Does Aerification Help Solve Compaction Problems?

By Beth Guertal and Dave Han

The effects of traffic and compaction on turf are usually easy to see — thin turf, worn paths and areas of bare ground that do not respond to applications of fertilizer or water. Turfgrass growing in compacted areas has shallow rooting, poor water utilization and greater susceptibility to stress. The soil in compacted areas has low air porosity and reduced infiltration.

Such compaction is most likely to occur in fine-textured soils (i.e., those with higher clay content), but all soils may be susceptible to compaction over time.

Turf managers know one key to correcting soil compaction in turf is aerification, which is performed using equipment that drills, slices, spikes, punches or water-injects the turf and its underlying soil to various depths. Sometimes the equipment removes a plug of turf, and sometimes it only cuts a slit or punches a hole. With some equipment, there is the additional benefit of thatch control, as slicing or core removal also removes some thatch. Most turf managers have a piece of aerification equipment.

Research has shown that double-ring infiltrometers with an inside ring diameter of at least 12 inches produce the most accurate measurements of water infiltration.

Given that turf aerification is common, you might think a great deal of research evaluating different equipment (and variables such as aerification frequency and depth) has been done. That's a mistake.

Factors affecting aerification are many, including soil moisture, tine size, depth of aerification, soil texture, aerification frequency and equipment type. Therefore, compaction research is difficult because it requires large plots, uniform areas of compacted (and non-compacted) turf, and several different pieces of equipment.

Additionally, data collected to show treatment differences is often difficult to obtain, requiring intensive sampling. Typical data collected from compaction studies may include soil bulk density, soil penetrometer resistance, surface hardness, water infiltration, shoot density and root length or weight. The objective of this article is to provide some explanation about the type of data collected in turf-compaction experiments. It will also discuss some of the turfgrass compaction research that has been conducted.

What the experiments measure:

Soil bulk density: Bulk density is defined as the mass of a unit volume of dry soil. To collect a bulk-density reading, a known depth and diameter of soil (typically 6 inches deep and 3 inches in diameter) is removed. The soil sample is then dried, and the bulk density is expressed as the mass per volume (grams per cubic centimeter). As the soil is compacted, bulk density will increase because soil pore space will be reduced.

Sandy soils typically have a higher bulk density than soils high in clay or loam because sandy soils have few tiny pores associated with fine-textured soils that have clay and organic matter. Additionally, sandy soils that contain sand in a range of sizes (as is a typically sand-based putting green) are already tightly packed, as smaller sand grains fit in between larger ones.

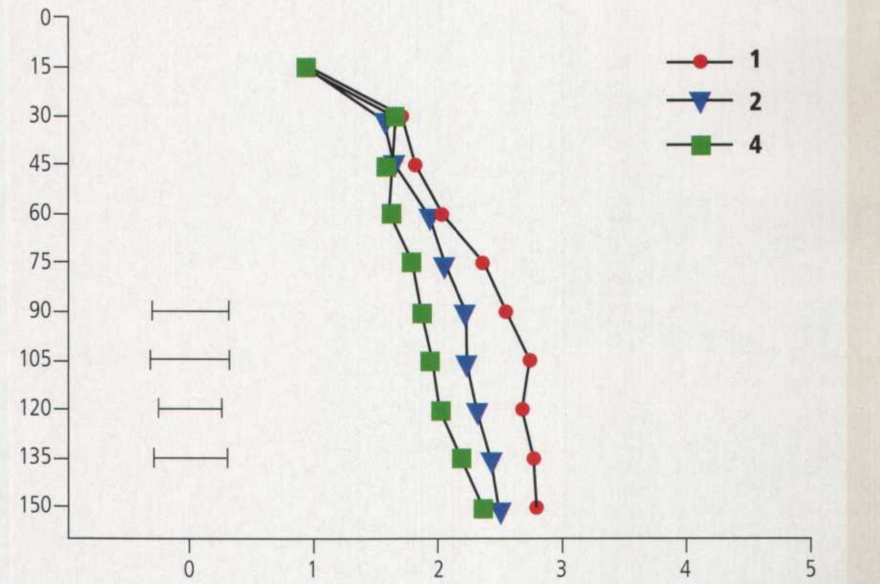
Typical bulk densities for clay and silt loam soils may range from 1 gram per cubic centimeter (g/cm^3) to 1.5 g/cm^3, while the bulk density of sand-based soils may range from 1.3 g/cm^3 to 1.8 g/cm^3. At the upper end of these ranges, the bulk density may inhibit root penetration. In comparison, the USGA recommendation for bulk density of putting greens mix is 1.2 g/cm^3 to 1.6 g/cm^3. Also, bulk density is highly variable from location to location, and one sample will usually not be an indicator of the bulk density of an entire field or turf area.

Soil penetrometer readings: A soil penetrometer is a device used to measure the compaction of the soil.

What is actually measured is the resis-

TABLE 1

Soil resistance in a heavily trafficked hybrid bermudagrass athletic field as affected by frequency of core aerification, July 1999, Auburn, Ala. Depth is 0 to 6 inches. Legend indicates the number of core aerifications applied in one year. Horizontal bars indicate significant differences at those depths.



tance, or amount of pressure, needed to push a tipped rod through the soil. The rod tip is equipped with a load-sensing cell to record the soil strength as it varies throughout the soil depth. Soil penetrometers used for research are extremely sensitive and require some practice to use correctly. They are also expensive, costing as much as $6,000.

Hydraulic conductivity: Hydraulic conductivity is the ease with which soil transmits water. In turfgrass, what we often measure is the saturated hydraulic conductivity, which occurs when all soil pores are filled with water.

Turf aerification research is rather scarce, probably because it is very difficult to do.

Saturated hydraulic conductivity is typically measured using a double-ring infiltrometer, which consists of two metal rings (one around 12 inches in diameter and the other around 18 inches), with the smaller placed inside the larger. Water is added to both rings until a height of water is maintained for a period of time, which indicates that the underlying soil is saturated.

The drop in the height of water inside the smaller ring during a given period is used to calculate the saturated hydraulic conductivity, which is reported in units such as inches per hour.

Small-diameter (6-inch) infiltrometers can be purchased by turfgrass managers in many turf supply catalogs. The intended use of these units is to provide turf managers with infiltration rates quickly.

Since research has shown that double-ring infiltrometers with an inside ring diameter of at least 12 inches produce the most accurate measurements of water infiltration, the accuracy of 6-inch-diameter rings was a concern.

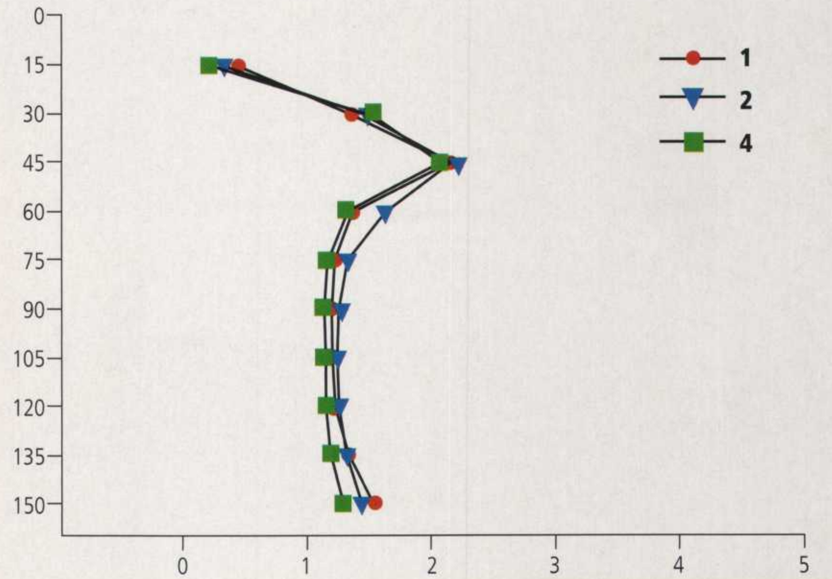
A 1991 research study by D.H. Taylor compared single- and double-ring infiltrometers with inner-ring diameters of 6, 8 and 12 inches on a variety of turf areas, from golf greens to football fields. Taylor found that infiltration rates varied widely within each sampled turf area, even when the largest diameter rings were used. Taylor concluded that infiltration rates measured with standing water should be used only as a rough estimate, and results should be used with caution (Taylor et al., 1991).

Clegg impact readings: Typically used to measure the hardness of a turf surface, the Clegg hammer calculates the hardness of a surface based on its reaction to a weight dropped on the surface from a consistent height.

A diagnostic tool for discovering differ-

TABLE 2

Soil resistance in a lightly trafficked hybrid bermudagrass athletic field as affected by frequency of core aerification, July 1999, Auburn, Ala. Depth is 0 to 6 inches. Legend indicates the number of core aerifications applied in one year. Absence of horizontal bars indicates no significant differences between treatments.



ences in surface hardness due to aerification, work has also started using Clegg hammer readings to measure field hardness or softness. The Clegg hammer uses an accelerometer attached to a weight where the maximum deceleration of the impact is measured. The units for such measurements are g_{max}.

For example, a survey of 24 high school athletic fields had Clegg values that ranged from 33g_{max} to 167 g_{max} (Rogers et al., 1988).

In another study, compacted Kentucky bluegrass plots had a value of 206 g_{max} while plots that were not compacted had a value of 93 g_{max} (Rogers and Waddington, 1992).

A survey of college and professional soccer players was used to compare their perceptions of soccer fields that had been used to collect Clegg data. Typically, fields with a hardness reading between 90g_{max} and 120 g_{max} generally could not be differentiated by players (Miller, 1999). As comparison, a tiled concrete basement floor had a g_{max} reading of 1,280, which was reduced to 260 g_{max} when the floor was covered with a carpet pad (Rogers et al., 1988).

The research

The earliest aerification research was usually conducted as a part of a thatch management study using bermudagrass putting greens. In these studies, aerification tines were usually small in diameter (one-quarter to 2 inches) and did not penetrate deeply into the soil (2 to 3 inches). Frequency of core aerification ranged from biweekly to twice yearly (Smith, 1979; White and Dickens, 1984).

The focus of both these studies was to explore the impact of treatments such as fertilizer source, vertical mowing, topdressing and aerification on thatch depth, not soil compaction. Therefore, direct measurement of soil variables such as bulk density or soil resistance are missing from these studies.

Care should be taken to avoid creation of a compaction pan, which might be caused by aerifying at the same depth for a long period of time.

In one study, increasing aerification from twice yearly to once monthly did not affect thatch depth (White and Dickens, 1984). In another study, however, increasing aerification from twice yearly to monthly slightly decreased thatch depth (Smith, 1979).

One study recognized that most turfgrass cultivation research evaluated thatch removal, so it focused instead on the effects of core cultivation on saturated hydraulic conductivity, porosity and penetration resistance (Murphy et al., 1993). In this study, bentgrass putting greens were treated with hollow or solid aerification tines. There were an equal number of compacted and non-compacted greens, and the soils were a mixture of moist or wet soils when the cultivation treatments were applied.

Compaction of the turf soil reduced the percentage of macropores in the soil, which are the larger pores from which water drains quickly, leaving air spaces in the soil. Reductions in macropore volume can lead to soils that do not drain well and have reduced air movement.

The lightly compacted site needed only one aerification in a given year to produce a significant reduction in soil resistance.

In fixing the compacted soils, the use of hollow tines was more effective than solid in creating macropores. Any type of aerification (hollow or solid) increased soil porosity in compacted soil. In the non-compacted plots, aerification had no effect.

Compaction increased the soil resistance, as measured by the pressure required to push a soil penetrometer through the soil. Reductions in soil compaction were obvious one week after aerification, and the effects lasted nearly three weeks. After three weeks, the plots that had been aerified with hollow tines were less compacted than those aerified with solid tines.

The authors concluded that routine cultivation is needed to prevent soil compaction, especially if solid tines are used. However, care is needed to avoid the development of a compacted layer at the end of the aerification depth. Aerification at different depths should help prevent development of a cultivation pan at some lower depth (Murphy et al., 1993).

Research at Auburn University also found that aerification was less likely to have an effect when soils where noncompacted, as compared to soils that are compacted. The tables illustrate soil penetrometer readings over a 6-inch depth taken from two different hybrid bermudagrass athletic fields with similar soil types.

One field (Table 1) was heavily compacted, while the other (Table 2) only received traffic from equipment and occasional foot traffic. The tables illustrate soil penetrometer readings taken after a different number of hollow-tine (8 inches deep, three-quarter-inch diameter) core aerifications had taken place. Plots were aerified either one time (July), twice (July and October) or four (July, October, January, April) times a year.

At the heavily trafficked site, every additional core aerification in a given year decreased soil resistance. This was not the case at the lightly compacted site, and only one aerification was need in a given year to produce a significant reduction in soil resistance.

At the heavily trafficked site, the effects of deep-tine aerification usually lasted about three weeks. This supports the conclusions of previous work that frequent aerification might be needed on compacted sites. Again, however, care should be taken to avoid a compaction pan at the bottom of the tine working depth.

In conclusion, here's what we do know about the relationship between compaction and aerification of turfgrass soils:

- Compaction of turfgrass soils lowers the percentage of macropores in the soil. A decrease in macropores limits soil aeration, which hurts root growth.
- Core aerification, especially solid tine, may not help eliminate thatch.
- The effects of aerification, especially in heavily trafficked soils, may be short-lived (about one month).
- Diagnostic techniques for detecting compacted soils, such as infiltration measurements or soil penetrometer readings, are widely variable, even across supposedly uniform surfaces such as a putting green.
- Care should be taken to avoid creation of a compaction pan, which might be caused by aerifying at the same depth for a long period.

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