Winning Strategies to Overcome Adverse Soil Conditions

Improving the rooting environment of nearly impermeable soils irrigated with reclaimed water.

BY BRIAN WHITLARK

Golf facilities built in north Scottsdale, Arizona, offer some of the best playing conditions in the country for much of the year and attract winter visitors from many domestic and international locations. The golf industry in Arizona yields an annual economic impact of $3.4 billion (Economic Impacts and Environmental Aspects of the Arizona Golf Industry) and employs more than 20,000 people locally. Additionally, Scottsdale is the top ranked "Golf-Home" market in the west as identified by *Golf Digest*.

In an effort to conserve precious water resources, the golf courses in Scottsdale converted to using recycled water that contained elevated salt levels when compared with groundwater or water delivered from the Colorado River. The recycled water, in combination with adverse soil conditions, eventually led to poor-quality turf where salts accumulated. The net result was decreased revenues and increased inputs to try to alleviate the situation, ultimately affecting the facilities' profit margins.

In this article we will investigate methods several facilities have employed over the past decade to overcome poor-quality irrigation water and adverse soil conditions. Note that while this article focuses on the challenges in a specific part of the country, the concepts of managing fairways with poor-quality water under the most demanding of conditions are universal.

Dr. Norm Hummel collects a soil core for physical analysis. An AMS Soil-Core Sampler was used to collect 8- to 12-inches-deep soil-core samples from fairways. The sampling equipment was broken multiple times when driving the device into these hard, compacted soils.

HOW BAD ARE THE NATIVE SOILS?

Golf facilities constructed in north Scottsdale, Arizona, were built on soil containing a wide particle-size distribution, including over 30 percent gravel, in most cases, and up to 30 percent clay. In general, courses in this area share similar soil types and soil classifications, ranging from a gravelly sandy loam or gravelly sandy clay loam to a sandy loam or sandy clay loam.

When courses were first constructed in the Scottsdale area, the native soils drained fairly well. However, after only a few months, in some instances, salts from the irrigation water began to accumulate and water infiltration rates slowed to as low as 0.05 inch per hour. Personal experience and years of soil testing at these facilities showed that the native soil at newly constructed courses had sodium levels of 55 to 80 parts per million (ppm). Samples collected after applying recycled water for only six months revealed sodium levels of 400 to 860 ppm and an electrical conductivity (ECe) of over 3 dS/m. Why did the salts accumulate so rapidly in these soils? Could gypsum or other calcium amendments and leaching have reduced or prevented the rapid salt accumulation? Read on to discover what methods have been successful over the past decade.

To gain a better understanding of just how bad the soils perform and why, a project was initiated with Dr. Norm Hummel from Hummel & Co., Inc. The project visited 11 golf facilities in north Scottsdale in December 2012 to collect and analyze soil cores from fairways. Each facility was asked to

TABLE 1
Soil particle-size characteristics in the surface and subsurface layers in unmodified fairway soils at three golf courses (ASTM F-1632)

Course	Gravel		Soil Separate %			Sieve Size/Sand Fraction % Retained				
	No. 5 4mm	No. 10 2mm	Sand	Silt	Clay	No. 18 V. Coarse 1mm	No. 35 Coarse 0.5mm	No. 60 Medium 0.25mm	No. 140 Fine 0.10mm	No. 270 V. Fine 0.05mm
A (0-3")	08.3	14.9	71.3	18.4	10.3	16.5	17.7	16.5	13.5	07.2
A (6-9")	09.4	16.4	66.8	24.5	08.7	19.8	13.7	11.0	11.7	10.7
B (0-3")	04.4	02.7	41.5	30.1	28.4	07.2	08.8	08.8	08.8	07.8
B (4-7")	08.3	04.6	31.5	35.4	33.1	06.7	06.2	05.3	05.7	07.7
C (0-3")	13.7	12.9	66.0	17.6	16.4	13.2	13.3	15.8	15.8	07.8
C (6-9")	13.2	16.6	60.0	26.5	13.5	15.7	10.3	10.0	12.8	11.2
USGA Recommended Guidelines for Putting Greens	None	≤ 3	89-100	5 Max.	3 Max.	≤ 7 to 10	At Least 60		20 Max.	5 Max.

Soil test values courtesy of Hummel & Co., Inc.

collect soil samples from at least two fairways, and several courses sampled up to four fairways. Each superintendent took samples from an area where the turfgrass was healthy and an area where the turfgrass had declined. Additional samples were collected from fairway areas where the superintendent had employed some form of soil modification, such as sand topdressing, rototilling, or sand capping. Two soil cores were collected from each fairway for physical analysis at Hummel & Co., Inc. Each sample was sectioned to isolate a surface layer (0-3 inches) and a subsurface layer (3-6, 4-7, 5-8, or 6-9 inches). The depth of the subsurface layer was chosen based on visual observations of soil textural changes within the profile. Take a close look the soil characteristics below to see if the soils at your facility have similar qualities to those in this evaluation.

PHYSICAL CHARACTERISTICS OF THE NATIVE, DECOMPOSED GRANITE SOILS (TABLE 1)

PARTICLE SIZE DISTRIBUTION

The particle-size analysis is the most important and predictive test when evaluating soil qualities. The range of particle size influences the potential for soil compaction, moisture retention, water infiltration through the soil profile, and the ability to leach salts. The soil-particle analysis for three of the facilities participating in this evaluation is included in Table 1. These fairway samples were collected from areas where the soil had not been modified. As such, these analyses offer a good representation of the native, decomposed granite soils in the area.

Course A — The soil collected from a fairway on Course A has a wide particle-size distribution (notice the percentage of gravel, very coarse sand, medium sand, and fine sand are uniform) and is classified as a gravelly sandy loam. The bulk density of this soil is high at 1.6 and 1.95 grams per cubic centimeter in the surface layer and subsurface layer, respectively, indicating compacted, hard conditions.

Course B — The soil in the fairway on Course B contains significantly more clay than the other fairways tested and not coincidentally was the worst-performing fairway. This soil is a clay loam with a wide particle-size distribution.

Course C — The fairway soil on Course C is a gravelly sandy loam and, like the others in this table, has a wide particle-size distribution. In addition, notice the high gravel component that comprises about 27 percent of surface layer and 30 percent of the subsurface layer 6-9 inches deep.

Soil from Courses A, B, and C in Table 1 are all well graded, meaning they have a uniform particle distribution in each size category, from silt, clay, and fine sand to gravel. Such a wide particle-size distribution predisposes this material to compaction.

HIGH GRAVEL COMPONENT

The gravel content in the unmodified soils at these facilities is elevated and ranges between 30 to over 50 percent in the subsurface layer (below 3 inches) and 15 to 35 percent in the surface layer. The high gravel component lowers the total porosity value and increases the bulk density, effectively lowering infiltration rates. The high amount of gravel combined with fine materials like organic matter, silt, clay, and fine sand creates a poor rooting environment and limits the ability to leach salts.

INFILTRATION RATE

The infiltration rates, measured as saturated hydraulic conductivity (K-Sat), of these native soils is extremely low

TABLE 2
Physical soil properties in the surface and subsurface layers in unmodified fairway soils at three golf courses (ASTM F-1815 modified for undisturbed soils, SSSA Methods of Soil analysis)

Course	Bulk Density g/cc	Infiltration Rate (in/hr)	Total Porosity %	Volumetric Water Content Field Capacity %	Percent Saturation at Field Capacity %	Volumetric Water Content at 3 Bars %	Plant Available Water (in/ft soil)
A (0-3")	1.60	0.40	38.4	34.8	90.6	27.9	0.83
A (6-9")	1.95	0.10	27.8	20.8	74.8	10.2	1.27
B (0-3")	1.56	0.03	41.1	38.1	92.7	36.1	0.24
B (4-7")	1.64	0.03	38.9	37.7	96.9	36.0	0.20
C (0-3")	1.49	3.70	42.3	37.1	87.7	32.5	0.56
C (6-9")	1.93	0.05	28.7	23.1	80.5	19.1	0.50
Desired		> 1.5*	40-60**		35-65**		

**Desired infiltration rate based on feedback from the golf course superintendents at the facilities submitting samples during this evaluation and comparison lab data.*

***Desired values proposed by Dr. Norm Hummel, Hummel & Co., Inc.*

(Table 2). The soil sample collected from Course A had an infiltration rate of 0.4 and 0.1 inch per hour in the surface and subsurface layers, respectively. Course B is even worse, with water moving at a snail's pace of 0.03 inch per hour through the entire profile. Lastly, the infiltration rate in the surface layer on Course C was much better, at 3.7 inches per hour, but beneath 3 inches the water movement essentially stops, yielding a K-Sat of only 0.05 inch per hour. Interestingly, soils draining in excess of 1.5 inches per hour were generally performing well, according to the superintendents.

The inability to move water through these soils was the dominant factor limiting salt movement past the rootzone. In the article "Best Management Practices for Salt-Affected Golf Courses: Why and How?," Drs. Carrow and Duncan stated, "If water cannot move through the soil, neither can salts." Previous experiments were conducted over several years on these golf course fairways utilizing various soil amendments, such as organic matter and calcium, in an effort to reduce sodium and expedite salt leaching. Surprisingly, although such additions increased calcium levels and reduced the sodium adsorption ratio (SAR), they did not improve leaching and did not reduce the total salt content of the soil. Why were these inputs unsuccessful? It was the inability to move water through and past the rootzone. The physical limitation of the soil outweighed any potential benefits of the amendments.

ORGANIC MATTER

In general, organic matter exceeded 3 percent in the surface layer and was 1 percent or less in the subsurface zone. In several of the surface samples, organic matter measured 8-12 percent in the unmodified soils. High organic matter near the surface can be confirmed by visual observations of soil profiles. In such instances, the turf system grows on top of the compacted native soil continually building organic matter. Some have perceived this as a thatch problem, but the underlying issue is the hard, compacted soils.

Several Green Committee members asked a thought-provoking question while samples were collected at one facility: "If we initiate a sand topdressing program on our fairways, will our water use increase?"

POROSITY AND PERCENT SATURATION AT FIELD CAPACITY

The total porosity values for the fairway soils at Courses A, B, and C were low in both the surface and subsurface layers. The average porosity of the three courses was 40.6 percent in the surface layer and only 31.8 percent in the subsurface zone. Total porosity is typically 40-60 percent, ideally greater than or equal to 50 percent, in healthy soils, with half the pore space occupied by water at field capacity. The low porosity in these soils indicates poor oxygen status and limited ability of the soil to provide plant-available water to turf roots. Furthermore, the percent saturation at field capacity was extremely high, averaging more than 90 percent in the surface layer. Such a high percent saturation at field capacity confirms the low soil-oxygen levels and explains why these soils remained wet or nearly saturated even after the gravitational water had drained from the soil. The soft, wet conditions caused by saturated soils have a significant effect on playability and cause "mud balls" that golfers often complain about.

PLANT-AVAILABLE WATER

Plant-available water is a value calculated by measuring the volumetric water content at field capacity — the water content in the soil after gravitational water has drained — and subtracting the volumetric water content at the wilting point, in this case determined to be 3 bars suction. For practical purposes, the difference between these two parameters indicates the amount of water in the soil that turf roots are able to access. For example, if the volumetric water content at field capacity is 40 percent and the volumetric water content at wilting point is 20 percent, the difference of 20 percent, or 0.2, represents the amount of plant-available water. Multiplying 0.2 by 12 inches yields 2.4 inches of plant-available water per foot of soil.

An analysis of all the samples reveals the best-performing soils generally have 1 to 1.75 inches of plant-available water per foot of soil. The plant-available water in the worst-performing soil, such as that at Course B, was only 0.2 inch per foot of soil. As you can imagine, this soil characteristic has an important impact on turf health. In an environment where the annual water demand exceeds 5 acre-feet of water per acre and precipitation is only 6 inches per year, the amount of plant-available water has real economic and political ramifications. Water use often increases when soils have poor plant-available water-holding capacity because frequent irrigation applications are necessary to replenish the small about of plant-available water that is easily lost through evapotranspiration. The increased water use required to manage turf when soil conditions are poor may significantly affect economic inputs required to purchase and pump water. Moreover, low plant-available water may increase the potential for a facility to exceed its annual water allotment as imposed by the Arizona Department of Water Resources, especially in a dry year.

SOIL SALINITY (ELECTRICAL CONDUCTIVITY)

The electrical conductivity (EC) of the soil was measured using a soil-to-water dilute extraction ratio of 1-to-1. The dilute extraction method uses more water than the standard saturated soil-water paste extract (ECe) and therefore will yield lower values than the ECe method. The EC of the soil at Course B was 7.62 dS/m and the EC at Course C was 4.97 dS/m, indicating that both courses had saline soils. The EC in the top 3 inches at Course A was 1.64 dS/m. Soil salinity will be revisited later in this article and a comparison will be made with the modified soils.

PREVIOUS METHODS TO OVERCOME CHALLENGES

For years the thought was that a combination of aeration strategies, soil amendments, and periodic leaching events would eventually improve soil conditions at these challenged facilities. A study was conducted from 2006 through 2008 on four golf courses in central Arizona in an effort to quantify the effects of such strategies on salt leaching (Comparison of Cultivation Techniques in Turfgrass). At the end of the three-year study and after collecting hundreds of soil tests, the results were somewhat discouraging with respect to the impact these strategies had on the ability to leach salts. The Vertidrain® aeration machine outfitted with 0.75-inch solid tines and deployed three times per summer marginally reduced sodium levels compared to the untreated area. The gypsum inputs, despite rates exceeding 100 pounds per 1,000 square feet, had no beneficial impact on the hard, compacted soils with very low infiltration rates. Aeration plus gypsum did prove beneficial at two of the golf courses participating in that study; however, the soil texture at both facilities was much different from the compacted, gravelly sandy loam soils described in this article and, as a result, they responded more positively to the aeration and gypsum treatments.

WHY HAVE THESE METHODS FAILED?

Solid- and hollow-tine aeration, spiking, verticutting, and myriad soil amendments failed to offer significant improvements in the gravelly sandy loam soils that were studied. As stated earlier in this article, the physical limitation of these soils outweighed the benefits that aeration and calcium amendments were expected to provide. The lesson to be gleaned from this experience is that the chemical and physical properties of the soil should be investigated prior to developing an agronomic plan.

WHAT STRATEGIES HAVE BEEN SUCCESSFUL?

Golf courses in Scottsdale, Arizona, have used a variety of aeration and soil-amendment strategies for several years to little or no avail. Field experience and test results from this evaluation clearly show that the facilities with superior playing surfaces are those that have employed some form of soil modification. Soil modification strategies were employed at seven of the 11 facilities where soil samples were collected. The remaining eight courses had not conducted any extensive soil improvement tactics as of December 2012. The rest of this article will focus on the seven facilities that utilized an aggressive form of soil modification.

TABLE 3
Physical soil properties in the sand-topdressed surface layer and underlying native soil on four golf courses (ASTM F-1815 modified for undisturbed soils, SSSA methods of soil analysis)

Courses 1-4 Surface (0-3") and Subsurface (4-7" or 6-9")	Bulk Density g/cc	Infiltration Rate (in/hr)	Total Porosity %	Percent Saturation at Field Capacity %	Volumetric Water Content Field Capacity %	Volumetric Water Content at 3 Bars %	Plant Available Water (in/ft soil)
1 (0-3")	1.29	3.60	50.6	70.3	35.6	23.2	1.48
1 (6-9")	1.80	0.05	34.5	90.1	31.1	28.2	0.36
2 (0-3")	1.07	10.0	57.0	66.7	38.0	25.6	1.5
2 (4-7")	1.82	0.80	33.3	70.5	23.5	18.5	0.6
3 (0-3")	1.19	11.5	53.4	73.6	35.8	25.7	1.21
3 (6-9")	1.58	0.20	38.7	81.8	34.0	27.5	0.78
4 (0-3")	1.32	7.80	48.6	73.7	35.8	21.2	1.75
4 (4-7")	1.86	1.10	30.6	76.1	23.3	18.2	0.61
Notes: Change Compared to Subsurface Layer	**31% Less in Surface Layer (avg.)**	**Increased Over 2000% in Surface Layer (avg.)**	**Increased by 54% in Surface Layer**	**Decreased by 10% avg. in Surface Layer**			**Sand at Surface Increased PAW by 253% (avg.)**
Desired		> 1.5*	40-60**	35-65**			

The percent saturation at field capacity is a measure of the percentage of soil pores filled with water after gravitational water (free water) has drained from the soil. A very high percent saturation such as that in the subsurface zone at course No. 1 indicates a very low percentage (only 9.9% in this case) of the pores contain oxygen. Ideally, only half of the pores are filled with water at field capacity.

**Desired infiltration rate based on feedback from the golf course superintendents at the facilities submitting samples during this evaluation and comparison lab data.*

***Desired values proposed by Dr. Norm Hummel, Hummel & Co., Inc.*

Data and explanations of how each method improved the native soil will be presented and successful soil-modification strategies will be identified. The methods utilized can be described as follows:

- **Extensive sand topdressing** – All of the facilities that employed this strategy have applied in excess of 3 inches of sand to date.
- **Sand channels** – Channels in low-lying areas of fairways were excavated and filled with sand. The sand channels were constructed 12 feet wide and were tapered from a depth of 4 inches along the edges to a depth 6 inches in the middle of the channel, where drainage pipe was installed and covered with bridging gravel. These channels were constructed on all 18 holes of the golf course, with some holes receiving more than one channel, and an estimated 1.5 miles of drainage pipe were installed.
- **Rototill plus coarse material incorporation** – Two of the courses rototilled the native soil to a 6-inch depth, added 2-4 inches of coarse sand/gravel to the area, and then rototilled the added material to a depth of 4-6 inches. The area was graded and sprigged to bermudagrass following the rototilling procedure.

SAND TOPDRESSING

Sand topdressing has been a successful strategy for golf courses throughout the country, especially in the Northwest during periods of high precipitation. This tactic is relatively new in the southwest portion of the U.S. but is gaining popularity. Four of the seven golf courses partaking in this evaluation employed sand topdressing on fairways. The four courses have been sand topdressing for more than three years and the depth of accumulated sand was greater than or equal to 3 inches in each fairway tested. Sand accumulation from topdressing exceeded 5 inches at several of the facilities. Table 3 compares several key soil characteristics in the surface and subsurface soil layers at the four facilities that applied sand topdressing to fairways. The results overwhelmingly support the use of sand topdressing:

- Bulk density decreased by an average of 31 percent in the surface-sand layer when compared to the underlying native soil.

Specialized spreading equipment is critical to successfully implementing an aggressive sand-topdressing program.

- The infiltration rate increased by over 2,000 percent in the surface zone with the addition of sand topdressing.
- Total porosity increased by 54 percent when compared to the subsurface layer comprised of native soil.
- The percent saturation at field capacity decreased by an average of 10 percent in the surface-sand layer, indicating a more oxygen-rich environment for turf roots.
- The amount of water available to turf roots in the soil increased by 253 percent in the surface layer as a result of sand topdressing.
- The average electrical conductivity in the surface layer at the four facilities was 2.4 dS/m. Compare that to the EC of Courses A, B, and C in Table 1 with an average of 4.74 dS/m in the surface layer.

TOPDRESSING MATERIAL

The sands used to topdress the fairways at the four facilities were coarser than sand commonly used for bunker or green construction. The topdressing material contained up to 5 percent fine gravel (2-3.4mm) and 12-18 percent very coarse sand (larger than 1mm). There was very little fine sand (less than 3 percent) and nominal silt and clay (less than 1 percent). More than 65 percent of the material was sized in the coarse to medium range.

Although there are no set specifications for fairway topdressing sand, Dr. Hummel has developed a set of general guidelines for fairway topdressing sand (Table 4).

It is interesting that Henderson and Miller, 2009, found that fine sand, sand that meets USGA guidelines for putting green construction, and coarse sand all yielded benefits, including improved turfgrass quality, color, cover, firmer conditions, and reduced surface wetness. With that in mind, it is suggested to explore a variety of sand choices for fairway topdressing with consideration of physical characteristics and costs.

TURF QUALITY

Turf quality improved significantly at the four golf courses where sand topdressing was applied to fairways when compared to the quality of turf grown on native soil. The overseeded ryegrass was faster to mature, and there was less potential for the salt-related rapid-blight disease. The bermudagrass recovery following overseeding also improved.

PERCHED WATER TABLE

At the four golf facilities that employed sand topdressing, there was a distinct and abrupt change in soil texture due to the layer of accumulated sand. This abrupt change in texture and the very poor hydraulic conductivity of the underlying soil created a perched water

TABLE 4
Particle-size guidelines for fairway topdressing sand

Particle Size Category	Sieve Mesh	Sieve Diameter (mm)	Allowable Range % Retained
Coarse Gravel	5	4.00	0%
Fine Gravel	10	2.00	0-5%
Very Coarse Sand	18	1.00	0-20% combined with gravel
Coarse	35	0.50-1.0	20-50%
Medium	60	0.25-0.5	20-50%
Fine	100	0.15-0.25	15% maximum
Very Fine	270	0.05-0.15%	5% maximum
Silt and Clay		< 0.002-0.05	3% maximum

In addition, there should be no more than 5% combined very fine sand, silt, and clay, and a minimum of 60% in the medium and coarse size fractions. Ideally the sand will have a coefficient of uniformity (D60/D10) of 2.5 to 4.0.

Guidelines provided by Dr. Norm Hummel, Hummel & Co., Inc.

table. As a result, sand topdressing alone did not solve all the drainage problems or wet surface conditions. In low-lying areas, it is necessary to install drain lines, preferably 12-18 inches deep, in the native soil to enable soil water and salts to exit the fairway. Additionally, deep-tine aeration can help fracture the subsoil and encourage water movement below the sand layer.

INCREASED WATER DEMAND?

Several interested green committee members from one club joined the group collecting fairway samples and asked a thought-provoking question: "If we are to initiate a sand-topdressing program, will our water use increase?" The answer can be found in the soil test results. While native soils at the course retained a high amount of moisture, the water was held at tensions exceeding the ability of plants to access the water. Although it is true that sand does not hold moisture to the same degree as fine-textured soils, i.e., soils containing silt and clay, sand may provide more plant-available water. The sand-topdressed fairways in this evaluation consistently demonstrated significantly more plant-available water — up to a 253 percent increase — when compared to the underlying native soils. Furthermore, observation of soil profiles revealed rooting depth was much deeper in the sand-topdressed fairways, thereby enabling the plants to access water from a greater soil volume. Therefore, one can deduce that water use may actually decline as a result of fairway topdressing.

CHALLENGES

The primary challenge in the future for the facilities that have spent up to $1 million on sand topdressing is to avoid excessive organic matter accumulation on top of the sand. So far, the four properties have continued to apply sand, albeit at lighter rates than originally applied, and conduct core aeration and vertical-mowing practices to manage thatch and organic matter. Organic matter in the surface layer of the fairways at these courses ranges from 2.5 to 4.5 percent (ASTM F-1647, loss on ignition method). If organic matter is allowed to increase, it may eventually negate the benefits of the sand.

SAND CHANNELS

One of the facilities participating in this evaluation chose to construct "sand channels" in low-lying areas of fairways rather than apply sand topdressing. The maintenance staff excavated channels of native soil 12 feet wide that tapered from 4 inches deep along the edge of the channel to 6 inches deep in the center of the channel where drainpipe was installed.

As you might expect, the soil physical properties, including porosity, infiltration rate, and plant-available water, significantly improved in the channels. Salinity measurements revealed that the sand channels also leached salts effectively. Furthermore, the channels enabled the agronomic staff to increase irrigation on mounds and adjacent turf without saturating the low-lying areas. The playability of the golf course improved as a result.

The superintendent noted that organic matter accumulation (more than 6 percent) is a concern, and black layer has developed in localized areas within the sand. Despite this, the sand channels have continued to conduct water better than the surrounding native soils.

ADVANTAGES AND DISADVANTAGES

The "sand channel" strategy improved cosmetics and yielded firmer playing surfaces, but how does this method stack up to sand topdressing? The benefits from installing sand channels are immediate and offer improved salt leaching and firmer conditions in low, water-collection areas. Furthermore, the surrounding turf can be watered adequately without fear of creating saturated, soft conditions in low-lying areas. However, this strategy only affects a relatively small area of the fairways and introduces inconsistent soil conditions across the playing surface. Sand-channel areas are typically firm and dry, while the surrounding soil may be near saturation.

ROTOTILLING PLUS COARSE MATERIAL INCORPORATION

One of the facilities participating in this evaluation rototilled the fairways more than a decade prior to testing in 2012. Approximately 3-4 inches of coarse sand and gravel were applied to the fairways, and the material was rototilled into the top 6 inches of the soil profile. The test results classify the modified soil in the surface 3 inches as a loamy sand with 21 percent gravel, 81.5 percent sand, 11.3 percent silt, and 7.2 percent clay. The total porosity was good at 55.1 percent, but the per-

TABLE 5

Advantages and disadvantages to the "sand channel" soil-modification strategy compared to sand topdressing

Advantages	Disadvantages
Significantly cheaper, due to less impacted area	Only a relatively small area of the fairways has been improved
Much faster positive impact; can improve the most problematic areas in one summer	Introduces inconsistent moisture and playing conditions in the fairways
Avoids the need to continually raise sprinklers, valve boxes, and drains	Droughty conditions when compared to adjacent soil create irrigation challenges
Immediately improves low, wet areas with drainage and 4-6 inches of sand	Organic matter management above the sand can be challenging years after installation

cent saturation at field capacity was 81.5 percent, which can be attributed to the elevated organic matter of 8.4 percent and the wide particle-size distribution. The infiltration rate was 5.3 inches per hour in the 0- to 3-inch layer and 1.1 inches per hour in the zone 5-8 inches beneath the surface.

THERE ARE ADVANTAGES, BUT . . .

There are several advantages to rototilling and incorporating coarse sand when compared to sand topdressing fairways, including:

- The facility was able to complete the incorporation of coarse material over a period of only several months. By comparison, it will likely require at least three years of sand topdressing to accumulate enough sand to improve soil conditions.
- The rototilling process was deep enough to eliminate/avoid any soil layers within the top 5 inches of the profile. As a result, there is no perched water table.
- Although the facility needed to close for several months to complete this process, the members only had to endure one closure. Facilities where sand topdressing is performed often report complaints from members every year during/following topdressing events.

The soil test results and observations in the field clearly show this method has been successful for this facility. However, this approach will not work for all soil types. Had this approach been employed with soils exceeding 15-20 percent clay, the incorporation of the coarse material likely would have made conditions worse. The key message is to submit several soil samples to an accredited laboratory and work with the lab to determine the best approach to modify the soils at your facility, if needed.

CHALLENGES

The biggest hurdle revealed by the soil tests was excess organic matter at the surface — 8.4 percent in the top 3 inches. The elevated organic matter retains moisture, reduces rooting depth, and potentially creates soft, wet playing conditions. Reducing the

Over 6 inches of sand has been applied to these fairways, yielding firm surfaces and excellent turfgrass quality.

Black layer has developed near the surface in this sand channel due to organic matter accumulation.

organic matter will continue to be a challenge moving forward. Given the high gravel content in the top 3 inches — 21 percent gravel, 6.1 percent larger than 4mm — core aeration is problematic. Core aeration can transport gravel to the surface, disrupting playing conditions and damaging mowing equipment. A combination of verticutting and light sand topdressing — 10-20 tons per acre per year — is likely the best approach to dilute organic matter and improve surface firmness.

CONCLUSION

Poor soil conditions have a significant impact on the ability to provide quality playing surfaces, especially when the irrigation water contains an elevated level of dissolved salts. Consider the following summary points when faced with challenging soil conditions at your facility:

- Collect soil cores from several fairways and submit them to an accredited physical testing laboratory prior to initiating a cultural program or purchasing soil amendments.
- If the physical soil properties are poor, such as those evaluated in this article, soil amendments and aeration likely won't make a significant positive impact.
- All three of the soil-modification strategies discussed in this article — sand topdressing, sand channels, and incorporating coarse material through rototilling — are worth considering should the soil conditions at your facility warrant such aggressive and expensive methods. Sand topdressing yielded improved soil porosity and infiltration rates. Sand channels improved soil permeability, but only in a limited area. Rototilling plus incorporating coarse materials improved infiltration rates and the ability to leach salts.
- There was more plant-available water in fairways topdressed with sand, rototilled, or in the sand channels when compared to the unmodified decomposed granite soils.

Given the data collected in this evaluation, it is clear that the practices discussed in this article had a significant and positive effect on soil properties, turf health, and playability. However, these strategies are expensive, time-consuming, and disruptive to golfers and should only be considered if the native soils at your facility are very poor and warrant such intensive efforts.

BRIAN WHITLARK *is an agronomist in the USGA Green Section's Southwest Region.*