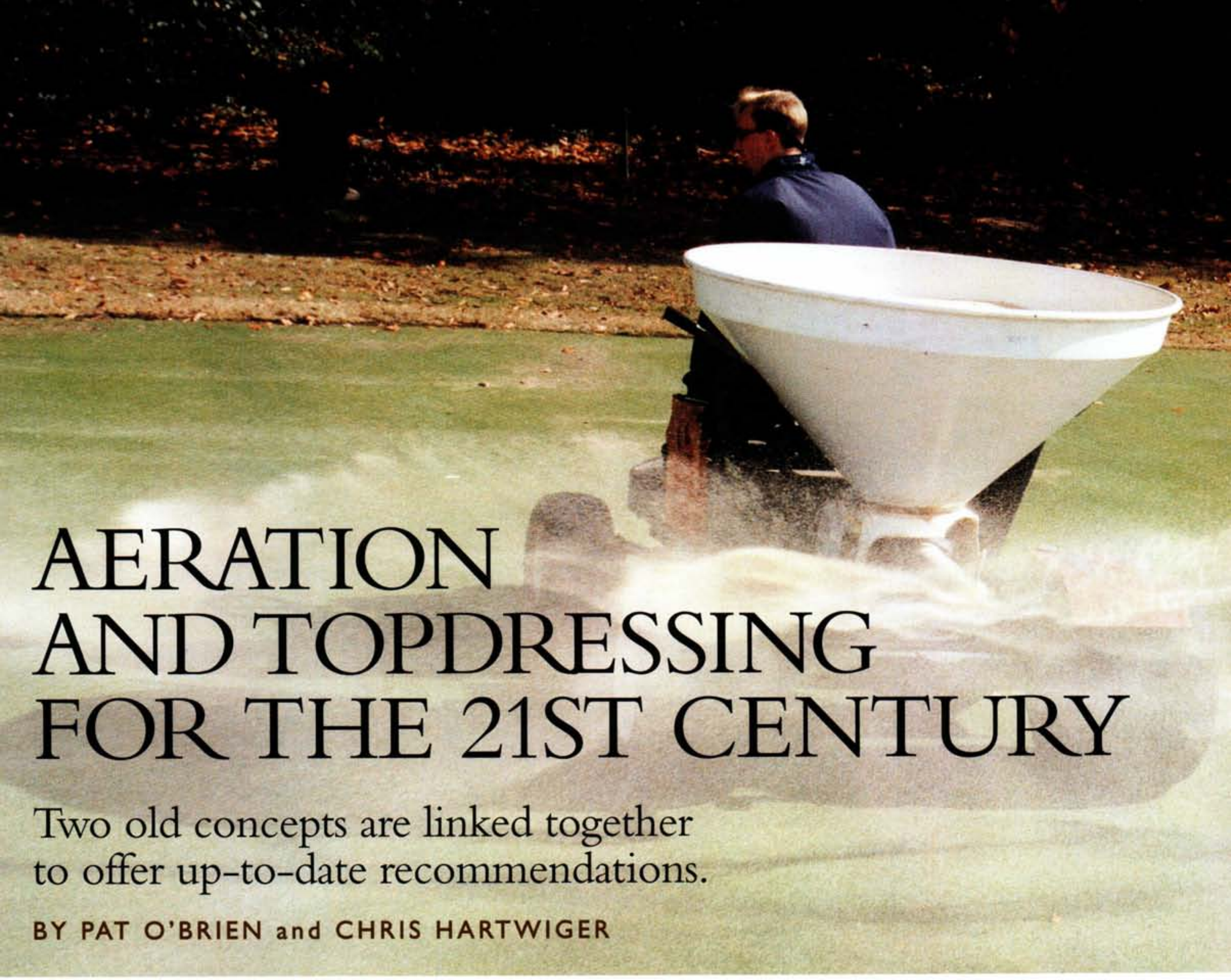


AERATION AND TOPDRESSING FOR THE 21ST CENTURY

Two old concepts are linked together to offer up-to-date recommendations.

BY PAT O'BRIEN and CHRIS HARTWIGER

Putting green aeration and topdressing are literally and figuratively dirty words. Golfers begrudgingly accept the fact that to protect the long-term health of the grass on a putting green, it is necessary to aerate and topdress each year. With more sophisticated products and techniques, gone are the days when putting greens were aerated in the spring and fall and buried in a blanket of sand. But lost in the changes to these programs may be an incomplete understanding of how much aeration and topdressing are needed to protect the long-term health of the greens.

The long-term health of putting greens depends on maintaining sand as the primary medium. If organic matter accumulates beyond a reasonable degree, the physical benefits of sand are diminished and putting green physical properties decline along with the health of the turf. For too long golf courses have been making changes in their aeration and topdressing programs without comparing these changes to a standard or target level. A previous *Green Section Record* article titled "Core Aeration by the Numbers" detailed how tine size and spacing affects the amount of surface area impacted by an aeration treatment and made a recommendation to impact 15-20% of the surface each year (O'Brien and Hartwiger, 2001). This recommendation did not go far enough because it did not include surface topdressing applications, which go hand in hand with core aeration in diluting organic matter accumulation. This article expands upon these concepts and links core aeration and sand topdressing.

THE SIGNIFICANCE OF CORE AERATION AND SAND TOPDRESSING

According to University of Georgia turfgrass researcher Dr. Bob Carrow, the number-one problem experienced on sand-based putting greens is the excessive accumulation of organic

Using dry sand and the proper topdressing equipment improves worker productivity and helps reduce golfer complaints.

matter in the upper portion of the soil profile (Carrow et al., 2002). Core aeration and sand topdressing are the two most effective means to control the content and distribution of organic matter in this zone. The scientific literature is full of references to the benefits of core aeration and sand topdressing. Unfortunately, details on how much aeration and topdressing are needed are lacking.

The moment any type of grass is planted on a putting green rootzone mix, the soil physical properties in the upper few inches of the rootzone begin to change (Habeck and Christians, 2000; Curtis, 2001). In a new putting green the cycle of root growth, decline, and new growth is repeated year after year. Roots grow down through the soil in the large soil pores (macropores) and provide the plant with needed water, oxygen, and nutrients. When a root is no longer viable, it begins to plug up soil macropores and can hinder the ability of living plants to function.

Table 1
Conversion rates for sand topdressing

Ft.³ of Sand per 1,000 ft.²	Lbs. per 1,000 ft.² Dry Sand	Depth of Application in Inches
0.50	50	0.006
1.00	100	0.012
2.00	200	0.024
4.00	400	0.048
50.00	5000	0.600

Dr. Carrow conducted extensive research (Carrow, 1998) in the mid-1990s on the organic matter dynamics in the rootzone of sand-based putting greens. He concluded as organic matter in a sand-based putting green reaches 3-4% by weight, the percentage of soil macropores begins to decrease. The reduction of pore space has three distinct implications, and a host of primary problems can be expected: 1) The diffusion of oxygen into the rootzone begins to decline. Oxygen is vital for plant growth as well as soil microorganism balance and function. 2) Water infiltration decreases, which can result in puddling and saturation of the surface. 3) Moisture content in the upper rootzone increases, which can make the surface less firm. The decrease in macropores (aeration pores) is accompanied by an increase in capillary or water-holding pores.

If organic matter accumulation begins to exceed 3-4% by weight, putting greens become vulnerable to a host of secondary problems such as disease, wet wilt, soft surfaces, poor root growth, black layer, and more frequent high-temperature injury. These secondary problems are often called summer bentgrass decline (Carrow et al., 2002), and trying to treat them curatively can be expensive. They occur often at courses that have not adequately aerated and topdressed the greens. Many of these courses are doomed to many years of frustration because they are not willing to make the effort to do the additional aeration and topdressing needed to prevent the situation.

Dr. Carrow's research shows that core aeration and applying sand can help dilute organic accumulation and create new macropores. The remainder of this article will be devoted to developing an aeration and topdressing program that keeps organic matter levels below 3-4% by weight. This proactive approach ultimately will cause less disruption and be less expensive than trying to alleviate primary and secondary problems through a curative approach.

The *organic matter dilution program* is a catch-all term that includes core aeration accompanied by sand topdressing to fill the holes and sand topdressing applied directly to the surface. References to *core aeration* refer only to hollow-tine aeration at a standard depth of 3 inches. Aeration depth can vary significantly based upon machine and type of tine used. Deep-tine aeration or similar practices designed to correct deep rootzone issues are not considered. *Surface topdressing* refers to sand applied directly to the turfgrass canopy. Light, medium, and heavy topdressing applications are approximately 0.50 ft.³ per 1,000 ft.², 2.0 ft.³ per 1,000 ft.², and 4.0 ft.³ per 1,000 ft.², respectively.

AERATION AND TOPDRESSING RECOMMENDATIONS

The case has been made for the importance of using core aeration and sand topdressing to dilute the accumulation of organic matter. The question is, How much of each needs to be done? We propose answering this question in a slightly different way. The answer requires linking the topics of aeration and topdressing together. We link the two together because they are the key elements in an organic matter dilution program. Core aeration removes organic matter. Filling the holes with sand makes sure those columns stay open. Dustings of sand applied directly to the surface also help manage organic matter accumulation.

Applying at least 40-50 ft.³ of sand per 1,000 ft.² per year is recommended to keep organic matter content below 3-4% by weight in the upper portion of the rootzone. Although this recommendation is brief, understanding all its ramifications is more complex, and it should stimulate many questions that will be addressed in the following sections.

UNDERSTANDING SAND VOLUMES

Rates of sand topdressing can be difficult to conceptualize. Table 1 shows quantities of sand expressed in different units and yields some interesting comparisons. Conveniently, it turns out that 100 pounds of dry sand is equivalent to 1.0 ft^3 of sand. Wet sand is approximately 6-10% heavier for an equivalent volume. Finally, the sand quantities are expressed in inches, which are easier to conceptualize for large quantities of sand.

TO CORE OR NOT TO CORE, THAT IS NOT THE QUESTION

By now, many readers will have looked at the recommendation and said, "Aha. If we apply 40-50 ft^3 of sand per 1,000 ft^2 through regular topdressing applications, we will not need to core aerate the greens." It is easy to see how this interpretation could be made, but this strategy is not recommended. There are agronomic and practical reasons for not trying this approach. There are merits to removing organic matter through core aeration and packing these vertical columns that cut through the high organic matter zone with sand. Applying 50 ft^3 of sand per 1,000 ft^2 through surface topdressing would only require approximately 25 applications of 2.0 ft^3 per 1,000 ft^2, or one application every two weeks. This would be far too stressful during the summer and would be difficult to work into the canopy during periods of slow winter growth. Invariably, interference with play and weather make this program impractical.

Similarly, do not try to meet the topdressing requirement with only core aeration and filling the holes with sand. This method could result in layering. All applied sand is not worked into the holes; some falls between the holes. This excess sand would only be mixed into the canopy twice per year if the greens are aerated twice per year. Additionally, it would be difficult to keep sand as the primary component of the rootzone matrix near the surface without regular surface topdressing applications.

SAMPLE PROGRAMS

The best program is one that includes a certain amount of core aeration along with regular sand topdressings. When considering tine sizes, select a size that allows easy and complete backfilling of the aeration holes. Based upon field observations, the smallest hole that can be reliably filled with sand is created by a tine of just less than ½ in. Holes of ⅜ in. diameter are not easily filled, even with the driest sand. Outlined below are a few sample programs to stimulate thought. There is no single program that is right for everybody, but with an overall goal of total topdressing applied, a plan that meets the needs of any course can be developed.

• **Program 1: Big Holes, Big Spacing.** This approach uses traditional aeration equipment with ⅝ in. tines on a 2 in. × 2 in. spacing. The greens are aerated once in the spring and once in the fall. A total of 36 ft^3 per 1,000 ft^2 (3,600 lbs. per 1,000 ft^2) is applied for the two core aerations. See Table 2 to see sand volumes required to fill aeration holes for other tine sizes and spacing patterns.

The remaining 14 ft^3 of sand necessary per 1,000 ft^2 to meet the 50 ft^3 goal is applied via light to moderate topdressings throughout the year. A light to moderate topdressing is considered to be anywhere from 0.5 ft^3 to 2.0 ft^3 per 1,000 ft^2. This is roughly equivalent to 50 to 200 lbs. of sand per 1,000 ft^2

• **Program 2: Dethatching.** This program is for new construction only or for a putting green that has met the topdressing requirement. A dethatching machine is used to physically remove organic matter from the upper portion of the

Table 2

Volumes of sand needed to fill aeration holes for various tine sizes and configurations

Outside Aeration Tine Diameter (in.)	Spacing (in.)	% Surface Area Impacted	Ft^3 of Sand per 1,000 ft^2 Needed to Fill Holes to 3 in. Depth	Lbs. of Dry Sand per 1,000 ft^2 Needed to Fill Holes to 3 in. Depth
1/4	1 × 1	4.91%	12.27	1227
1/4	1 × 2	2.45%	6.14	614
1/4	2 × 2	1.23%	3.07	307
3/8	1 × 1	11.04%	27.61	2761
3/8	1 × 2	5.52%	13.81	1381
3/8	2 × 2	2.76%	6.90	690
1/2	1 × 1	19.63%	49.09	4909
1/2	1 × 2	9.82%	24.54	2454
1/2	2 × 2	4.91%	12.27	1227
5/8	1 × 1	30.68%	76.70	7670
5/8	1 × 2	15.34%	38.35	3835
5/8	2 × 2	7.67%	19.17	1917

profile. Spring and fall dethatching treatments are performed. Less disruption to play is the primary advantage. This program is not recommended as a curative approach on greens with excessive organic matter. It is too difficult to incorporate sand into the channels made by the dethatching equipment, especially when the grooves are cut greater than 0.25 in. deep.

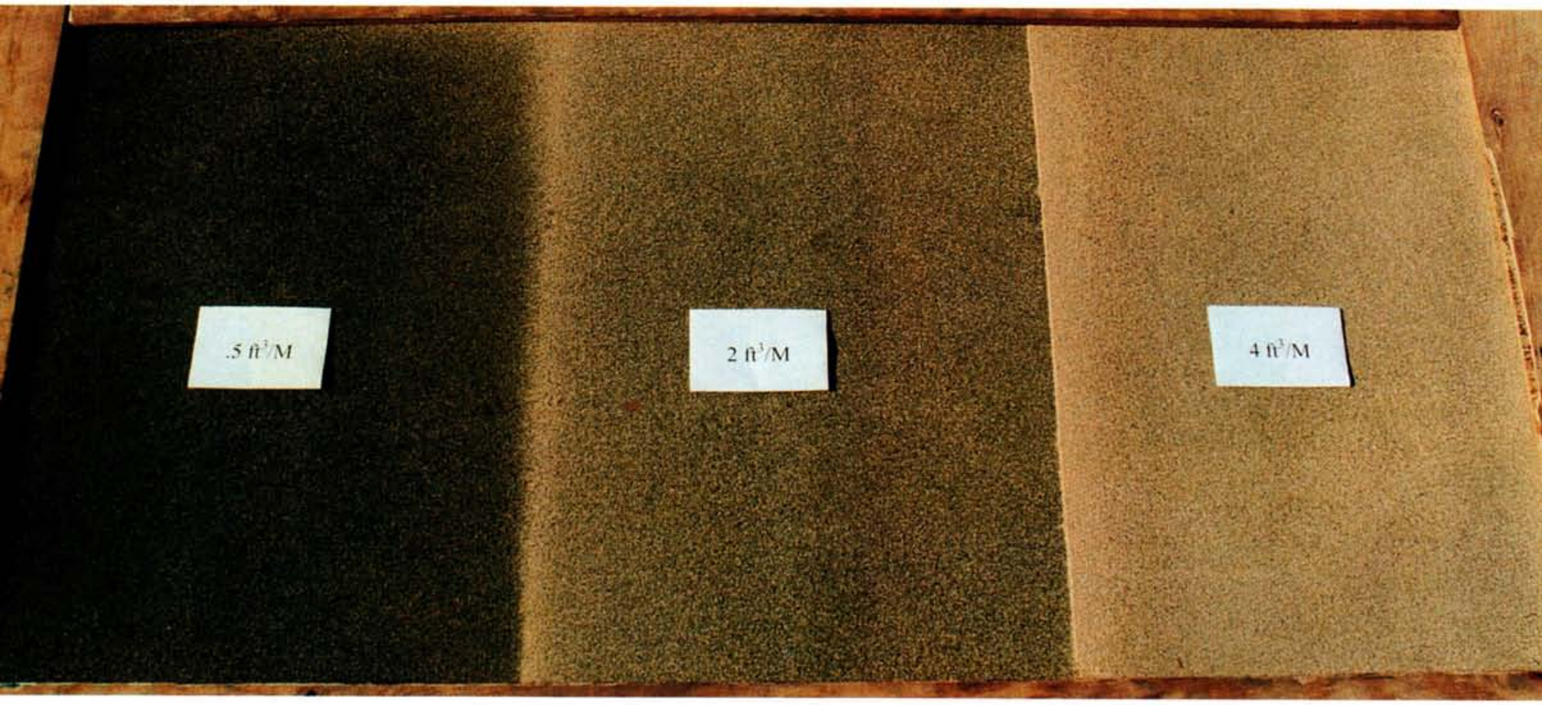
The amount of sand incorporated into the canopy following dethatching is much lower than with core aeration. As channel depth increases, sand incorporation decreases because the channels collapse and seal off. This may be considered a disadvantage because much more time must be spent applying light and moderate topdressings throughout the year. For example, assume the greens are dethatched with 9/64 in. blades. Approximately 14% of the surface area is impacted, but only 1-3 ft.^{3} per 1,000 ft.^{2} of sand is applied. This amount is highly variable and depends on how well the dethatching channels stay open. This leaves 40-44 ft.^{3} per 1,000 ft.^{2} left to be applied through light and moderate topdressings.

Many courses that use a dethatching machine use it in combination with an aerator. Some dethatch and aerate at the same time, while others dethatch and aerate on separate dates.

The moderate topdressings (2.0 ft.^{3} per 1,000 ft.^{2}) should be applied at a time of year when organic accumulation is most rapid. On bentgrass putting greens in the South, the period of October through April is the most prolific period of organic matter production. Bermudagrass greens generate the most organic matter in the summer months. Light topdressings can be applied at any time of the year.

• **Small Holes, Small Spacing.** A sample program using this approach might include the following: super quad tines with an outside tine diameter of 0.420 on a 1 in. × 1⅛ in. spacing. The greens are aerated twice in the spring and once or twice in the fall. The total amount of sand required to fill the holes after each aeration is approximately 6.15 ft.^{3} per 1,000 ft.^{2} or 18-24 ft.^{3} per 1,000 ft.^{2} per year. The remaining 16-32 ft.^{3} per 1,000 ft.^{2} can be applied through light or moderate topdressings throughout the year.

This approach relies on smaller tine diameters and a tighter spacing pattern. The advantage of this program is reduced healing time because smaller diameter holes require less time to heal than larger holes. The disadvantages are the need for special equipment and more difficulty filling the aeration holes. As hole size decreases, the likelihood of sand particles bridging over the surface of the hole increases. The super quad tine only goes 1.75 in. into the rootzone, which could be a concern with a thick layer of organic accumulation. An aerator with variable spacing and a tractor with a creeper gear are necessary to duplicate this program. For best results, take the time to make sure the holes are open and clean, and try to use the driest sand possible.



Seeing is believing with volumetric measurements. Light, medium, and heavy surface topdressing rates are approximately 0.50 ft.^{3} per 1,000 ft.^{2}, 2.0 ft.^{3} per 1,000 ft.^{2}, and 4.0 ft.^{3} per 1,000 ft.^{2}, respectively.

THEORY VS. REALITY: CALCULATING SAND VOLUME

Every golf course is faced with a unique set of circumstances. Determining the total amount of topdressing applied can be challenging. Table 2 shows the approximate amount of sand necessary to fill aeration holes with sand for common tine sizes and spacing.

When recommended topdressing amounts are in hand, the turfgrass manager must adjust the topdressing applied if it is determined that the sand is not working easily into the holes. Sometimes the greens are damp or the sand is wet. The degree to which sand is filled into the holes can vary, too. The key point is not whether the suggested amount is applied to fill the holes, but how much sand actually is applied. This information is helpful when calculating yearly volume and determining how much sand must be added through light or moderate topdressing applications.

When calculating sand volume applied, another consideration is estimating how much sand is thrown onto areas other than the putting green. This is an issue when spinner topdressers are used to apply light or moderate topdressings.

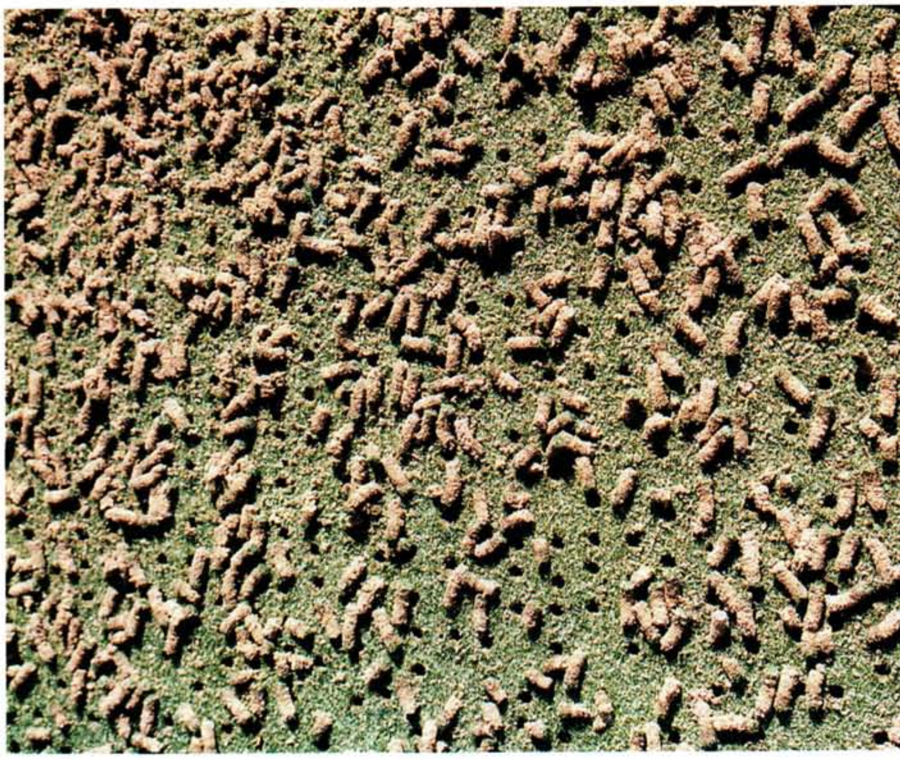
MEETING THE RECOMMENDATION: IS MORE OR LESS NEEDED?

The beauty of coupling aeration and topdressing together and making an annual topdressing recommendation as a target value is its simplicity and flexibility. It may need to be adjusted upward or downward, depending on individual circumstances. The Atlanta, Georgia, climate was selected for this recommendation. Other areas may require a higher topdressing or lower requirement based upon some of the factors listed below.

• **Nitrogen Levels.** Nitrogen is directly related to organic matter production. Higher nitrogen programs may be required on putting greens with extremely high traffic levels or on greens that must be grown in from some type of seasonal damage. More topdressing may be required. Greens managed under low nitrogen programs may require somewhat less sand.

• **Soil pH.** A soil pH > 5.5 is optimal for bacterial activity and organic matter decomposition. Soil pH much below this level reduces organic matter decomposition, and more topdressing may be required.

• **Turfgrass Species.** The 40-50 ft^3 per 1,000 ft^2 recommendation is the minimum requirement for many bentgrass and/or *Poa annua* putting greens and may need to be adjusted annually. Non-overseeded Tifdwarf or Tifgreen bermudagrass putting greens will have a slightly lower annual topdressing requirement, somewhere in the range of 35-40 ft^3 per 1,000 ft^2. Non-overseeded ultradwarf greens may require 40-50 ft^3 per 1,000 ft^2. Overseeded Tifdwarf or Tifgreen bermudagrass putting greens will require 40-50 ft^3 per 1,000 ft^2, but with newer ultradwarf cultivars that tend to accumulate organic matter in the surface 1-2 in., a somewhat higher amount may be necessary. For newer bermudagrass cultivars, the "small holes, small spacing" program applied at more than two times per year is a good option. High annual topdressing sand rates are important for the newer bentgrass cultivars that tend to accumulate organic matter in the surface or in climates where organic matter accumulation is favored. In these situations, the "small holes, small spacing" program is worth trying.



Organic matter accumulation in the upper rootzone is the primary reason why putting greens sometimes fail over time. Proper aeration and topdressing programs can prevent excess organic matter accumulation.

UNUSUAL FIELD CONDITIONS

Two common field conditions exist that may require a higher sand requirement or an adjustment as to when sand should be applied.

• **Rapid Root Dieback.** This condition is characterized by the rapid death of a bentgrass root system caused by high temperatures in the summer months. When bentgrass roots die back suddenly, the nature of some of the organic matter

Rapid root dieback on bentgrass putting greens in the summer produces a gel-like layer in the upper rootzone and low soil oxygen levels. Turf loss can occur within 24 to 72 hours, and extra aeration and topdressing will be needed to promote recovery.

changes from live root structures to decomposing organic matter with a gel-like consistency. Dr. Carrow states, "It is not the lack of roots from root dieback that is the problem, but the creation of an excessively moist layer from the decomposing root tissues with very low oxygen during hot weather in response to the rapid root dieback" (Carrow et al., 2002). The remaining roots are under low oxygen stress and cannot take up enough water for transpirational cooling. Reduced water uptake, stomatal closure, and high-temperature kill can follow. Field symptoms are a yellowing of the turf and death over a one- to three-day period of hot, humid weather. This scenario can occur at organic matter levels of 3-5% by weight in the top 1 in. of the rootzone, but it is much more likely when organic matter is greater than 5% by weight (Carrow et al., 2002). After the hot weather has ended, it will be necessary to continue diluting this rapid accumulation of organic matter created from the dead roots as well as organic matter arising from new root initiation. The topdressing requirement will increase and should be met through a combination of surface topdressing and filling aeration holes.

• **Cool-Weather Organic Accumulation.** Root growth can be rapid during periods of cool weather. Roots grow down through the macropore channels and adventitious roots grow near the surface. Although live organic matter does not reduce oxygen availability as severely as decomposing organic matter, oxygen infiltration and water infiltration can decrease as the roots fill many of the macropores. This is commonly observed in the winter to early spring months when greens begin to puddle more substantially after a rain. The problem is more severe in cooler climates with prolonged soil temperatures above 32°F, but less than 55°F. Bentgrass/*Poa annua* will grow in temperatures above 32°F, but soil microbes necessary for organic matter decomposition do not function below 55°F. These conditions are more common in northern climates and, particularly, coastal northeastern and coastal northwestern climates. Other than a reduction in water infiltration, surface symptoms are not observed, but suboptimal oxygen levels can reduce the rate of deeper rooting. After spring aeration, adequate oxygen will be available for maximum root growth.

PROGRESS REPORT

Turf managers who have embarked on an organic matter dilution program will be curious about how the program is working. There are three ways to assess the program's effectiveness.

The first is to send a core sample of the top 1-2 in. of the rootzone profile to a physical soil testing laboratory. Request a test to determine organic matter by weight.

A result of less than 3% organic matter by weight is good news and indicates that organic accumulation has been well diluted with sand. A result of 3-5% organic matter by weight is borderline, and problems caused by plugged macropores could occur. Pay careful attention to the organic matter dilution program over the next few seasons. A result of 5% or more is cause for concern. A serious effort must be made to reduce organic matter buildup. Place more emphasis on core aeration and topdressing to fill the holes. Some superintendents may sample and find organic matter contents greater than 5% without any apparent symptoms at the time of sampling, but the chances for future problems are much greater.

In the cooler regions of bentgrass adaptation, organic matter content can be above the 5% limit without immediate concern. The reason is that these climates have fewer hot periods in the summer. When periods of high heat do occur, bentgrass can decline rapidly. Also, in these climates organic matter can continue to increase to a point where decline occurs from oxygen stress, regardless of the temperature.

Cases of seasonal organic matter accumulation fluctuations occur on bentgrass during the winter in the southern transition zone and on overseeded bermudagrass greens in the late spring. Root growth during cool periods may increase organic matter 1-2% from the fall level due to live roots contributing to the overall organic matter content. The seasonal changes suggest that sampling for organic matter for both bentgrass and bermudagrass should be in May and late summer. The highest organic matter content will occur during May, especially on overseeded bermudagrass greens, and late summer should be the time of the year with the lowest organic matter content.

A second method to assess the program's effectiveness is to take field observations of the soil profile. If layering is present, as evidenced by a distinct sand or organic matter layer(s), it is likely that topdressing applications are being made too far apart or that light applications between moderate applications are too light. Also, look for the columns of sand created by aeration and topdressing. Checking this right after aeration allows the turf manager to see if the holes are being completely filled with sand.

A final assessment method involves the use of a double ring infiltrometer to take seasonal infiltration readings. Readings taken in conjunction with organic matter sampling can be especially useful. By taking an infiltration measurement at the same place on a green a few times a season, the superintendent can obtain several important pieces of information. First, the changes in infiltration by season will be apparent. Second, after taking readings for a few years, the superintendent can see if infiltration rates are increasing, decreasing, or staying the same in response to the organic matter dilution program.

CONCLUSION

"More sand, laddie," is a quote attributed to Old Tom Morris. Although Old Tom probably never imagined that the science and art of putting green maintenance would ever reach today's quality levels attained on a daily basis, his emphasis on sand still rings true. The information presented in this article has the scientific backing to confirm what most in the industry know — that aeration and topdressing are the foundation for successful putting greens.

ACKNOWLEDGEMENTS

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