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University of Arkansas scientists conducted studies to determine how cultivating a sand-based putting green with various aggressive verticutting and core aeration treatments affects rootzone organic matter content and turf. Although verticutting treatments removed more surface organic matter, plots that were core aerated recovered significantly faster.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of $29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Cultivating to Manage Organic Matter in Sand-based Putting Greens

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SUMMARY

Organic matter accumulation near the rootzone surface can be detrimental to the physical properties of sand-based putting greens. Aggressive verticutting and core aerification using closely spaced tines are two relatively new management options that may by effective in removing organic matter from putting green rootzones. Our objective was to determine how cultivating a sand-based putting green with various aggressive verticutting and core aeration treatments affects rootzone organic matter content and turf recovery. Major conclusions from this research include:

- Aggressive verticutting was more effective at removing surface organic matter than core aerification treatments.
- Turf recovery from aggressive verticutting was much slower compared to core aerification. Turf cultivated with ½ inch diameter tines recovered in half the time of turf that was verticut. In addition, turf treated with ¼ inch diameter tines recovered in half the time of turf treated with ½ inch diameter tines.
- Tine spacing did not affect recovery time. Therefore closely spaced tines can be used to increase the affected surface area (and organic matter removal) without delaying recovery.
- Aggressive verticutting resulted in a lower organic matter content near the rootzone surface compared to core aerification following three sets of treatments over 14 months.

Putting greens constructed according to USGA guidelines contain a medium to coarse sand rootzone, which provides rapid water infiltration, drainage, and oxygen diffusion, while maintaining acceptable water retention (7). It is a considerable investment for a golf facility to construct USGA putting greens, so it is important that they are maintained to perform as designed with regard to water retention and drainage.

It is not uncommon for newly constructed creeping bentgrass (*Agrostis stolonifera* L.) greens to perform very well during the first few years following establishment, but then decline in subsequent years, especially during periods of high temperature and humidity. This is likely the result of the rootzone physical properties changing over time, especially near the surface where organic matter accumulates. It has been demonstrated that organic matter concentrations greater than 4 to 5% in a USGA rootzone will decrease water percolation through, and air movement into, the rootzone (5, 6), resulting in wetter than desirable conditions. Such conditions can be devastating when temperatures are high and bentgrass respiration rates (and rootzone oxygen requirements) are greater than oxygen diffusion rates into the rootzone, ultimately leading to summer decline (1).

Recent cultivation techniques that may be effective in reducing organic matter and maintaining desirable rootzone physical properties include aggressive verticutting and core aeration with closely spaced tines. Verticutting equipment such as the Graden GS04 has been demonstrated to

The Graden GS04 verticutter is capable of cutting channels through the surface organic layer of putting green rootzones.

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This greens aerator has been retrofitted with tine adapters allowing for a tine spacing of 1.25 x 1.5 inches.

aggressively cut channels through surface organic layers in putting greens, removing more organic matter than traditional core aeration treatments. However, some turf managers have expressed concern with the difficulty involved in backfilling cultivation channels and slower recovery times associated with aggressive verticutting.

Another recent trend in putting green core aeration is the use of more closely spaced tines, either by retrofitting older aeration units with adapters or through the introduction of new aeration units with closer tine spacing. It is important to note that turf managers can quadruple the affected area when cultivating putting greens by reducing the tine spacing in half. It also stands to reason that decreasing tine spacing should not affect turf recovery since individual hole sizes do not change. This may allow for a more aggressive organic matter control approach without the limitations associated with aggressive verticutting.

Another factor to consider when managing surface organic matter with core aeration is tine depth. A moderately aged USGA putting green typically has desirable physical properties throughout the profile, except near the surface where organic matter has accumulated. So, it is probably not beneficial to remove desirable rootzone sand from below the surface organic matter layer during aeration. Under such conditions, an aeration tine only needs to be long enough to completely penetrate and remove cores from the organic matter layer. Longer tines would only result in excess sand debris being pulled to the surface, increasing the labor required to remove the debris and the amount of sand needed to backfill aeration channels.

The objective of this research was to determine the effects of various aggressive verticutting and core aeration treatments on surface organic matter removal from a sand-based putting green.

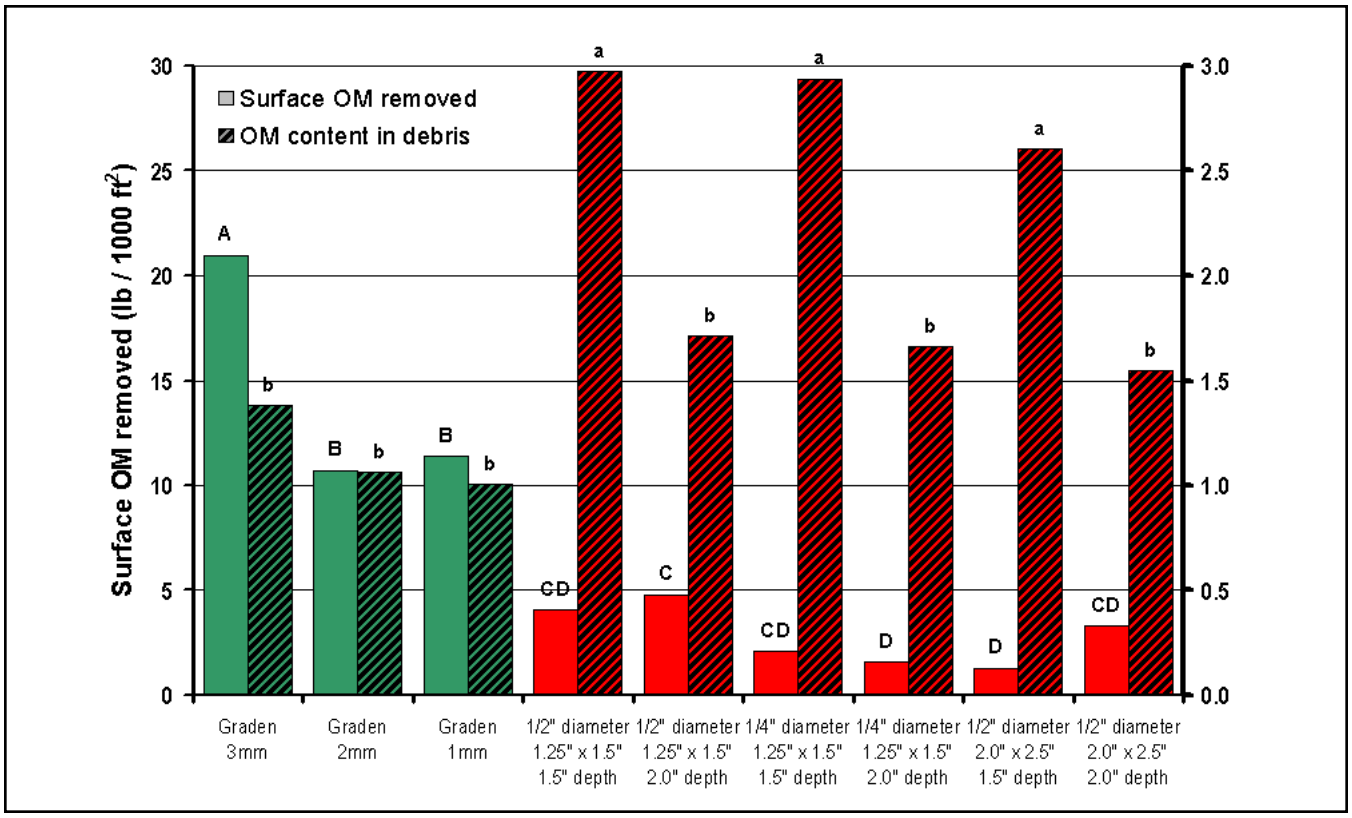

Figure 1. Surface organic matter removed and percent organic matter in the cultivation debris as affected by cultivation treatment. Data collected May 21, 2003 in Fayetteville, AR. Within evaluations, treatment with bars sharing a letter are not significantly different.

Various verticutting blade widths and core aeration tine diamaters, spacings, and depths were investigated.

Cultivation Experimental Methods

A two-year experiment was initiated in the spring of 2003 at the University of Arkansas Research and Extension Center (Fayetteville, AR) on a one-year-old 'Penn G-2' creeping bentgrass putting green built according to USGA recommendations (3, 7). The research green was mowed six days per week at a 0.125-inch height and N, P, and K were applied at annual rates of 3.5, 0.5, and 3.5 lb 1000 ft^{-2}, respectively. Deep irrigation was applied as needed to encourage root growth and prevent drought stress. In addition, light sand topdressing was applied bi-weekly throughout each growing season.

Cultivation treatments were applied using either a Graden verticutter (GS04 Verti-Cutter/Scarifier, Graden Industries, Victoria, Australia) or a Toro greens aerator (Toro Greens 09120, Toro Company, Bloomington, MN) in the spring and fall of each study year. Verticutting treatments were made to a 1-inch depth to ensure complete penetration through the thatch/mat layers and included varying blade widths (1, 2, and 3 mm). Core aeration treatments included various combinations of tine spacing (1.25 x 1.50 or 2 x 2.5 inches), tine diameter (1/4 or 1/2 inch), and tine penetration depth (1.5 or 2 inches). Cultivation treatments were made to individual plots measuring 5 by 20 feet and each treatment was applied to four replicate plots.

The day before cultivation treatments were applied, the percent organic matter in the surface inch, and from 1 inch to the depth of cultivation, was measured in each plot. Immediately following cultivation treatments, scoop shovels were used to collect the debris (sand and organic material) from each plot. Once the debris was collected, sand topdressing was applied and brushed into the turf until the cultivation channels were filled.

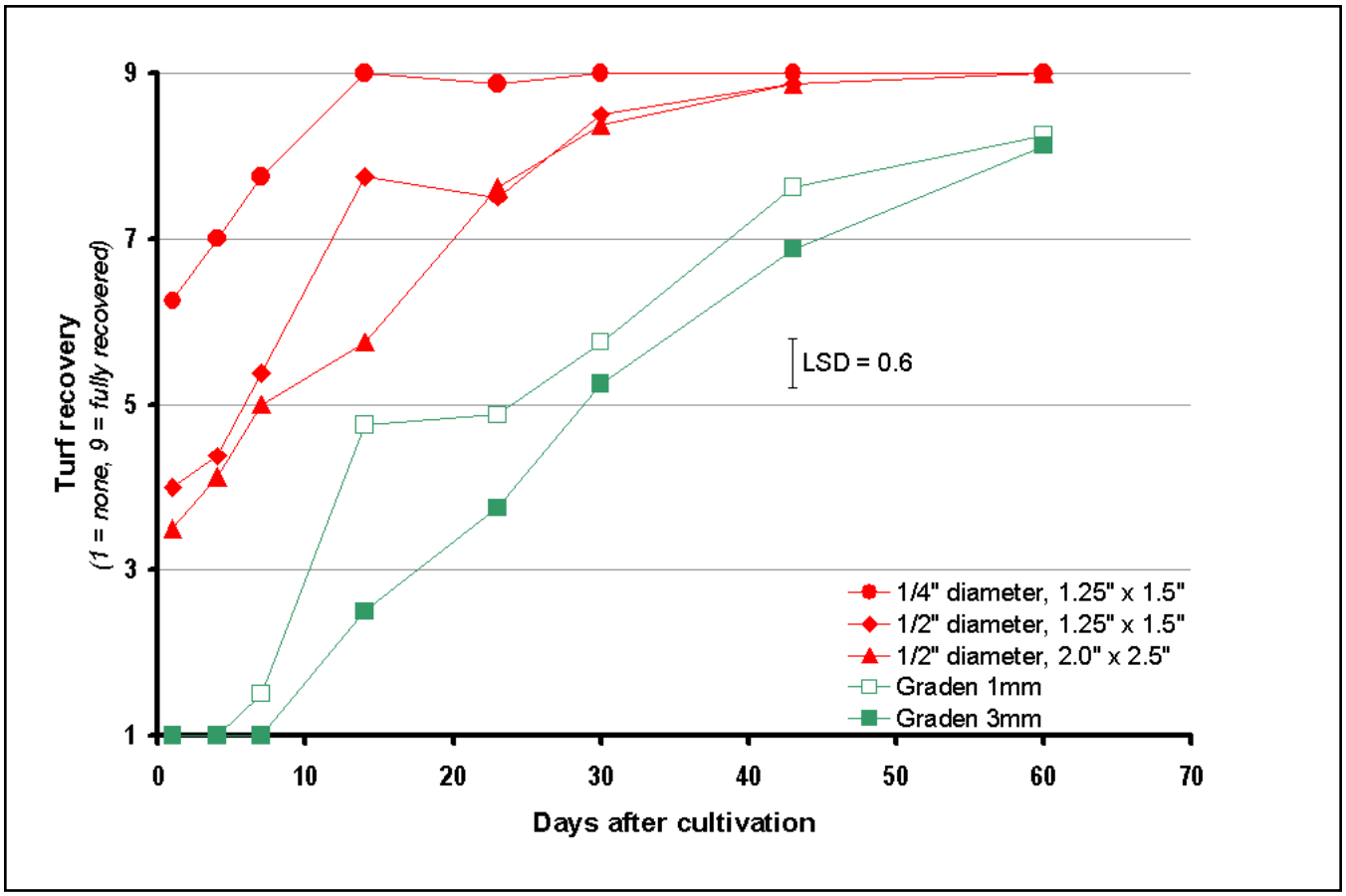

Figure 2. Turfgrass recovery from cultivation as affected by cultivation treatment. Data collected September through November 2003 in Fayetteville, AR. Error bar represents least significance difference value between treatments within a single evaluation date.

The amount of debris removed and topdressing sand incorporated into cultivation channels was recorded for each plot. The organic matter in the cultivation debris originating from the surface inch was calculated based on the distribution of organic matter from the surface inch and to the depth of cultivation (evaluated the day prior to treatment applications). In addition, each plot was rated for recovery and overall turf quality twice weekly following cultivation treatments.

Organic Matter Removal

All of the verticutting treatments removed more surface organic matter than any of the core aeration treatments (Figure 1). In fact, the 3-mm verticutting treatment removed more than 4 times the amount of organic matter than each core aeration treatment. There was not much difference in organic matter removal between the 1 and 2 mm verticutting treatments; however, they only removed about half the organic matter compared to the 3 mm treatment. Turf managers with sand-based rootzones very high in organic matter content should consider aggressive verticutting to remove excessive organic matter near the rootzone surface. Among the core aeration treatments, the larger diameter, closely-spaced, deeper-penetrating treatment removed the most organic matter from near the rootzone surface.

Although core aeration was not as effective as verticutting in removing large amounts of organic matter from the rootzone, it was more efficient in completely penetrating through the organic matter layer without bringing excess sand to the surface, especially those treatments with shorter tines. Verticutting treatments and the deeper-penetrating hollow tines had significantly

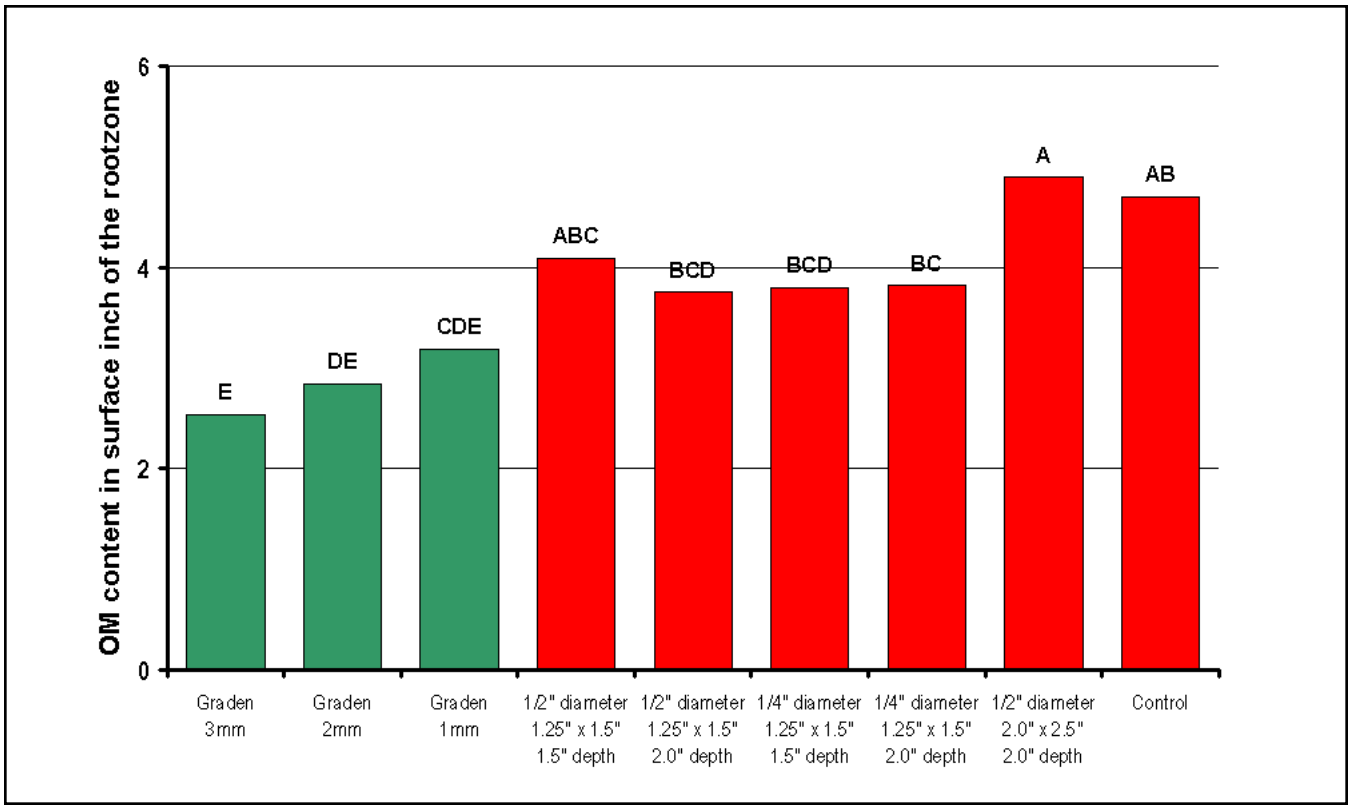

Figure 3. Organic matter content in the surface inch of the rootzone as affected by cultivation treatment. Data collected June 21, 2004, 2 months after the third set of treatments were applied. Treatments with bars sharing a letter are not significantly different.

less organic matter in the cultivation debris compared to the more shallow-penetrating hollow tines (Figure 1). Cultivation debris that was not surface organic matter was predominately rootzone sand with desirable physical properties and thus could be considered wasteful to deal with when cultivating.

Turfgrass Recovery and Quality

Turfgrass recovery evaluations following cultivation are summarized in Figure 2. To improve the clarity of Figure 4, the 2-mm verticutting treatment and core aeration treatments with 1.5-inch deep tines were not included. However, it should be noted that the 2-mm verticutting treatment recovered similarly to the other verticutting treatments, and the 1.5-inch tine depth treatments recovered similarly to those with 2.0-inch tines. Cultivation channels healed over more quickly for core aeration treatments compared to the verticutting treatments. The time required for the verticutting treatments to heal following cultivation was nearly 60 days, approximately twice that necessary for turf that was core aerified. This difference was likely the result of the problems in backfilling cultivation channels with sand. Once the cultivation debris was removed from those plots, many of the verticutting channels had partially closed, making it difficult to fill the channels with sand and smooth the surface.

Aerification holes created by coring treatments were less prone to collapsing and were more completely filled with topdressing sand, creating a smoother surface which hastened recovery. In fact, in all plots that were core aerified, the amount of topdressing sand that was incorporated back into the turf canopy was greater than 100% of the volume of the debris that was removed during cultivation. In contrast, only 70% of the volume of cultivation debris could be incorporated back into the canopy as topdressing sand for turf that was verticut. After this research was completed, a new Graden verticutting unit was released which verticuts and backfills channels with sand in a single operation (1). Turf recovery

Once the debris was collected, sand topdressing was applied and brushed into the turf until the cultivation channels were filled.

from aggressive verticutting would likely be enhanced with sand injection, although no published research is documented this at this time.

Among core aeration treatments, recovery time was affected predominantly by tine diameter. Turf cored with 1/4-inch diameter tines recovered in 14 days, about half the time of turf treated with 1/2-inch tines. Neither tine depth nor tine spacing affected turf recovery in this study. Consequently, a turf manager can use a closer tine spacing to affect a larger percentage of the putting surface without affecting recovery time. This is a better alternative to increasing tine diameter, which would also increase the affected area, but would delay recovery time. In addition, a shallow tine is preferable to a deeper tine (so long as the tine completely penetrates the surface organic layer), since less debris is brought to the surface, and the amount of organic matter removed and recovery time is equivalent.

Cultivation treatments did not affect turf quality in this trial except during periods of recovery from treatment. This study was conducted in a full-sun location with considerable air movement, resulting in minimal disease pressure and summer stress symptoms. Cultivation treatments would have been more likely to enhance turf quality in an environment with limited sun exposure and air movement. Although visual quality was not affected by cultivation treatment in this study, untreated plots were considerably softer by the end of the study and probably had less desirable ball roll characteristics. In a follow-up study on the same plots, uncultivated turf consistently had lower hardness values than all treated turf (2).

Organic Matter Content

After three sets of cultivation treatments and 14 months after the study was initiated, aggressive verticutting was most effective at minimizing organic matter content in the surface inch of the rootzone (Figure 3). In particular, the 3-mm verticutting treatment reduced surface organic

Although verticutting treatments (left) removed more surface organic matter, plots that were core aerated (right) recovered significantly faster.

matter content significantly below that of the untreated control and all core aeration treatments. These results are not surprising considering the large amounts of organic matter brought to the surface by verticutting treatments.

Although all of the closely-spaced core aeration treatments resulted in lower surface organic matter content than the control, differences were slight and not statistically significant after three sets of treatments. It is important to note once again the ideal environment (full sun and air movement) under which this study was conducted, providing favorable conditions for microbial breakdown of organic matter. A putting green with limited air movement and limited sun exposure would probably have greater moisture content at the rootzone surface, limiting microbial activity. Under such conditions, core aeration treatments would be expected to significantly reduce surface organic matter content compared to untreated turf.

Conclusions

Verticutting treatments were more aggressive and effective at removing organic matter from the surface inch of the putting green rootzone than core aeration treatments. However, the verticutting treatments removed a disproportionately large amount of debris and recovered slower. Therefore, aggressive verticutting may be most useful when a large amount of organic matter must be removed at once and recovery time is not a primary consideration, such as during putting green renovation. Core aeration with closely spaced tines may provide more general surface organic matter maintenance for putting greens that must return to a high level of quality shortly following cultivation.

Acknowledgements

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