Soil Compaction: A Case Study at Candlewood Country Club

by Larry Stowell, Ph.D.

Summary: One method of measuring soil compaction, or strength, entails recording the pressure needed to force a rod (cone tip penetrometer) into a soil. If the soil provides resistance of more than 300-400 psi, plant roots have difficulty or are unable to penetrate the soil. For this reason, plant roots are frequently found only in the top 2 - 3" of soil, where compaction is usually less than 300 psi. In this study, readings taken inside the sand-filled vertidrain holes, one day after vertidrain treatment showed that the vertidrain reduced compaction at depths of 3 - 5" from about 500 psi to less than 400 psi (Figure 1). Five weeks later, we went back to evaluate compaction again, but it was difficult to identify vertidrain holes. For this reason, the readings we obtained (Figure 2) were probably taken from areas between holes. As expected, readings remained unchanged at 500 psi at depths of 3 - 5". It is likely, however, that the compaction level in the vertidrain holes remained below 400 psi. The common observation of deep roots in vertidrain holes supports this hypothesis. An additional advantage of vertidraining may be improved water infiltration. Even though compaction was not relieved in general throughout the green, the greens take water well in the summer indicating that water infiltration is one of the greatest benefits of this method.

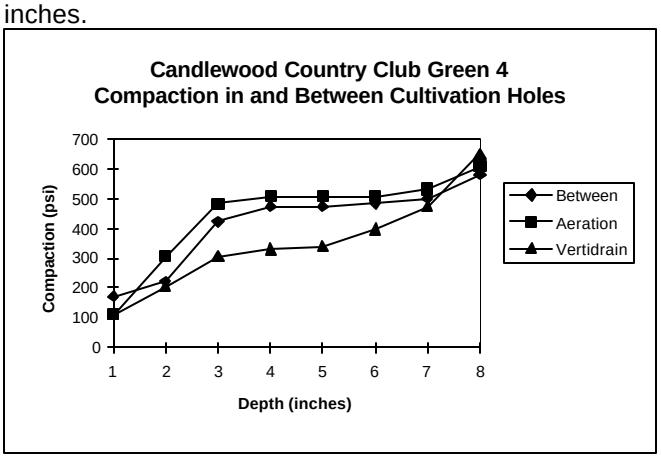
Further studies are needed to determine if it is possible to relieve compaction uniformly throughout the surface of a green without damaging the surface to the point where golf play will be hindered for a long period following the treatment.

NOTE: Unlike the vertidrain holes, aerification holes did not show a decrease in compaction one day after aerification (Figure 1). This reading may be misleading due to the fact that aerification holes are shallow (3") and the penetrometer may not accurately read under these conditions. Therefore, despite the apparently high readings of 500 psi in the aerification holes, they are probably actually less compacted in the top 3" where new sand fills the holes.

Methods: Caranci prepares the greens for vertidrain treatment by first core aerifying with 5/8" tines and removing the cores. He then top dresses with 20-30 silica sand prior to vertidrain treatment. The vertidrain is adjusted so that there in no lateral "kick" to prevent disruption of the green that would be difficult to level out. Following the vertidrain treatment, the sand is dragged in several directions and the remaining sand is blown into the holes.

Compaction was evaluated using a Daiki recording cone penetrometer. A cone penetrometer measures the pressure as a cone tipped rod is pushed by hand into the soil. The recording penetrometer uses a pen to draw on a chart that is attached to a rotating drum that provides a continuous record of the depth and pressure during soil penetration. The continuous charts were digitized by reading the pressure at one inch increments on the chart.

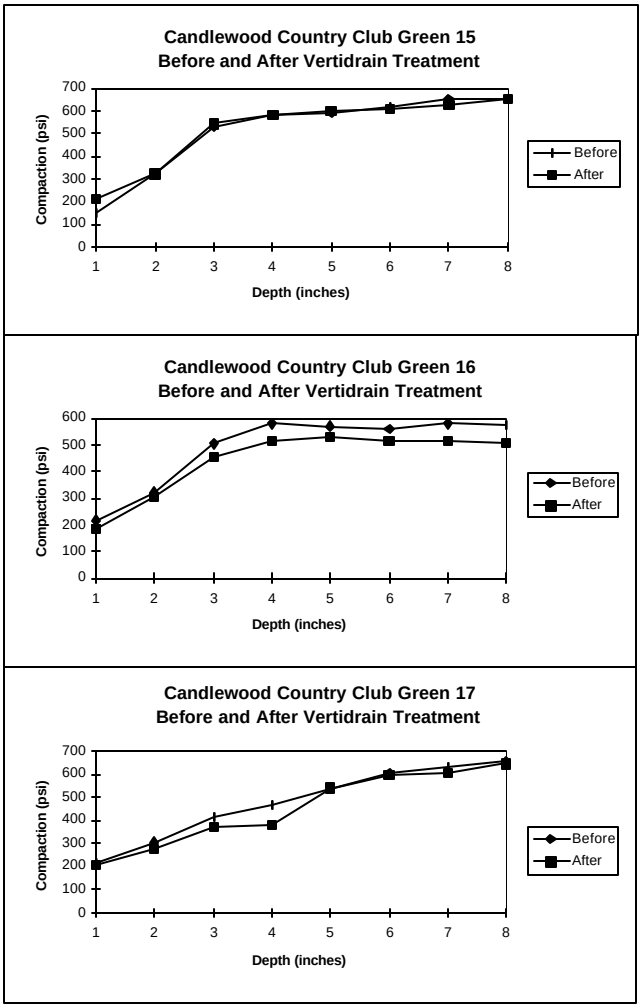
Figure 1. Penetrometer readings taken the day after aerification and vertidrain cultivation and irrigation. Between indicates penetrometer readings taken between the aeration and vertidrain holes (average of three readings). Aeration refers to penetrometer readings taken directly into sand-filled aeration holes. Vertidrain refers to penetrometer readings taken directly into sand-filled vertidrain holes. Only the vertidrain treatment reduced penetrometer readings to below 400 psi for the top five inches.



One green was evaluated one day after treatment and irrigation. In this instance, the penetrometer was probed directly into aeration and vertidrain holes and also into the area between the holes. Three probes were recorded between holes, in aeration holes and in vertidrain holes (Figure 1).

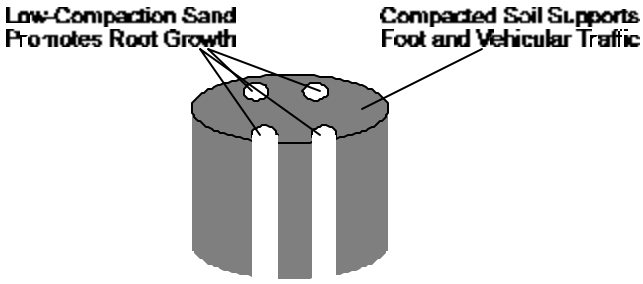
Prior to vertidrain treatment in March, greens 15, 16, and 17 at Candlewood were probed in six locations to provide a before vertidrain profile of the compaction level in the greens. Five weeks later, the same greens were probed with the penetrometer to evaluate the difference in compaction levels (Figure 2). There was no difference between before and after vertidrain penetrometer readings.

Figure 2. Penetrometer readings taken before and 5 weeks after aeration and vertidrain treatment. Six penetrometer readings were collected for each green. All three greens exceed 300 psi within the top three inches before and after treatment.



Compaction: Compaction has been an issue in greens management since there were golfers. Compaction reduces water infiltration, reduces the ability of roots to penetrate the soil and limits gas exchange between the soil surface and the atmosphere. To reduce compaction, the soil particles need to be "loosened-up" to provide more air-filled pore spaces. What happens to air spaces when someone steps on the soil or a piece of equipment drives over the soil? The soil compacts again. Without some type of support for the traffic mixed throughout the green, the green will rapidly revert back to its compacted state following aeration. Unless, as Caranci and Mills have shown, the compacted greens are vertidrained and the holes filled with sand. The low compaction sand in the holes may not compact rapidly because the surrounding high compaction soil supports foot and vehicular traffic (Figure 3). In addition, some superintendents have begun to aerify frequently in the summer using smaller 1/4 inch tines and leaving the holes open. The area will slowly compact as traffic pushes the holes closed. But, the holes give the soil some elasticity and enhances gas exchange with the atmosphere.

Figure 3. Illustration of how the high compacted soil surrounding vertidrain holes may provide support that prevents rapid compaction of the sand in the holes.



Conclusions: One of the objectives of having sand based greens is to provide a firm surface for playing the game of golf. If the sand is too soft, the surface will not remain flat and true following foot or vehicular traffic. There is a basic conflict between the needs of the game for a firm surface and the needs of the plant for a low compaction soil.

Compaction is the major limiting factor for root development in modern golf course greens. When the demand for fast and smooth greens prevail, soft greens will not be tolerated. Learning to manage turfgrass under high compaction conditions will be essential to provide a premiere golfing experience. The method implemented by Caranci and Mills not only appears to be a reasonable compromise but a possible solution to the compaction conflict.