 10 and an improved African bermudagrass (a diploid) from our collection. Patriot is well adapted to golf course tee and fairway use and is currently experienc-

Table 4

Mean bermudagrass quality from multiple locations during the 1997-2001 National Turfgrass Evaluation Program Bermudagrass Trial.*

Entry	Regime A**	Regime B
Arizona Common	4.7	4.5
Blackjack	5.3	5.4
Blue-Muda	5.1	5.0
Cardinal	5.4	5.7
CN 2-9	6.1	5.8
J-540	5.3	5.2
Jackpot	5.0	4.9
Majestic	5.3	5.3
Midlawn	5.8	6.5
Mini-Verde	5.6	5.1
Mirage	5.1	4.9
NuMex-Sahara	5.0	5.0
OKC 19-9	5.8	6.1
Patriot	6.1	6.6
Princess 77	6.5	6.1
Pyramid	5.2	5.0
Riviera	6.4	6.6
Savannah	5.4	5.3
Shanghai	5.6	6.1
Shangra La	5.2	5.1
Southern Star	5.4	5.4
Sundevil II	5.3	5.0
SWI-11	6.1	5.5
Sydney	5.2	5.2
Tifgreen	6.1	6.3
Tifsport	6.5	6.1
Tifway	6.4	6.2
Transcontinental	6.0	5.6
LSD (0.05)	0.2	0.2
Coeff. of variation	14.0	14.9

*Excerpted from Tables 1a and 2a of the 1997-2001 NTEP Bermudagrass Trial Final Report NTEP No. 97-9. Quality rated on a 1-9 scale, where 1 is poor and 9 is excellent.

**The 9 Regime A trials were mowed at 0.5 to 0.75 inch and fertilized with 0.75-1 lb. of N per 1,000 sq. ft. per growing month. The 11 Regime B trials were mowed at 0.75 to 1.0 inch and fertilized with 0.5-0.75 lb. of N per 1,000 sq. ft. per growing month. Both regimes included irrigation to prevent visual drought stress.

ing increased use by the golf course industry.

EXPERIMENTAL OKLAHOMA SELECTIONS WITH PROMISE

OKC 70-18 bermudagrass, developed in part with funding from the USGA, has recently undergone intensive internal as well as external testing (2002-2006 NTEP bermudagrass trial). This variety ranked first in overall quality at nine transition-zone test sites during several years of the 2002-2006 NTEP trial. OKC 70-18 has several meritorious characteristics, and a decision concerning possible release is forthcoming.

Three promising experimental bermudagrasses from our program were entered into the 2007-2011 NTEP bermudagrass trial. These included OKC 11-19 and OKC 11-34, vegetatively propagated types and a seeded type, OKS 2004-2. Sixteen NTEP testing sites are in place for the 2007 NTEP trial. Besides the traditional parameters of color, quality, texture, density, green-up, and living cover, additional parameters monitored at selected sites will include sod tensile strength as well as tolerance to spring dead spot disease, salinity, and traffic.

CURRENT BREEDING AND DEVELOPMENT WORK

A new broad-based breeding population was recently formed using desirable Chinese *Cynodon* material selected from a collection by Dr. Wu made in 11 provincial regions of China. Selections were made based on extensive evaluation of chromosomal, morphological, seed yield potential, and DNA marker investigations completed in 2004. The population contains favorable traits for turf cultivar development, including darker green color, relatively fine texture, good winter-hardiness, and good sod density. Study of genetic relatedness assists the turf breeder in elimination of possible duplication of breeding efforts due to close relatedness of parents. Additionally, this work may help in locating crosses that have increased likelihood of compatibility. Complementary to this work, Dr. Kevin Kenworthy (now of the University of Florida Turfgrass Program) recently completed an assessment of the variability in 21 performance traits of African bermudagrass while in our program. The work determined which traits can most easily be improved in the African bermudagrass parents that are subsequently useful for developing interspecific crosses.

Applied field trials comparing later-stage promising experimental entries and industry standards are ongoing for turf quality, divot recovery, spring dead spot resistance, and sod tensile strength. Due to inability to eradicate pre-existing aggressive *C. dactylon* var. *dactylon* types from many installation sites, some superintendents choose not to renovate to improved bermudagrass cultivars. In order to address this issue, a preliminary study investigating the resistance of hybrid bermudagrasses to encroachment by common bermudagrass was initiated in 2006 by M.S. candidate Holly Han.

Above left: An interspecific hybrid and an aggressive common bermudagrass "duke it out" during the establishment phase. Inability to eradicate on-site aggressive common bermudagrass leads to mixtures with diminished playing surface quality. Work is underway at Oklahoma State University to determine if rapid-spreading improved types can better compete against common bermudagrass. Above right: Patriot is a high-quality, vegetatively propagated, interspecific hybrid bermudagrass with improved cold-hardiness and rapid divot recovery rate.

ADDITIONAL BERMUDAGRASS PERFORMANCE FEATURES

Development of bermudagrasses with high turf quality and suitable cold-hardiness will remain a key focus of our efforts, although pursuit of additional improvements has begun. Limited freshwater resources threaten the vitality of the golf turf and landscape industries. Work commenced in late summer 2007 by M.S. candidate Santanu Thapa to evaluate the water use rate of several experimental OSU bermudagrasses. Evaluation of leaf firing resistance under drought will also be incorporated into our screening program in future years. Development of bermudagrasses with delayed leaf firing may help superintendents maintain quality turf during periods of limited natural rainfall and during irrigation restrictions.

Lack of suitable shade tolerance is a key limitation of bermudagrass. As the golf course landscape matures, increased shading of turf occurs. Breeding and selection for improved shade tolerance in bermudagrass has been successfully conducted by turfgrass scientists at the University of Georgia. Screening of bermudagrass germplasm for improved shade tolerance was initiated in the summer of 2007 by Drs. Greg Bell and Yanqi Wu. The work incorporates the use of a combination of natural and artificial shade.

CONCLUSIONS

USGA support has been instrumental in supplementing a long-term turf bermudagrass development effort at Oklahoma State University. A comprehensive, interdisciplinary team of scientists has been assembled, focusing on turf bermudagrass improvement. The effort has resulted in extensive collection, characterization, and improvement of breeding populations of bermudagrasses from the *Cynodon dactylon* and *C. transvaalensis* species.

Studies have aided in the understanding of fundamental mechanisms of stress tolerance. Improvements have been made in turf quality, cold-hardiness, and spring dead spot tolerance. The improved turf bermudagrasses Yukon, Riviera, and Patriot were direct results of the USGA investment. Training a number of graduate students can also be attributed to USGA contributions. Two clonally propagated selections and one seed-propagated selection with improved characteristics for the golf industry were entered into the 2007 NTEP bermudagrass trial. New germplasm from China has recently been introduced into our program. Incorporation of increased water use efficiency, leaf firing resistance under drought, and improved shade tolerance in bermudagrass are future goals of our development effort.

ACKNOWLEDGEMENTS

The authors wish to thank the USGA Turfgrass and Environmental Research Program for support of this research and development program. We also gratefully acknowledge support of the Oklahoma State University Agricultural Experiment Station and the Oklahoma Turfgrass Research Foundation.

EDITOR'S NOTE: An expanded version of this paper can be found at *USGA Turfgrass and Environmental Research Online* (http://usgatero.msu.edu/v06/n17.pdf).

DENNIS L. MARTIN, PH.D., *professor, Horticulture and Landscape Architecture Department;* YANQI WU, PH.D., *assistant professor, Plant and Soil Sciences Department;* JEFF A. ANDERSON, PH.D., *professor, Horticulture and Landscape Architecture Department;* MICHAEL P. ANDERSON, PH.D., *professor, Horticulture and Landscape Architecture Department;* GREGORY E. BELL, PH.D., *professor, Horticulture and Landscape Architecture Department; and* NATHAN R. WALKER, PH.D., *associate professor, Entomology and Plant Pathology Department.*

CONNECTING THE DOTS

An interview with Drs. Dennis Martin, Yanqi Wu, Nathan Walker, and Greg Bell regarding the bermudagrass germplasm enhancements at Oklahoma State University.

Q: *Oklahoma State University has been breeding and developing bermudagrasses with USGA support since the mid-1980s. Is there one achievement or cultivar that stands out over the rest as proof of significant achievement?*

A: Our goal was to produce high-quality seeded and vegetative varieties with improved cold-hardiness. Our vegetative bermudagrass products OKC 70-18 and Patriot held the top two positions for turf quality among vegetative types in 2005 and 2006 when summarized over the nine transition-zone climates of the NTEP bermudagrass test. Likewise, Yukon and Riviera held the top two positions for turf quality among seeded types during 2005 and 2006 when summarized over the nine transition-zone climates. We believe we have met the original goal, but we have no intention of resting on our laurels. Hopefully we can continue to make advancements that will benefit the golf and turf industry. (Dr. Martin)

Q: *Improving cold-hardiness of bermudagrass is a very worthy goal by anyone's standards. Do you have a feel for how far north the transition zone can be pushed by these newer, more cold-hardy cultivars?*

A: We are uncomfortable with bermudagrass actually being used farther north in the U.S. than where it is already deemed appropriate by local experts. What we hope our impact will be is (1) that we have produced cultivars that offer improved quality/winter-hardiness where only lower-quality/winter-hardy types were in use before, and (2) where high-quality cultivars were already in use, but they suffered occasional winterkill. Use of the newer products will further reduce the risk of serious winterkill. (Dr. Martin)

Q: *Do you think the seeded bermudagrasses will eventually have the same level of acceptance had by the vegetative types that cover most of the southern golf courses in the U.S. and many tropical and subtropical locales worldwide? What are the main obstacles to overcome that would enable seeded types to garner that level of acceptance by golf course superintendents?*

A: Realistically, I doubt that bermudagrass seed will ever be used as extensively as vegetative types on golf courses in the southern U.S. Seeded types have been experiencing more extensive use, though. But it is just so easy to propagate bermudagrass from sprigs in most instances. Certainly, seeded types can rival the quality and performance of vegetative types on tees, fairways, surrounds, and rough. Seeded types are experiencing increased use in international markets in areas where local sod/sprig production is not well developed and when shipping costs and/or restrictions on shipping vegetative material presents roadblocks. (Dr. Martin)

Q: *Spring dead spot (SDS) is the most serious disease of bermudagrass and seems to be linked with cold-hardiness. Do you find that to be true in your work? In other words, do bermudagrass cultivars that are more cold-hardy tend to be more resistant to the pathogens that cause SDS?*

A: Yes, research conducted on both commercially available and experimental bermudagrass lines continues to support earlier observations that, in general, those varieties with improved cold-hardiness have improved tolerance to SDS. When we state that a variety has improved SDS tolerance, it can, in fact, still get the disease, but the disease tends to be less severe than it is on more susceptible varieties. Of course, poor management practices by the end user, such as allowing excessive thatch to accumulate and/or use of excessive late-season nitrogen fertilization, can encourage severe SDS symptoms on both susceptible and tolerant varieties. (Drs. Martin, Walker, and Bell)

Q: *How far has your work with shade tolerance of bermudagrass progressed? Does the OSU bermudagrass breeding and development program have selections that are considerably more shade tolerant? If they are developed, to what extent do you think they will impact the golf course industry in the southern U.S.?*

A: Our first screening of germplasm for response to shade was planted in summer of 2007. If improved shade tolerance is found, additional breeding and recurrent selection can then proceed, followed by more extensive field testing. Superintendents tell us they want bermudagrasses with improved shade tolerance. If such types existed, one could envision cases where shade-tolerant types would be used in more shaded areas, with other varieties predominating in the more sunny areas. Other courses might try to use a "wall-to-wall" application of the more shade-tolerant types if they had general widespread adaptation. (Drs. Bell, Wu, and Martin)

Q: *What characteristic of the Chinese collection of bermudagrass germplasm is particularly appealing? How long will it be before your program is able to incorporate those characteristics into new selections?*

A: Our genetic studies indicated Chinese bermudagrass is highly diverse. Some of the germplasm accessions contain desirable traits for the development of improved turf cultivars, including seed yield and quality, leaf texture, and color, as well as adaptation. Normally 10 to 15 years are required to develop improved selections incorporating the desirable new traits. (Dr. Wu)

Q: *Have you been able to use information from the bermudagrass "genetic roadmap" being constructed by Dr. Andrew Paterson and his colleagues at the University of Georgia in your bermudagrass development program? If so, how?*

A: Scientists at the University of Georgia have published the first bermudagrass molecular marker linkage map using a cross of two important turf species, common and African bermudagrasses. The work is significant in that it provides a "genetic roadmap" to locate genes responsible for important turf traits. Thus far, we have not used this information. However, if important genes are mapped and further tagged to markers, which are easily used by breeders, then marker-assisted selection can be added to conventional breeding programs. (Dr. Wu)

JEFF NUS, PH.D., *manager, Green Section Research.*

Show Me the Money

Adding up the environmental factors to reach the bottom line.

BY JEAN MACKAY

Talk about pressure! Not only are we expected to do right by the environment, but most golf course superintendents are increasingly expected to do good with fewer dollars to spend or to prove that environmental stewardship will save money. Measuring success means *show me the bottom line.*

In the long run, environmental outcomes must be affordable to remain sustainable. So measuring costs and benefits is critical. How can you show that a new environmental management practice or habitat project will have a positive financial impact or benefit the success of your facility? Let's look at some ways to measure return on investment for environmental performance.

1. Start by identifying where you may be impacted most:

- **Revenues** — Will environmental improvements generate new revenue by improving operations or attracting new customers?
- **Expenses** — Low-intensity maintenance costs less than high-intensity maintenance (e.g., you may save gas, equipment wear and tear, time, chemical inputs, and water). These expenses can be measured. Improving environmental performance may also make you eligible for tax breaks or lower insurance premiums.
- **Staff Resources** — Will the new management practice help you put staff resources where they count most? For example, naturalizing a non-play area may enable the grounds crew to focus more attention on maintaining quality greens or improving Integrated Pest Management practices.
- **Product Quality** — Can you show that improved environmental performance will improve your product

THE NUMBERS TELL THE STORY

The Landings Club and its surrounding homeowners association in Georgia have measured their success in increased habitat, reduced costs, reduced water use, and enhanced beauty since joining the Audubon Cooperative Sanctuary Program in 1995. Take a look at the numbers:

- More than 170 golf course natural landscaping projects completed.
- 120 nest boxes on six golf courses, with 809 bluebirds fledged in 2006.
- More than $81,000 raised through an annual Audubon Golf Tournament to support Audubon program initiatives.
- 2,600 Skidaway Island Wildlife Guides sold, raising $12,000 to help support wildlife projects.
- A 2.5-mile nature trail developed as a result of program expansion throughout the residential community.

quality or give you an edge in the marketplace?

2. Measure return on investment by comparing various management strategies. And don't miss the low-hanging fruit. There are many simple changes that improve wildlife habitat and water quality or reduce waste and energy use. Sometimes, these cost the same or less than more traditional maintenance. Consider these:

- Planting native trees and shrubs costs no more than choosing non-native ones, but it has a higher environmental value in terms of biodiversity conservation.
- Choosing flowers that provide nectar for butterflies and hummingbirds costs no more than traditional flower plantings, but it improves wildlife habitat and brings these welcome visitors to your property.
- Naturalizing an area of your property may require an initial investment of seeds or plants, but it typically results in long-term savings when compared with maintaining the same area in turfgrass. Calculate the cost of the initial investment, as well as yearly maintenance costs (e.g., gas, fertilizer, staff time to mow, manicure, maintain, etc.) for several years. You may be quite surprised by the difference.
- Switching to energy-efficient lighting carries an up-front cost, but it packs a powerful punch in terms of long-term financial savings and positive environmental outcomes. Measure both.
- There's a lot to be said for becoming more efficient. Conserving water can be measured in terms of gallons and dollars saved, as well as in electricity savings from running the irrigation system less. Likewise, reducing waste can be quantified in lower waste hauling costs and pounds of trash.

3. Try to capture maintenance hours spent on particular tasks. Becoming more efficient may save you money or improve your services or products. But be careful: You might want to emphasize that improving environmental performance is resulting in *more efficient operations*, as opposed to *reduced costs*. Reduced costs sometimes result in a reduced budget or staff cuts. Instead, invest these "saved" dollars back into your operations to improve quality or customer satisfaction.

4. Identify intangible benefits of improved environmental quality. These may be harder to measure from a cost point of view, but they add value nonetheless. When proposing improvements, find ways to tie them to these value-added benefits:

- **Environmental Quality** — The environmental management practices required for Audubon Cooperative Sanctuary or Signature certification improve the quality of our land, water, and air, and conserve natural resources for future generations.
- **Image and Reputation** — Proven environmental performance can help your facility differentiate itself from others in a crowded market and add value by improving public relations and marketing opportunities that attract new customers. Outreach and education activities also spread community goodwill and are well worth the investment.
- **Customer or Employee Satisfaction** — Enhancing the nature of your facility may enrich customer satisfaction or add a new dimension to your employees' jobs that results in improved performance.
- **Worker Safety and Reduced Liability** — Best practices for chemical management reduce exposure and liability risks associated with storing, handling, and applying chemicals.
- **Improved Efficiency** — Proper environmental management cuts down on waste and promotes efficient operations.
- **The Nature of the Game** — Enhancing and protecting golf course natural areas preserves the unique natural heritage of the game of golf for all to enjoy.

JEAN MACKAY *formerly served as director of education at Audubon International and is the current director of communications and outreach for the Erie Canalway National Historic Corridor in New York State. To find out how you can improve environmental performance through the Audubon Cooperative Sanctuary Program for Golf Courses, visit: www.audubonintemational.org.*

On Course *With Nature*

WHAT WERE THEY THINKING?

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.

Brookside Laboratories, Inc.
308 Main Street, New Knoxville, OH 45871
Attn: Mark Flock
Voice phone: (419) 753-2448
FAX: (419) 753-2949
E-Mail: mflock@BLINC.COM

Dakota Analytical, Inc.
1503 11th Ave. NE, E. Grand Forks, MN 56721
Attn: Diane Rindt, Laboratory Manager
Voice phone: (701) 746-4300 or (800) 424-3443
FAX: (218) 773-3151
E-Mail: lab@dakotapeat.com

European Turfgrass Laboratories Ltd.
Unit 58, Stirling Enterprise Park
Stirling FK7 7RP Scotland
Attn: Ann Murray
Voice phone: (44) 1786-449195
FAX: (44) 1786-449688

Hummel & Co.
35 King Street, P.O. Box 606
Trumansburg, NY 14886
Attn: Norm Hummel
Voice phone: (607) 387-5694
FAX: (607) 387-9499
E-Mail: soildr1@zoom-dsl.com

ISTRC New Mix Lab LLC
1530 Kansas City Road, Suite 110
Olathe, KS 66061
Voice phone: (800) 362-8873
FAX: (913) 829-8873
E-Mail: istrcnewmixlab@worldnet.att.net

Sports Turf Research Institute
hyperlink to www.stri.co.uk
St. Ives Estate, Bingley
West Yorkshire BD16 1AU
England
Attn: Michael Baines
Voice phone: +44 (0) 1274-565131
FAX: +44 (0) 1274-561891
E-Mail: stephen.baker@stri.org.uk

Thomas Turf Services, Inc.
2151 Harvey Mitchell Parkway South, Suite 302
College Station, TX 77840-5247
Attn: Bob Yzaguirre, Lab Manager
Voice phone: (979) 764-2050
FAX: (979) 764-2152
E-Mail: soiltest@thomasturf.com

Tifton Physical Soil Testing Laboratory, Inc.
1412 Murray Avenue, Tifton, GA 31794
Attn: Powell Gaines
Voice phone: (229) 382-7292
FAX: (229) 382-7992
E-Mail: pgaines@friendlycity.net

Turf Diagnostics & Design, Inc.
613 E. First Street, Linwood, KS 66052
Attn: Sam Ferro
Voice phone: (913) 723-3700
FAX: (913) 723-3701
E-Mail: sferro@turfdiag.com

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION

1. Title of Publication — USGA GREEN SECTION RECORD. 3. Date of Filing — September 1, 2007. 4. Frequency of issue — Bimonthly: January/February, March/April, May/June, July/August, September/October, and November/December. 5. Number of issues published annually — 6. 6. Annual Subscription Price — $18.00. 7. Complete mailing address of known office of publication — United States Golf Association (USGA), Golf House, 77 Liberty Corner Road, P.O. Box 708, Far Hills, NJ 07931-0708, Contact Person: James T. Snow, Telephone: 908-234-2300. 8. Complete mailing address of the headquarters or general business office of the publisher — USGA, Golf House, 77 Liberty Corner Road, P.O. Box 708, Far Hills, NJ 07931-0708. 9. Names and addresses of Publisher, Editor, and Managing Editor: Publisher — USGA, Golf House, 77 Liberty Corner Road, P.O. Box 708, Far Hills, NJ 07931-0708. Editor — James T. Snow, USGA, Golf House, 77 Liberty Corner Road, P.O. Box 708, Far Hills, NJ 07931-0708. Managing Editor — James T. Snow, USGA, Golf House, 77 Liberty Corner Road, P.O. Box 708, Far Hills, NJ 07931-0708. 10. Owner (If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address, as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.) — United States Golf Association (USGA), Golf House, 77 Liberty Corner Road, P.O. Box 708, Far Hills, NJ 07931-0708. 12. For completion by nonprofit organizations authorized to mail at nonprofit rates — The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes has not changed during preceding 12 months. 13. Publication title — USGA Green Section Record. 14. Issue Date for Circulation Data Below — Sept./Oct. 2007. 15. Extent and nature of circulation —

	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net press run)*	17,033	16,800
b.1. Mailed Outside-County Paid Subscriptions Stated on PS Form 3541	15,976	15,885
b.2. Mailed In-County Paid Subscriptions Stated on PS Form 3541	0	0
b.3. Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS	0	0
b.4. Paid Distribution by Other Classes of Mail through USPS	0	0
c. Total Paid Distribution	15,976	15,885
d. Free or Nominal Rate Distribution *(By Mail and Outside the Mail)*		
d.1. Outside-County Copies included on Form 3541	625	595
d.2. In-County Copies included on Form 3541	0	0
d.3. Copies Mailed at Other Classes Through the USPS	0	0
e. Free or Nominal Rate Distribution Outside the Mail *(Carriers or other means)*	245	230
f. Total Free or Nominal Rate Distribution	870	825
g. Total Distribution	16,846	16,710
h. Copies Not Distributed	187	90
i. Total	17,033	16,800
j. Percent Paid and/or Requested Circulation	94.8%	95.1%

I certify that all information furnished by me above is true and complete. — JAMES T. SNOW, Editor

Challenges of an Internet Agronomist

The Internet is great, but . . . .

BY TODD LOWE

The traditional means of becoming a golf course superintendent or turfgrass agronomist generally begins with working on a golf course and developing a desire to nurture and maintain fine turf playing conditions for golf. Next comes schooling, culminating in a degree in golf course management, horticulture, or agronomy. This is followed by several years of apprenticeship for becoming a golf course superintendent, turfgrass agronomist, or other turfgrass professional.

There is a new method of becoming a turfgrass expert that reduces years of schooling and apprenticeship (not to mention student loans) and is becoming popular on golf courses throughout the country. This new method simply requires you to be a golfer and have Internet access. With a few moments of research and the click of a mouse, you can amaze your fellow golfers with an abundance of information about growing grass. With the easy accessibility to the Internet and the fact that many golf club members are retired and have some free time, an increasing number of turfgrass "experts" are produced each year.

All kidding aside, turfgrass management is an art and a science and comes from years of working with turf, understanding seasonal changes, learning how it grows, and understanding the physiological stresses that turfgrass experiences. Just because a golf club member is a good player and can search the Web, it does not make him an expert — much like flying on commercial airplanes does not make a businessperson a pilot! It can be frustrating to a turfgrass manager when golfers gain *nickel knowledge* of turfgrass maintenance, especially if the information is incorrect or if it is used to undermine agronomic programs. Knowledge is gained through information exchange, then understanding, and finally wisdom. Nickel knowledge lacks wisdom and can be dangerous if some basic principles of turfgrass management are not first understood.

The Internet is one of the most important resources for information exchange. In the right hands, the Internet can be used to educate and provide insight into factors affecting management decisions. The challenge for effective Internet agronomists is to first develop a professional relationship with their superintendent and learn the peculiarities of the specific grass, soil, climate, environmental stresses, and budgetary/labor constraints particular to their course to properly use the information they gather. It is best to pass the information to the superintendent to see how it might relate to conditions at your golf course before spreading misinformation around the club.

The next step towards becoming an effective Internet agronomist is to utilize the right sources of information. Ask questions like, "Is my information source reputable? Are they non-biased? Are they specific to my region?" Be wary of companies that offer advice attached to products that can cure any ailment. Make certain the source is respected in the turf industry. Also, be cautious of advice from consultants in different regions, as different climatic conditions and turfgrass species impact specific cultural programs.

Some resources to consider include the USGA Green Section (*www.usga.org/turf/index.html*), the Golf Course Superintendents Association of America (GCSAA) (*www.gcsaa.org*), and the Turfgrass Information File (TGIF) (*http://tic.msu.edu*). Many of the resources on the GCSAA Web site are for members only, but the magazine archive can be searched by logging in as a non-member. The USGA Green Section Web site has numerous resources available, including helpful publications, research findings, regional updates, the *Green Section Record* archive, and an area where you can post specific questions to agronomists in your region. The largest database of turfgrass information is TGIF, and although there is a fee for the service, it is a must for any serious Internet agronomist. Another valuable resource might be your local land-grant university if it offers turfgrass management programs.

Improperly trained Internet agronomists can be quite a challenge for a golf club and its management. However, with the right training, they can be an asset to the club if they develop a professional relationship with their golf course superintendent, search reliable resources, learn the peculiarities of their onsite turf conditions, and understand how to properly utilize the information they find.

TODD LOWE *is an agronomist in the Green Section's Florida Region.*

USGA

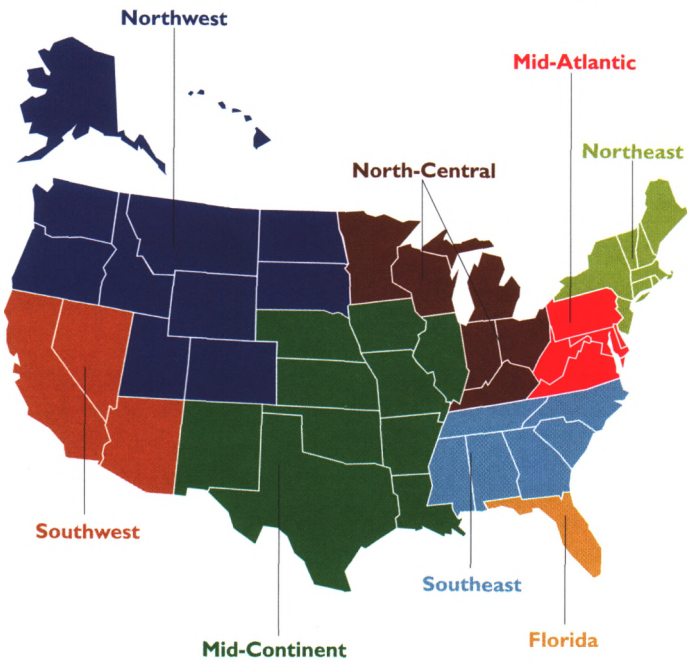
GREEN SECTION NATIONAL OFFICES

United States Golf Association, Golf House
P.O. Box 708
Far Hills, NJ 07931
(908) 234-2300 Fax (908) 781-1736
James T. Snow, *National Director*
jsnow@usga.org
Kimberly S. Erusha, Ph.D.,
Director of Education
kerusha@usga.org

Green Section Research
P.O. Box 2227
Stillwater, OK 74076
(405) 743-3900 Fax (405) 743-3910
Michael P. Kenna, Ph.D., *Director*
mkenna@usga.org

1032 Rogers Place
Lawrence, KS 66049
785-832-2300
Jeff Nus, Ph.D., *Manager*
jnus@usga.org

Construction Education Program
770 Sam Bass Road
McGregor, TX 76657
(254) 848-2202 Fax (254) 848-2606
James F. Moore, *Director*
jmoore@usga.org



REGIONAL OFFICES

Northeast Region
David A. Oatis, *Director*
doatis@usga.org
James H. Baird, Ph.D., *Agronomist*
jbaird@usga.org
P.O. Box 4717
Easton, PA 18043
(610) 515-1660 Fax (610) 515-1663

James E. Skorulski, *Senior Agronomist*
jskorulski@usga.org
1500 North Main Street
Palmer, MA 01069
(413) 283-2237 Fax (413) 283-7741

Mid-Atlantic Region
Stanley J. Zontek, *Director*
szontek@usga.org
Darin S. Bevard, *Senior Agronomist*
dbevard@usga.org
485 Baltimore Pike, Suite 203
Glen Mills, PA 19342
(610) 558-9066 Fax (610) 558-1135

Keith A. Happ, *Senior Agronomist*
khapp@usga.org
Manor Oak One, Suite 410,
1910 Cochran Road
Pittsburgh, PA 15220
(412) 341-5922 Fax (412) 341-5954

Southeast Region
Patrick M. O'Brien, *Director*
patobrien@usga.org
P.O. Box 95
Griffin, GA 30224-0095
(770) 229-8125 Fax (770) 229-5974

Christopher E. Hartwiger,
Senior Agronomist
chartwiger@usga.org
1097 Highlands Drive
Birmingham, AL 35244
(205) 444-5079 Fax (205) 444-9561

Florida Region
John H. Foy, *Director*
jfoy@usga.org
P.O. Box 1087
Hobe Sound, FL 33475-1087
(772) 546-2620 Fax (772) 546-4653

Todd Lowe, *Agronomist*
tlowe@usga.org
127 Naomi Place
Rotonda West, FL 33947
(941) 828-2625 Fax (941) 828-2629

Mid-Continent Region
Charles "Bud" White, *Director*
budwhite@usga.org
2601 Green Oak Drive
Carrollton, TX 75010
(972) 662-1138 Fax (972) 662-1168

Ty McClellan, *Agronomist*
tmcclellan@usga.org
165 LeGrande Boulevard
Aurora, IL 60506
(630) 340-5853 Fax (630) 340-5863

North-Central Region
Robert A. Brame, *Director*
bobbrame@usga.org
P.O. Box 15249
Covington, KY 41015-0249
(859) 356-3272 Fax (859) 356-1847

Robert C. Vavrek, Jr., *Senior Agronomist*
rvavrek@usga.org
P.O. Box 5069
Elm Grove, WI 53122
(262) 797-8743 Fax (262) 797-8838

Northwest Region
Larry W. Gilhuly, *Director*
lgilhuly@usga.org
5610 Old Stump Drive N.W.,
Gig Harbor, WA 98332
(253) 858-2266 Fax (253) 857-6698

Matthew C. Nelson, *Senior Agronomist*
mnelson@usga.org
P.O. Box 5844
Twin Falls, ID 83303
(208) 732-0280 Fax (208) 732-0282

Southwest Region
Patrick J. Gross, *Director*
pgross@usga.org
505 North Tustin Avenue, Suite 121
Santa Ana, CA 92705
(714) 542-5766 Fax (714) 542-5777

Subscriptions $18 a year, Canada/Mexico $21 a year, and international $33 a year (air mail).

Subscriptions, articles, photographs, and correspondence relevant to published material should be addressed to: United States Golf Association, Green Section, Golf House, P.O. Box 708, Far Hills, NJ 07931.

GREEN SECTION RECORD (ISSN 0041-5502) is published six times a year in January, March, May, July, September, and November by the UNITED STATES GOLF ASSOCIATION®, Golf House, Far Hills, NJ 07931.

Postmaster: Address service requested — USGA Green Section Record, P.O. Box 708, Golf House, Far Hills, NJ 07931-0708.

Periodicals postage paid at Far Hills, NJ, and other locations. Office of Publication, Golf House, Far Hills, NJ 07931.

Printed on recycled paper

Turf *Twisters*

Q: Our ninth green is located very close to our clubhouse. The clubhouse provides significant shade on this green, yet it has good air movement and performs well. Our fourth green is shaded by trees and performs poorly. Our superintendent says that we need to remove trees to promote sunlight penetration on the fourth green, yet our 18th green receives a similar amount of sunlight and performs well. Is our superintendent just making excuses? (Virginia)

A: Probably not. There is a big difference between shade provided by your clubhouse and shade provided by other green plants such as the trees surrounding your fourth green. Green plants can only use certain wavelengths of light to manufacture their food through photosynthesis. A building may cast shade, but the light that is received by the affected turf still has the necessary wavelengths of light for photosynthesis, albeit at lower intensity. Conversely, other green

plants, such as trees, greatly reduce the levels of these plant-active wavelengths of light before they reach the turfgrass. The result is that the greens (or other turf areas) do not get the light they need to grow vigorously.

Q: Our superintendent wants to implement a fairway topdressing program. We have tried to research this idea and really can't find any negatives regarding potential outcomes. Other than cost, are there issues we have not considered? (Delaware)

A: The strategy is being used by more and more golf course superintendents. First and foremost, if fairway topdressing is considered for implementation, commit to the technique for the long term. This is not something to try and then change after a season or two. Second, find sand that is coarser than the parent soil of the fairways. Laboratory testing can be conducted to determine if the particle distribution and chemical status are satisfactory. Third, adjust fairway aeration procedures so layering problems do not develop. When a fairway topdressing program is in place and core cultivation is conducted, all debris needs to be collected and removed. A more frequently implemented change is to use solid-tine aeration until sufficient sand accumulation has developed, allowing for the return to core cultivation practices.

Q: Is there a simple device on the market for measuring wind speed (air movement) on a putting green? I've been told that although the flag may move, there can be almost no air movement on the surface. I have a hard time selling this to my Green Committee for tree pruning and raising canopies. (Texas)

A: Yes. The Kestrel wind meter is very effective for measuring air movement. It is important to measure the air movement at flag level and then set the meter on the surface to see the difference. It is a great educational tool to use with the Green Committee. Some models also measure humidity.

USGA