suggesting that perennial ryegrass exhibited greater compaction tolerance than Kentucky bluegrass.

However, wear treatment has no significant effect on species composition. A significant effect from soil type was detected by June 2008. Specifically, there was a significantly greater perennial ryegrass in the stand over Kentucky bluegrass in the silt loam compared to the sand rootzone.

Wright et al. (1978) found perennial ryegrass had a competitive advantage over Kentucky bluegrass in soils with a more favorable moisture environment (low soil moisture tension), which may explain the higher perennial ryegrass populations in the silt loam.

However, Kentucky bluegrass increased in the population from 2006 to 2008, showing its greater recuperative potential compared with perennial ryegrass.

Rooting

Under compaction, the sand rootzone exhibited significantly greater rooting at the zero- to 3-inch depth compared to the silt loam corresponding to a 1.5- to 2.4-fold greater root mass, likely a result of high aeration porosity in the sand.

Alternately, rooting was significantly inhibited in the silt loam at the 3- to 6-inch depth compared to the zero- to 3-inch depth in response to an increase in soil strength and reduced aeration. Penetration resistance is closely associated with soil compaction and mechanical impedance to root penetration and was significantly greater in the compacted versus the non-compacted soil and in the silt loam versus the sand rootzone because of its greater soil strength.

Wear had no effect on penetration resistance.

Wear tolerance and recovery

There was significant wear injury noted immediately after wear was imposed in 2006 and 2007. Wear's main effect accounted for 87 percent to 90 percent of the total treatment variation in injury over both years (data not shown). The balance of variation was accounted for by compaction and soil type, which played a minimal role compared with wear.

During recovery in 2006, there was significant injury noted on all dates; however on the Aug. 29 rating, the plants had recovered with no observed bruising of the leaf tissue. In 2007, two of the five ratings during recovery were acceptable. On all other rating dates either some thinning and/or discoloration was observed.

Soil physical properties

There was a significant difference in air-filled porosity between the silt loam and sand rootzone corresponding to 7.6 percent and 20.1 percent, respectively.

Given the value for the silt loam of 7.6 percent, the value is below the cited minimum value of 10 percent, where aeration porosity can become deficient (Grable, 1971). Also, there was a significant decline in air-filled porosity due to compaction versus the non-compacted treatment across soils.

However, when comparing the values for compaction versus non-compaction on the sand rootzone (data not shown), the percent air-filled porosity for the compacted treatment is 16.8 percent, which is above the lower limit for air-filled porosity stated above.

The main effect for wear had no influence on air-filled porosity.

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Opportunity Knocks

By Michael Maurer, James Moken and Leon Young

Combination of fertigation and subsurface drip irrigation could provide quality turfgrass while reducing possible nitrate-nitrogen contamination and water use

Sixty 5-gallon buckets, each considered a lysimeter, were used in the study.

Limited water supplies and the increased population growth are placing greater demands on available water sources. The continued droughts across much of the Southwest and other regional areas of the United States have led to restrictions on water consumption, especially for landscapes. Subsurface drip irrigation (SDI) offers an attractive alternative to sprinklers for irrigation of turfgrass. SDI minimizes run-off and overspray by putting water at the site of plant uptake: the turfgrass rootzone.

Although sprinkler-irrigated turfgrass still dominates the industry, more turfgrass managers are beginning to use SDI on golf courses, athletic fields and commercial and residential turfgrass. In addition to irrigation, nitrogen (N) fertilization is essential to maintain a high-quality turfgrass. Nitrogen is a key component of fertilization of turfgrass because of its influence on color, growth rate, density and stress tolerance.

However, excessive nitrogen fertilization may adversely affect the environment through possible water contamination. The combination of fertigation (application of fertilizer via the irrigation system) and SDI could provide quality turfgrass while reducing possible nitrate-nitrogen contamination and water use. An increase of fertilizer costs along with limited water resources requires greater consideration to their utilization. The combined use of SDI and fertigation provides such an opportunity for the turfgrass industry. This study was designed to look at a range of fertigation rates and frequency combinations to minimize nitrate-leaching levels, while still producing quality bermudagrass.

The study was conducted at the Stephen F. Austin State University (SFASU) Mast Arboretum with the experimental setup and sodding in the fall of 2007, and data collection being performed during the 2008 growing season. Sixty 18.9-liter (5-gallon) buckets, each being considered a lysimeter, were used. Holes were drilled 17.78 centimeter (cm) from the top for drip tubing (Toro Dripline with one emitter 3.8 liters per hour [LPH]) so that a single drip emitter was installed at a depth of 15 cm below the surface. A final hole was drilled at the bottom with a stop-cock for collection of leachate.

The buckets were then filled with 2.54 cm of garden pea gravel. A piece of ground-cover cloth was placed on top of the pea gravel and then filled with a sandy-loam soil and sodded with Tifway 419 bermudagrass. Treatments were arranged as three fertigation frequencies (monthly, bi-weekly, weekly) times five nitrogen fertigation rates (0, 12.2, 24.4, 48.8, 97.7 kilograms of nitrogen/hectare/month (kg N/ha/month) or 0, 0.25,0 .5, 1.0 and 2.0 pounds of nitrogen/month/1,000 square feet) factorial design with four replicates per treatment to form a completely randomized block design. One kg/ha equals 0.89 pounds per acre. Nitrogen applications began on March 28, 2008, with all treatments receiving their appropriate urea ammonium nitrate (UAN) dosage. To see the variation in nitrate levels due to the UAN application, an intense four-week (28-day period) soil sampling was performed during the 2008 growing season (July 23 through Aug. 16, 2008). Soil samples were broken into 0 to 15 cm and 15 to 30 cm soil depths.

Leachate was collected three times after rainfall events from three separate fertigation cycles (28 days/cycle) once at four, 13 and 26 days into cycle — April 1, May 7 and Aug. 12, respectively. Leachate was analyzed for nitrate and nitrite being leached and compared to the EPA limits of 10 milligrams (mg)/1 and 1 mg/1 respectively. A biomass collection and several visual quality ratings were performed throughout the 2008 growing season to analyze the health of the turfgrass.

Two- and three-way analysis of variance (ANOVA) were performed on the collected data using the Statistical Analysis Software general linear model (GLM) procedure at the 0.05 probability level with the Tukey multiple-comparison test used to determine differences in means between the treatments.

There was no significant difference in fertigation frequency for any of the data collected, therefore only the rate means are shown.

Soil analysis showed large amounts of nitrate-nitrogen being retained in the soil and not being utilized by the turfgrass at rates of 48.8 and 97.7 kg N/ha/month.

During a natural rain event (Aug. 18, 2008) resulting in 8.28 cm of precipitation, this large buildup of nitrate-nitrogen in the soil was leached, causing excessive nitrate-nitrogen leachate over the EPA limits.

The first two water samples were taken early in the growing season when the applied nitrate-nitrogen was not being effectively used by the turfgrass. This led to higher nitrate-nitrogen leachate values in the lower 12.2 and 24.4 kg N/ha/month rates, which lowered significantly once the turfgrass was fully established. Leaf tissue N levels were 1.3 percent, 3.0 percent, 3.4 percent, 3.5 percent and 4.6 percent for the 0, 12, 24, 49 and 98 kg N/ha/month rates, respectively. The control was significantly lower and the 98 kg N/ha/month rate significantly higher than the other rates. However, all four rates had leaf tissue nitrogen percentages between the 3- to 5-percent sufficiency range for a fairway turfgrass (McCarty, 2001).

Visual quality ratings were highest for the 12.2, 24.4 and 48.8 kg N/ha/month rates compared with the control and 97.7 kg N/ha/month rate (data not shown). Visual quality rating for both the 48.8 and 97.7 kg N/ha/month rates were often lower due to excessive vegetative growth that led to scalping with the weekly clipping. Both these rates, however, did still produce an acceptable quality turfgrass.

When compared with the vegetative growth data, it was generally seen that as vegetative growth increased, visual quality increased as well. However, sometimes the quality of the turfgrass was affected if the growth was excessive. This would show up during the weekly clipping when some of the more vigorous turfgrass would have a scalping effect when clipped.

Results from the study indicate a fertigation rate of 12.2 kg N/ha/month produced a quality turfgrass, while minimizing nitrate-nitrogen leaching in sandy-loam soil. Optimum quality was obtained at the 24.4 and 48.8 kg N/ha/month rates. This range is currently recommended for optimum bermudagrass quality and growth. However, in this study, the 24.4 and 48.8 kg N/ha/month rates produced nitrate leachate levels that were well above EPA limits. These rates may have produced such high nitrate leaching values due to the limited root zone and soil profile of only 30 cm. If a deeper soil profile had been used, leachate values may not have been as high.

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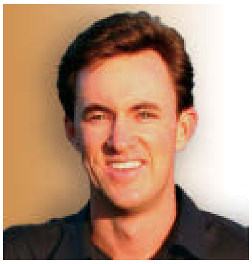
The Soul of the Game

MORE THAN EVER, THE SPORT NEEDS REMINDERS OF WHAT ST. ANDREWS IS ABOUT, AND JUST HOW FAR WE'VE DRIFTED FROM ITS SPIRIT

BY GEOFF SHACKELFORD



Greetings from the place that got us into this business. I wrote this column in St. Andrews, Scotland, while attending The Open last month. St. Andrews is not only the home of golf, it's the soul of the game. I know, you're probably thinking this is another laudatory column about the merits of the Old Course, served up with a big dollop of honey.

But if you were with me when I wrote this, you'd understand. The places oozes golf — the kind of golf of which we need more. As noted golf scribe George Peper said of St. Andrews, "This is what golf is, not what it isn't."

More than ever, the sport needs reminders of what St. Andrews is about, and how far we've drifted from its spirit.

A few more observations from St. Andrews and the United Kingdom:

■ The Old Course is as much a town park as it is a golf course. When there's no golf happening, people are free to walk their dogs or simply stroll the sacred soil. In fact, members commonly take their dogs for on-course walks in the early morning or late afternoon at other clubs throughout the area, and nobody thinks otherwise.

American courses, on the other hand, have become overprotective of their turfgrass to the point that any visitor seems destined to be shot on site. This attitude of anyone but a paying golfer as an intruder certainly can't help the game's image. Surely, we all understand liability issues and putting property at risk, but it's a shame we treat such visitors as criminals. Perhaps it's a reason why so many Americans are turned off by golf.

■ Speaking of our four-legged friends, they're welcome at most courses here. Folks are even encouraged to give their happy hounds a wee nip now and then, thanks to modified drinking fountains. It's just another example of the type of informality that rarely causes problems, and, more vitally, is essential to the beautiful convergence of community and sport here in Scotland.

■ It's not embarrassing to be a golfer or associated with the game here. Yes, no apologies are necessary and, quite often, folks are excited to hear about your desire to be in Scotland to see the home of golf. See above for the reasons why.

■ The contour doesn't have enough meaning in America. I'm not thinking about those nice, little linksy bumps and "hillocks" you see on television, nor am I thinking of the littering of containment mounding that American architects love.

No, these are large, often strange whale burial grounds you see at St. Andrews and other links in the middle of play. They are natural — remaining from the days when the sea shaped the ground, yet they play a vital role in how a hole plays. And, yes, they create blind shots, quite often for a poorly placed drive.

But almost always, the player is given another option that opens up a view of the putting surface. When there's a way, there's no room for complaining.

■ Slow play and lack of interest from younger golfers has become an issue here. Yes, even as wonderful and affordable as the game is in Scotland, the country is still struggling to attract and retain enough new golfers here, just as it is in the states.

There's little question the time and cost it takes to play are the primary issues. Both are a product of selling the game out to the manufacturers' need to constantly sell us new clubs, most definitely not from a lack of facilities or inappropriate conditioning.

Unfortunately, the Royal and Ancient Golf Club of St. Andrews also believes the game would suffer if the ball were to be rolled back allowing for shorter courses to be relevant and logjams from more reachable par 5s and par 4s to be resolved.

So at least we have one thing in common with Scottish golf. No one wants to stick up for the best interests of the sport.

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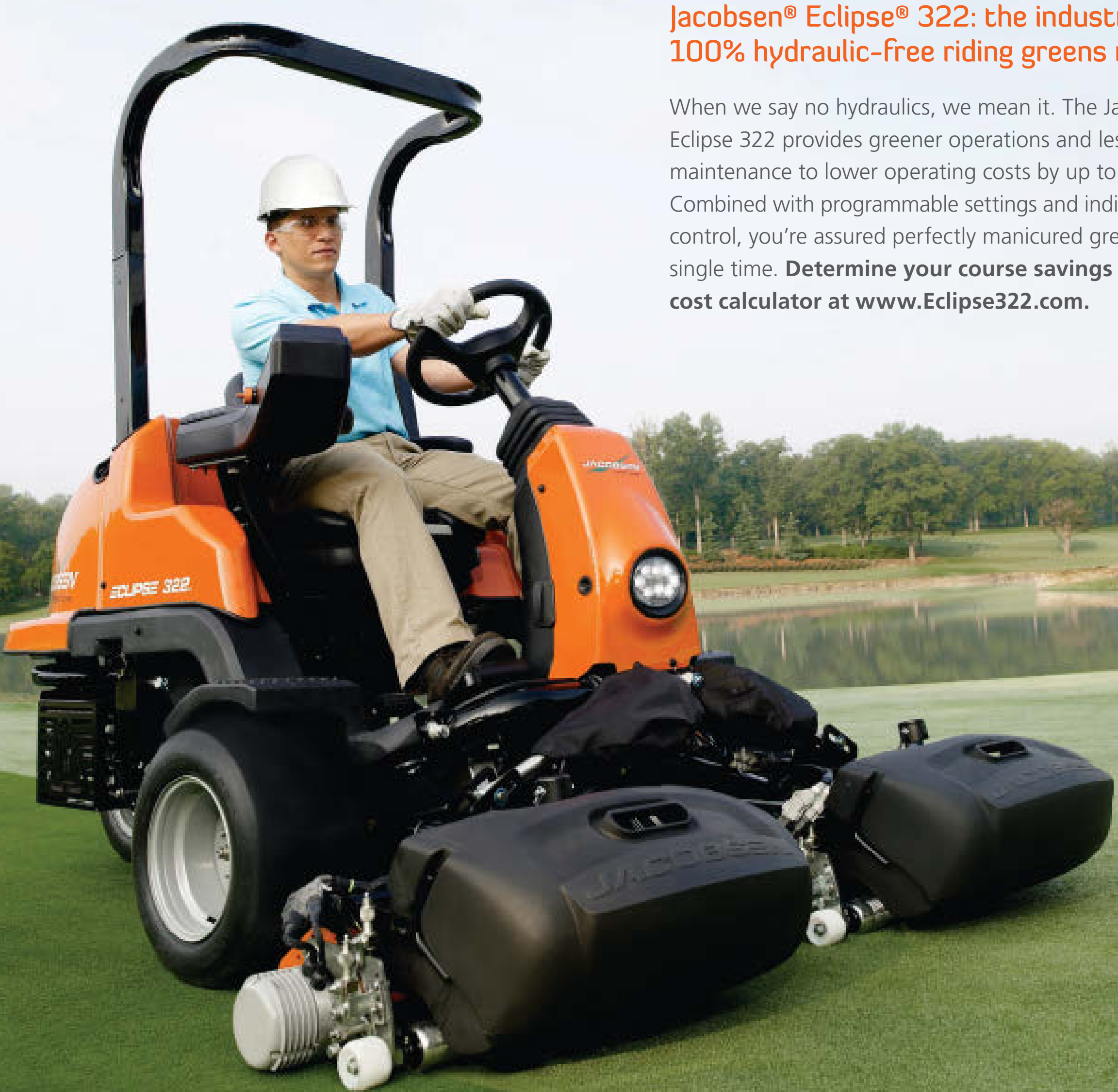
ON THE GREEN, "ALMOST" DOESN'T CUT IT.



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