HOLLOW AND SOLID TINE CORING RESEARCH

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Soil compaction is a major problem on intensely used and managed turf sites. Very simply, compaction of the soil decreases the size of soil pores and interrupts the continuity of those pores. These adverse effects on soil porosity inhibit the flow of air and water through the soil. Such conditions can lead to a lowered oxygen supply to plant roots and thereby restrict plant growth. With core cultivation, or aerification, the turf manager can open the compacted soil surface and enhance the movement of air and water through the soil.

Unfortunately, core cultivation operations require a considerable input of time and labor. In an attempt to reduce such costs some growers, particularly on golf courses, have adopted the use of solid tine cultivation. Solid tine cultivation eliminates the processing of soil cores needed when using hollow tines. However, opponents of solid tine cultivation suggest a severely compacted layer may form at the bottom of the cultivation zone as result of using this practice.

With this in mind a field study was designed to examine hollow and solid tine cultivation. The two cultivation methods were evaluated on the basis of their effects on soil structure and turfgrass root growth.

Appreciation is gratefully expressed to the Michigan Turfgrass Foundation and United States Golf Association for the financial support of this research.

METHODS

The study was initiated in May 1984 on a creeping bentgrass green grown a loamy sand soil (Murphy and Rieke, 1985; Murphy and Rieke, 1986). Solid and hollow tine cultivation along with two soil factors, which might influence the effectiveness of cultivation, were evaluated. The two soil factors were soil compaction and soil moisture at the time of cultivation.

Soil compaction was performed with a water filled power vibrating Ryan's roller. Each cultivation treatment was performed under two levels of compaction. The two levels of compaction were noncompacted and compacted. Soil moisture levels at the time of cultivation were moist (-0.5 bar) and wet (-0.03 bar). Soil moisture potentials were monitored with tensiometers. Thus, solid and hollow tine cultivation treatments were performed at two soil densities and two soil moisture contents. One check (noncultivated) was included under each compaction level for comparison.

Soil strength measurements were made with a penetrometer at the end of each growing season along with saturated hydraulic conductivity and root growth determinations.

RESULTS

In general, soil strength (hardness) was reduced in the 0-3 inch zone with all cultivation treatments (Figure 1). Differences between solid and hollow tine cultivation were found in all three years. In 1984, solid tine cultivation reduced soil strength more than hollow tine cultivaiton in the 0-3 inch zone (Figure 2). However, 1985 data showed hollow tine cultivation resulted in lower soil strength values when compared to solid tine cultivation (Figure 3). This reversal in soil strength values continued in 1986 (Figure 4). Interestingly, differences were observed below the 3 inch depth in 1986 with solid tine cultivation yielding greater soil strength values than hollow tine cultivation.

Therefore, both hollow and solid tine cultivation reduced soil surface compaction. Initially, solid tine cultivation loosened the soil surface more than hollow tine cultivation. However, with continued treatment hollow tine cultivation became the more effective treatment for relief of soil surface compaction. This was most likely due to the removal of soil with the hollow tine treatment which left large open voids in the surface. Data for 1986 suggests the soil below the cultivation zone (3-6" zone) is denser in soil under solid tine treatment when compared to the hollow tine treatment.

Saturated soil water conductivity measurements were made on soil cores removed from the plots in October, 1986. These 3" dia. x 3" deep cores were removed so as to include soil below the cultivation zone. Higher water conductivity indicates better soil structure.

In general, cultivation restricted water movement through these soil cores in noncompacted soil when compared to the noncultivated check (Table 1). However, cultivation in compacted soil had no significant effect when compared to the noncultivated check. These data suggest that formation of a cultivation pan was not a significant problem when cultivating severely compacted soil.

Hollow tine cultivation resulted in 56.3% higher conductivity rates when compared to solid tine cultivation (Table 1). This indicates hollow tines were less damaging to soil structure than solid tines. Soil moisture content also influenced conductivity rates. Cultivation during wet soil conditions lowered conductivity rates 34.5% below rates observed under moist soil cultivation.

Thus both hollow and solid tine cultivation reduced water conductivity through the cultivation zone in noncompacted soil. However, since this effect was not evident in compacted soil cultivation pan formation was not a problem under severely compacted soil. Also conductivity reductions were greater with solid tine cultivation compared to hollow tine cultivation. Wet soil conditions enhanced the compactive effect of cultivation.

Soil samples 1.75" x 1.75" x 9" deep were removed and sectioned into three 3" depth zones. These samples were washed free of soil and the roots collected. The total amount of roots declined with cultivation in both noncompacted and compacted soil (Table 1). Injury and/or removal of roots during the cultivation operations would be one reason for reduced rooting.

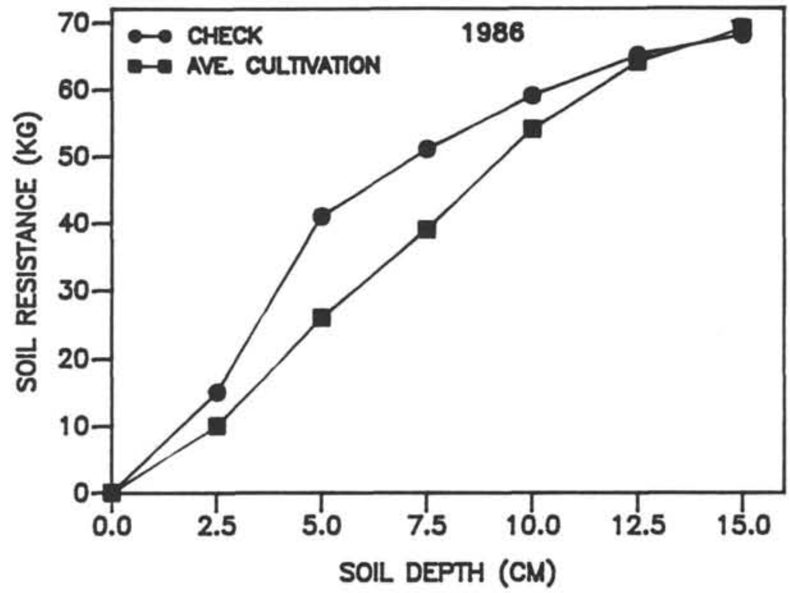

Figure 1. Cultivation effect in compacted soil.

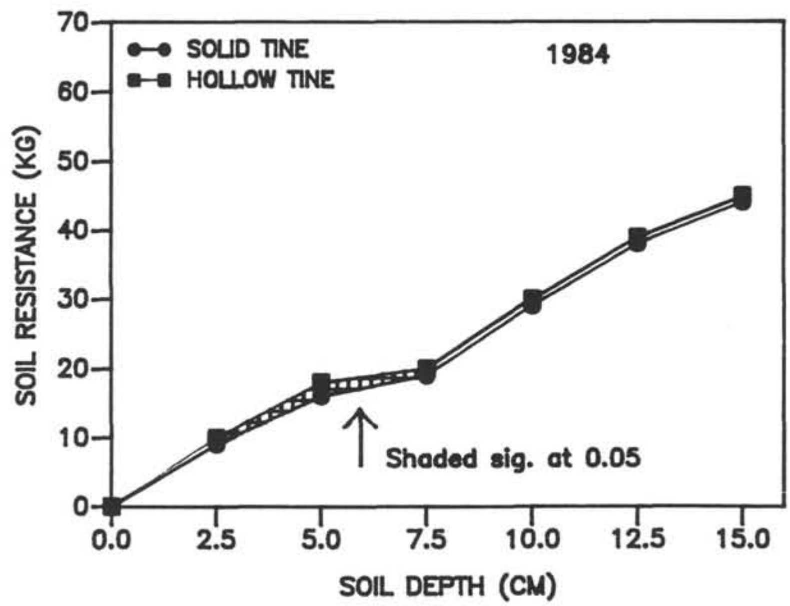

Figure 2. Tine effect on soil strength.

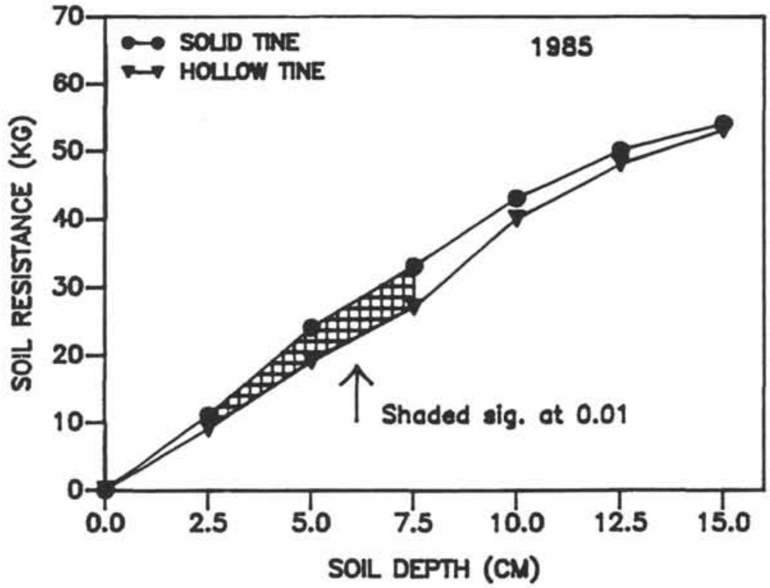

Figure 3. Tine effects on soil strength.

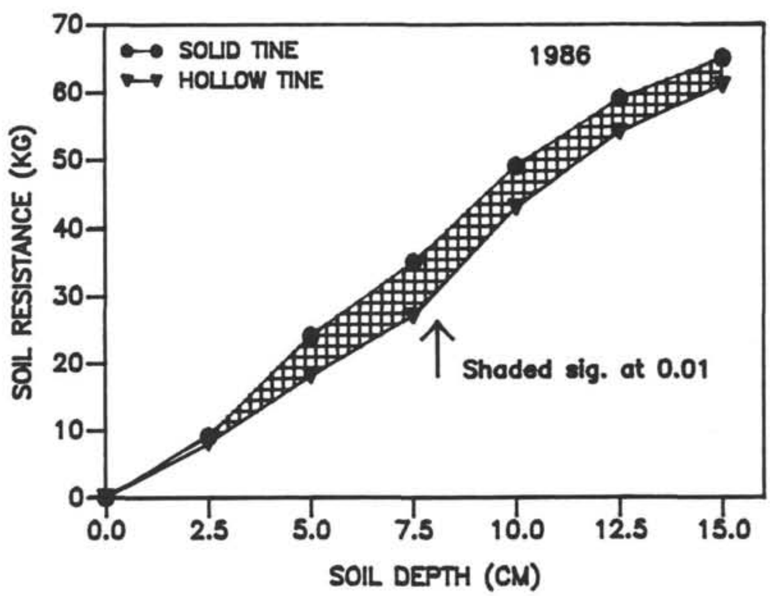

Figure 4. Tine effect on soil strength.

Table 1. The influence of compaction, cultivation and soil moisture during cultivation on saturated hydraulic conductivity and root growth in October and November, respectively, 1986.

Treatments	Conductivity	Total Root Weight	Root Weight Density Zones 0 - 3"	3 - 6"	6 - 9"
	cm/hr	mg/dm^2	-------- mg/dm^3 --------		
Noncompacted (NC)					
Check (CK)	6.2	10070	1080	210	50
Hollow Moist	6.5	7640	830	150	40
Hollow Wet	3.7	8430	940	160	20
Solid Moist	3.7	7680	820	160	40
Solid Wet	2.7	8360	930	150	30
Compacted (Cd)					
Check	2.4	8260	950	130	20
Hollow Moist	3.9	6890	770	120	30
Hollow Wet	3.2	6440	710	120	30
Solid Moist	3.0	6230	690	120	20
Solid Wet	1.6	7280	830	110	30

Comparisons[a]	Mean Squares[b]				
Compaction	22.71 **	1504.0 **	132.0 **	15.0 **	653 **
Tine Type	14.88 **	0.9	0.3	0.1	38
Moisture	13.05 **	1.8	32.3	0.0	38
NC-Ck vs Cult[c]	10.33 **	1001.2 **	97.6 **	8.2 **	482 *
Cd-Ck vs Cult	0.66	576.6 **	92.8 **	0.5	27
Error	1.07	63.0	8.0	0.3	88

a Interactions terms lacked significanc and are not shown.
b ** and * significance at 0.01 and 0.05, respesctively
c Average cultivation effect

Examination of rooting at various depth zones showed cultivation reduced rooting in all zones in noncompacted soil when compared to the noncultivated check (Table 1). Reduced rooting at depths below 3" with cultivation may indicate development of poor soil structure below the 3" depth in noncompacted soil. In compacted soil rooting was only reduced in the 0-3" zone with cultivation, when compared to noncultivated check (Table 1). These results again indicate the deleterious effect of cultivation in noncompacted soil but not in compacted soil. Under compacted soil conditions, reduced rooting with cultivation in the surface 3" of soil could be viewed as a positive response. Soil compaction has been shown to stimulate an increase in surface rooting in response to reduced oxygen levels (Agnew and Carrow, 1985). Cultivation effects on rooting in compacted soil could then be seen as improving soil surface oxygen levels and therefore avoiding oxygen stressed stimulation of adventious rooting in the soil surface.

SUMMARY & INTERPRETATIONS

Hollow tine cultivation provided the best relief of soil compaction when compared to solid tine cultivation. However, solid tine cultivation did provide some relief of soil surface compaction. Both tine types caused some damage to soil structure (e.g., reduced water conductivity, Table 1), although this was not of great importance in compacted soil because the initial soil structure was poor.

Allowing the soil to dry prior to cultivation will inhibit compaction caused during cultivaiton. But caution is advised when using this strategy as the turf will be quite susceptible to traffic injury when under drought stress.

Finally, data substantiate that solid tine cultivation has a role in the management of turf under severe soil surface compaction conditions. Solid tine cultivation provides the grower with a more efficient method to cultivate problem compacted sites where frequent cultivation is beneficial.

LITERATURE CITED

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