At the private Black Creek Club in Chattanooga, Tenn., superintendent Scott Wicker maintains all of his roughly 80 bunkers with a mechanical rake rather than by hand. He said he realized the cost-saving change was possible thanks to a Nationwide Tour official. Wicker's course has hosted the Chattanooga Classic Presented by Black Creek for the last eight years (this year's event is Oct. 7-10). A few years ago, a Nationwide official told Wicker that mechanical raking produced an acceptable surface in his eyes. Wicker commends the Tour for taking that stance.

"I think they're getting back to basics," he says.

Wicker also reduced the frequency of bunker work on the privately owned Brian Silva design that opened in 2000. In an average week, the crew will rake sand three times.

"Otherwise, we expect golfers to rake them accordingly," Wicker said, adding that the club's owners back that stance and believe that members are responsible for a portion of the daily upkeep.

At Black Rock Country Club in Hingham, Mass., superintendent Chuck Welch has cut back on the regularity of his bunker raking and so far the members haven't picked up the slack as they should.

"They don't seem to like to rake them themselves," Welch says. "You need to take care of your own golf course."

Part of the problem, he surmises, is that it's the first time most of the younger members have belonged to a club.

Welch cut five seasonal employees to work inside budget constraints and that has led to a reduction in not only how often the sand is maintained, but also the banks of the 109 bunkers. Rather than putting down chemicals in large applications, he switched to spot spraying.

The method John Davis uses to reduce the cost of taking care of his sand hazards involves workers taking on added responsibility. Davis, superintendent at the private Secession Golf Club, a mandatory walking course in Beaufort, S.C., had crew members whose morning assignment was greenside bunkers. He now has the four who walk mow greens take care of those same hazards, a necessity after his full-time staff was reduced by five.

While the greenside bunkers of the Bruce Devlin design

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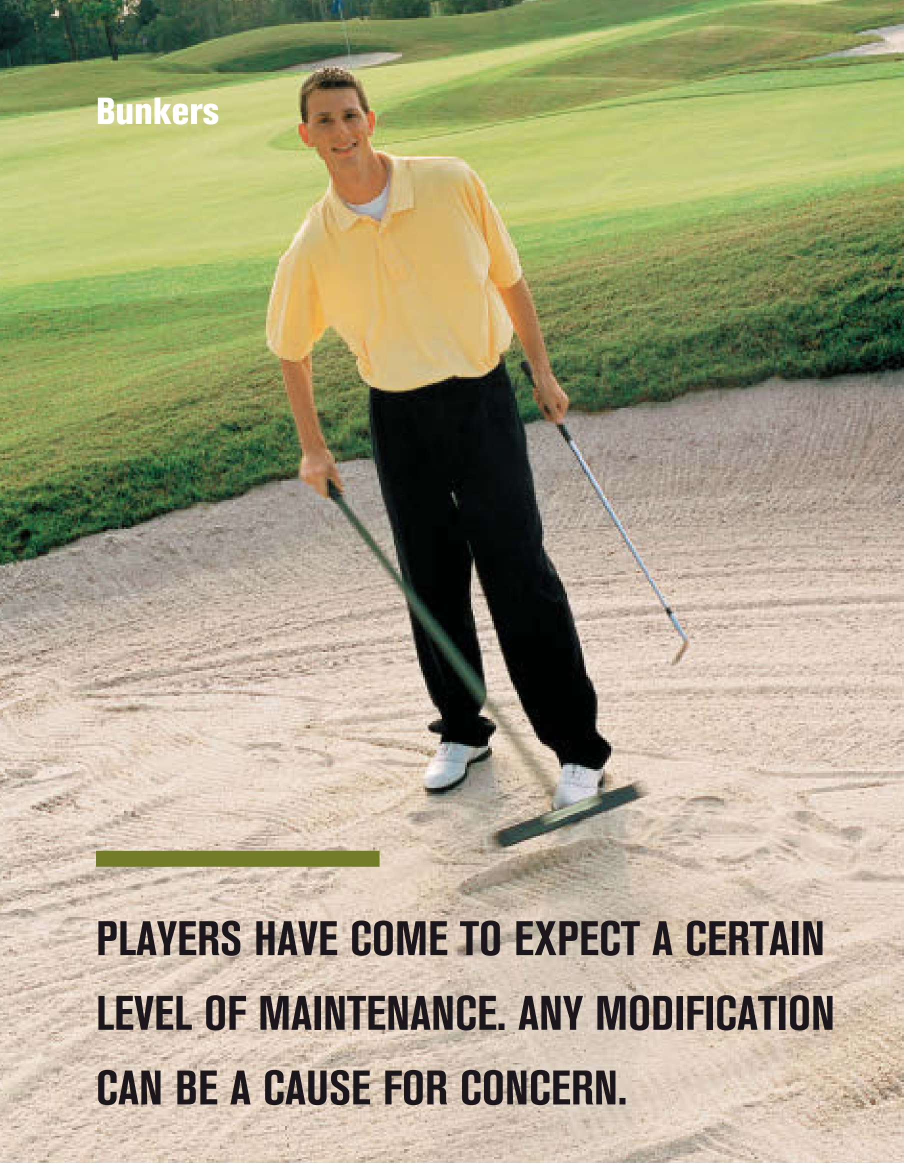

PLAYERS HAVE COME TO EXPECT A CERTAIN LEVEL OF MAINTENANCE. ANY MODIFICATION CAN BE A CAUSE FOR CONCERN.

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are raked every day, the fairway bunkers get attention only when they need it. Often times, it's Davis or assistants who are the ones with their hands on those rakes.

Sometimes spending more can reduce costs down the road.

Randy Wahler, the certified golf course superintendent in his 30th year at Knollwood Club near Chicago, says the club recently completed a renovation of its 76 bunkers, many of which have high-flashed sand faces. Under the guidance of architect Keith Foster, the club installed bunker liners as part of the process. They also filled the bunkers with sand that compacts better than average bunker sand.

"We don't have to shovel sand back up after a major rainfall," Wahler says of the improvements. "We put a little extra money in now to save a lot of money down the road."

Wahler has also been able to reduce hand-raking greenside bunkers to three times a week and fairway bunkers to once a week.

The Timbers Golf Club in Vassar, Mich., is a daily-fee layout with the cost to play about $50. Large portions of those who tee it up are vacationers. As a result, superintendent Tim Sheridan needs to produce a top-notch product every day even though his budget has been reduced in the last few years.

When the economy was better, Sheridan had eight full-time employees and four part-timers working 20 hours a week. Bunkers were maintained daily with a mechanical rake. All 41 sand hazards were hand edged biweekly.

"We had some really sharp-looking bunkers," Sheridan says.

Three years ago, with the economy slowing, Sheridan reduced edging to every three weeks. Now, with a crew of five full-timers and five part-timers, he's edging them about once a month and they are raked two or three days a week and touched up daily. Sheridan has also increased his use of growth regulators and wetting agents on the bunker surrounds to reduce the need to mow.

Sheridan says he has received no complaints from golfers, of which about 50 percent are regulars and the others vacationers. However, there have been gripes that work has not been done on bunkers that need to be renovated.

One other job that Sheridan had placed upon him was explaining to the two brothers who own his course how cutting back a budget can affect maintenance.

"I try to educate them that you can't just pick a number and say this is it because there are consequences to that," he says.

The lessons learned from reduced spending on course maintenance aren't just for golfers and owners, but also for superintendents. It appears, much to the surprise of many, that the level of daily course maintenance may have gone too far, well beyond what is required or desired.

In Chattanooga, Wicker has found the results of his cutbacks on bunker maintenance to be ironic.

"The more we did to them, the more we heard about them," Wicker says. "The less we do, the less we hear about them."

For Davis, perfect bunkers are a deviation from the intent of their role. Now, with less attention, bunkers are more in line with how they should be.

"They always want them perfect," Davis said of his members. "But they're hazards." ■

Pioppi, a longtime contributing contributor to Golfdom, is based in Middletown, Conn.

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Sherry Moss received her Ph.D. in Organizational Behavior in 1991 from The Florida State University. She is currently an Associate Professor of Organizational Studies in the Schools of Business at Wake Forest University where she is also the Director of the Full Time MBA Program. Prior to her appointment to the faculty at Wake Forest, she was an Associate Professor at Florida International University in Miami, Florida. For 10 years, she taught in and served as the Director of their Executive MBA program.

Her research interests include attribution theory, feedback, manager-employee relationships, abusive supervision and emergent leadership. Her work has been published in prestigious academic journals such as *Journal of Organizational Behavior, Academy of Management Journal, Journal of Management, Organizational Behavior and Human Decision Processes* and *Academy of Management Executive.*

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Continuing Education Points through GCSAA have been applied for regarding this webinar series.

CASE STUDY

A Change of **Diet**

Superintendents rethink the traditional way of fertilizing bermudagrass greens during grow-ins

By John Walsh, Contributing Editor

For the most part, fertilizing bermudagrass greens during a grow-in has been the same for many years — 1 pound of soluble nitrogen once a week for six to eight weeks. It's a lot of nitrogen and a lot of labor, but it has worked. Superintendents haven't deviated much from that formula … until recently.

Instead of 1 pound of soluble nitrogen a week, several superintendents have used 6 pounds of Polyon per 1,000 square feet with just one application during a grow-in. They say using the slow-release fertilizer this way during a grow-in works successfully. While the method has yet to catch on, that might change soon.

The use of Polyon in this way can be credited to Jeff Higgins, Ph.D., director of agronomy for ValleyCrest Golf Course Maintenance. He started this type of fertilizer application in 2001 when he worked at Pursell Technologies in Sylacauga, Ala. Pursell owned Polyon before the company was purchased by Agrium Advanced Technologies. When Pursell built Farmlinks Golf Course in Sylacauga, it conducted an environmental audit because there was concern about fertilizer leaching into the aquifer that ran beneath the course.

"We baselined it and monitored it during construction because of environmental concerns," Higgins says, adding that university research reveals that urea and ammonium sulfate have both exceeded contamination at the bottom of green cavities in some instances, but not contaminated groundwater.

When soluble nitrogen is applied directly to the soil, such as during a grow-in, there's no turfgrass established to take it up, so the available nitrogen is absorbed into the soil — it volatilizes — or it's leached down through the soil profile. Once the turfgrass becomes established, the uptake of nitrogen can occur.

Superintendents say they're seeing successful results by using 6 pounds of Polyon per 1,000 square feet in just one application.

PHOTOS COURTESY: VALLEYCREST GOLF COURSE MAINTENANCE

Polyon, which releases by temperature, was used to grow-in holes at Farmlinks. Higgins tested to see how much weekly nitrogen was needed and found three-eighths of a pound a week was sufficient.

"We put 6 pounds of nitrogen down in fairways, and they grew in faster than the others," he says. "Environmentally, there's less likelihood of leaching."

Two superintendents who've executed the Polyon method successfully are Jason Regan, the certified golf course superintendent at Ocala Golf Club, and Deron Rake, the certified golf course superintendent at Okeeheelee Golf Course. Both work in Florida for ValleyCrest and credit Higgins for the suggestion.

The renovation at Ocala began in March last year and encompassed the tee and green complexes and irrigation system. Regan planted Emerald dwarf bermudagrass, a cross between Tifdwarf and Ultradwarf, on the greens. He says Higgins told him to use Polyon during the grow-in.

"I was hesitant," Regan says. "It was my first grow-in, so I was open to other opinions."

Regan liked that Polyon wouldn't be affected much by rain and its slow-release technology meant the plant would be fed for 16 weeks.

Once the greens were ready to be planted, Regan needed to decide about how he was going to apply the fertilizer. One option was to till it 2 or 3 inches into the greens mix. But Regan ran over the green with a mechanical bunker rake and "scratched in" the fertilizer.

"The fertilizer needs to be deep enough so it won't float away if it rains," Regan says, noting the turf grew in consistently and quickly because of the slow-release fertilizer.

Regan also applied ammonium sulfate (1 pound per 1,000 square feet) three times in 12 weeks to supplement the Polyon. He says he saved money in the long run via product and labor. The cost of Polyon for the greens (112,000 square feet) was $2,600.

Aside from the fertilizer plan, the timing of the greens renovation was an issue. Regan planted the first seven greens July 2, the next eight greens July 16, the next four greens Aug. 7 and the last two greens Aug. 10. The course opened Oct. 21.

"I wish we would've done 11 greens at first and the last 10 in the middle of July," he says. "We lose daylight in September and October, so it's better to have all the greens planted by mid-July. The last greens we planted didn't have as much daylight, so they weren't as mature as the first 15 greens we did. They weren't quite dense enough."

At 27-hole Okeeheelee, where Rake has a $700,000 maintenance budget, the greens were renovated to upgrade the turf from Tifdwarf to TifEagle. The renovation, which was done in nine-hole stages, was a 30-week project (eight to nine weeks for each grow-in stage) that cost just less than $300,000.

Like Regan, Rake discussed with Higgins several ways to renovate the greens. Ultimately, the greens were stripped and fumigated because the soil was good.

Rake fertilized the greens (comprising five acres) three different ways to see which way he liked best: One, a typical grow-in applying nitrogen on a five- to seven-day cycle to feed the greens constantly; two, tilling Polyon into soil; and three, scratching in Polyon just over the top of the surface.

"Tilling down about 4 inches was the best because the fertilizer stayed in the soil and there was no chance of wash," he says. "There was minimal traffic on the greens and no foot traffic. Each time we tweaked it a bit more. The last nine holes were best."

The rate of Polyon was 6 pounds per 1,000 square feet. And, like Regan, Rake applied additional nitrogen a couple of times.

"I was very happy with it," he says. "We made all the deadlines. We had good turf coverage and had to do very little plugging." ■

Walsh is a contributing editor to Golfdom.

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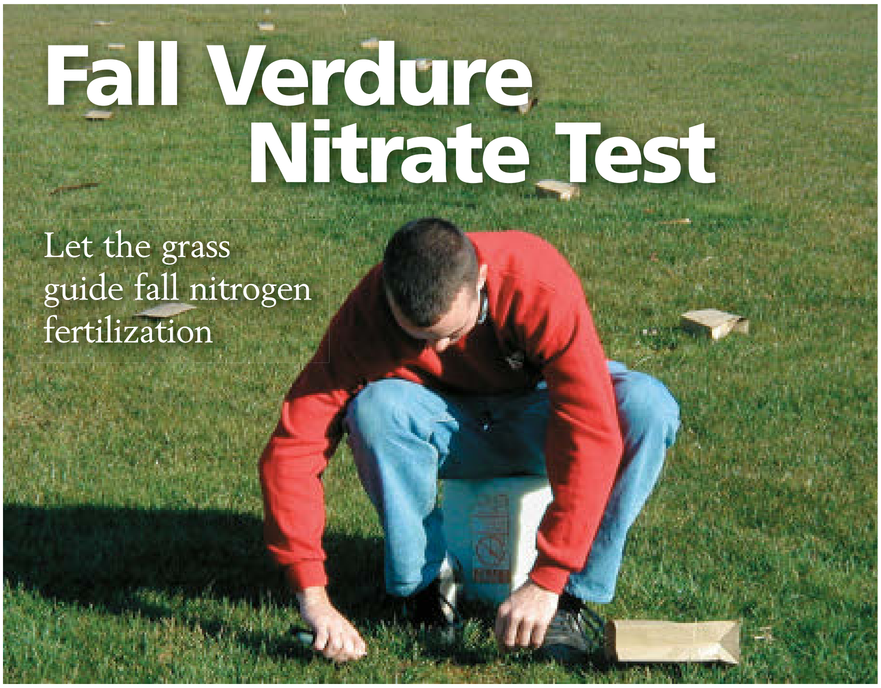

By Karl Guillard, Thomas F. Morris and Thomas J. Barry

Have you diligently followed the nitrogen (N) recommendations suggested by previous research studies or experience for your fall application? If you did, you're not alone. That's the fertilization paradigm most golf course superintendents have accepted and practiced since the late 1960s and early 1970s when the agronomic benefits from fall N applications were reported for turf. Since then, fall fertilization has become the foundation of N management for maintaining high-quality turf for many different uses, particularly in northern temperate climates.

But, have you ever questioned these recommendations or noticed that the N recommendations for fall fertilization are suspiciously uniform and consistent for different turf species and across wide geographical regions with different climates and soils?

Thomas J. Barry collects verdure plant tissue samples on research plots at the University of Connecticut during the fall that will be analyzed for concentrations of nitrate-nitrogren. The verdure is considered the aboveground parts of the turf plant remaining after mowing.

PHOTO COURTESY: UNIVERSITY OF CONNECTICUT

The standard fall fertilization recommendation is usually 1 pound N per 1,000 square feet, give or take a quarter-pound or so depending on formulation, and applied anytime from September into December (timing of application is a separate but related issue that needs to be addressed in a future article).

Given that you have undoubtedly seen different

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responses of turf to the same N rate on your own managed grounds for different species and within a much smaller area than an entire geographical region, how can this universal and similar recommendation be logical or even correct? We're not questioning the agronomic benefits from application of fall N where needed. However, as scientists, we don't accept that a common or universal N rate recommendation is a logical or correct approach for fall fertilization of all turf across many species, climates and soils. Because of this, we set out to find a better way to guide N recommendations for fall fertilization of turf.

In our climate, spring green-up typically occurs sometime in March to early April. We have always been intrigued at the suddenness of this event, as if a switch has been turned on to initiate the green-up almost overnight. While observing this rapid green-up, we wondered where the plant was obtaining the N to synthesize leaf chlorophyll and proteins in the new spring growth.

Measurements of available soil nitrate during the few days of green-up revealed almost non-detectable concentrations of nitrate-N, or concentrations considered to be much below typical background values. In our climate, we receive significant amounts of unfrozen precipitation during the winter. With our sandy loam soils, any nitrate remaining in the soil from the fall is lost by leaching.

It is also known that for nitrate to be taken up by turf, water must be moving through the plant (driven by evapotranspiration — ET — factors) through the transpiration process. Turfgrass ET values during early spring in southern New England are meager at best, and not much water is moving through the plant at this time. Therefore, faced with low ET and almost no soil nitrate, we ruled out plant uptake of soil nitrate as the main source of N for spring green-up for our conditions.

Our attention turned to the grass plant. The most plausible explanation for the primary source of N for spring green-up under our conditions before any fertilizer is applied was the grass plant itself. We hypothesized that N taken up during the fall was being stored over winter, and then used for growth during the following spring green-up. Research has shown that annual grasses, such as corn, wheat and barley, store N as nitrate in the bases of stems and shoots. Measurement of this nitrate pool has been used as an indicator of soil N availability for these grasses and subsequently as a guide for N fertilization.

Perennial grasses can also store N as nitrate, but storage of nitrate is typically minimal during the active growing season because of frequent mowing, which leads to the rapid assimilation of nitrate into leaf proteins as new leaf blades are formed. In northern climates, however, fall marks the period when new leaf blade formation in perennial turfgrasses declines as the onset of winter dormancy begins. It is during this time that we think N storage as nitrate increases in the turf plant because the amount of N assimilated into leaf proteins is reduced because of a decline in overall leaf formation.

Our hypothesis is that this stored nitrate may be the primary source of N for the turf plant at the onset of new growth in the spring after winter dormancy. We also think that a measure of this nitrate pool could be used to improve the management of fall N for turfgrasses.

We developed a theoretical model for turf spring color in relation to fall verdure

PHOTO COURTESY: UNIVERSITY OF CONNECTICUT

This photo details the removal of the verdure plant tissue down to ground level. The verdure is considered the aboveground parts of the turf plant remaining after mowing.

nitrate-N concentrations. The verdure in turf is the aboveground parts of the turf plant remaining after mowing. We thought the verdure would be a better tissue to measure for nitrate than leaf tissue, because nitrate assimilation is relatively rapid in leaves.

If perennial turfgrass plants do store nitrate in the fall, we thought it would be most likely stored in the verdure shoot bases than in the leaves, and therefore a more stable pool of nitrate than the leaves.

Based on our theoretical model, spring turf color response will rapidly increase starting from low verdure nitrate-N concentrations (below optimum; deficient) in the fall, then the rate of response will begin to slow as the verdure nitrate-N concentration approaches optimum (also called the critical level).

At the optimum critical level and beyond, the response will plateau or flatten out — increasing the concentration of nitrate-N concentrations in the verdure plant tissue beyond the optimum critical level by fertilizing with N will not increase the grass color in the spring; the maximum color response has been reached.

Research at the University of Connecticut suggests that nitrate will accumulate in the shoot bases of perennial turfgrasses during the fall. We collected samples of the verdure and extracted the nitrate from the dried tissue.

Our preliminary data fit the theoretical model, and suggest that spring turf color will be maximized when the previous fall verdure nitrate-N concentrations are between 500 and 1,500 parts per million on a dry-weight basis. Earlier verdure tissue sampling (September) would use the higher end of this range (1,500 ppm dry-weight basis), whereas later sampling (October) would use the lower end of the range (500 ppm dry-weight basis).

We think this test has considerable value in developing more efficient and environmentally sound fall N fertilization practices for turfgrasses. It should help prevent excess application of N fertilizers in the fall when the probability for leaching losses is high in our climate, and offer budgetary savings on fertilizer costs.

On the other hand, it should also suggest when N fertilization may be needed for optimum turf quality. We raise caution, however, because our critical range of values is preliminary and more research is required for different grass species, soils and climates. Further evaluation of this approach will be ongoing, which is likely to change the critical values.

Although this research was conducted for taller-cut turf (2 to 2.5 inches), it should work with short-cut turf as well. The next steps for research are to determine if clippings can be used instead of verdure. This would make the logistics of sample collection much easier for both tall- and short-cut turf.

Karl Guillard is a professor of agronomy and teaching fellow and Tom Morris is an associate professor, both in the department of plant science and landscape architecture at the University of Connecticut. Thomas J. Barry earned his master's degree in turfgrass science from the University of Connecticut.

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A Primer on Soil Redox Potential

Superintendents need to know how to avoid redox potential

By William L. Berndt

Redox potential is a measure of soil aeration. It's a vital factor in culturing quality turf and is influenced every day through cultural practices. Golf course superintendents should be aware of what redox potential is and how it's manipulated.

The basics of redox potential

Chemical reactions in soil involve the gain and loss of electrons. Gain of electrons is reduction and loss is oxidation. An acronym for reduction and oxidation is redox. Redox potential is a measurement describing the tendency or potential to transfer electrons in chemical reactions.

Soil layering resulting from topdressing. Note how thatch is sandwiched between successive topdressings.

To illustrate the concept of electrons transfer, consider that when soil organic matter (SOM) decays electrons and hydrogen ions are lost from it, meaning it's breaking down into simpler substances.

If oxygen (O_2) is present in the soil, its chemistry is such that it attracts and binds the electrons and hydrogen ions and creates water (H_2O) in the process.

In this reaction, SOM loses electrons and O_2 accepts electrons. This is called a redox reaction, and is commonly known as respiration.

The tendency to transfer electrons between SOM and O_2 can be measured by determining the voltage (V) associated with it. This voltage, or redox potential (Eh), is plus 0.82 V. This is the highest voltage encountered in natural systems like soils. Thus, when O_2 is present in sufficient quantities and electrons from SOM or other sources flow to it, there is said to be a high redox potential.

When O_2 becomes depleted, the electrons released by SOM or other substances are transferred to other electron acceptors, creating substances other than water. If O_2 is absent and sulfate is present, then electrons flow to sulfate, creating highly toxic hydrogen sulfide (H_2S). This reaction is called sulfate reduction. The voltage associated with sulfate reduction is minus 0.21 V, a much lower redox potential. Hydrogen sulfide produced by this reaction kills turf, and is the basis for the formation of the dreaded black layer.

Maintaining high levels of soil O_2 prevents the release of H_2S and subsequent black layer formation by maintaining the flow of electrons to O_2, hence a high redox potential.

Preventing formation of black layer requires keeping redox potential higher than minus 0.21 V. An easy way to do this is to fertilize with nitrate. Because of its chemistry, nitrate has a greater affinity for electrons than SO42–. It is more electronegative than sulfate, but less electronegative than O_2. This means that if both are present and O_2 remains absent, the electrons preferentially flow to nitrate, which generates an Eh of plus 0.43 V.

The reduction of nitrate is also known as denitrification. If O_2 is present, neither denitrification or sulfate reduction can occur, because the redox potential is too high.

Soils with low redox potential are anaerobic, which means they lack available O_2. Anaerobic soils can develop in a variety of ways. Water-logging because of rainfall or over-irrigating creates anaerobic soils. So does the presence of layers within the soil profile. Microbial respiration may also consume available O_2. Sometimes cultural practices inadvertently generate anaerobic soils. For example, applying natural organic forms of nitrogen (N) fertilizer (sewage sludge) or soil amendments like elemental sulfur can induce low redox potential by scavenging soil O_2.

Consider the application of elemental sulfur to help lower soil pH. This is a common turf cultural practice. The only way elemental sulfur lowers soil pH is by reacting with O_2 to produce sulfuric acid. The sulfuric acid then dissociates releasing acidity, which lowers pH.

As elemental sulfur must react with O_2

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