RESEARCH UPDATE ON TURF CULTIVATION

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Soil compaction is a common problem associated with high use recreational turfs. Compacted soil results in lower water infiltration rates and air movement, and impedes root growth. These conditions can lead to greater plant stress susceptibility and reduced water use efficiency. Core cultivation is often used to alleviate these poor soil conditions.

Recent research here at Michigan State University suggests that core cultivation compacts the soil along the sides and at the bottom of the coring hole. Under this assumption, coring has the potential to cause the formation of a cultivation pan. Also, there is considerable interest in the idea of "coring" with solid tines. Supporters of this practice feel a shattering of soil is taking place. A field study was begun in May of 1984 to compare hollow tine and solid tine coring at two different moisture levels on a soil receiving compaction treatments. Penncross creeping bentgrass was maintained under greens conditions on the loamy sand green at the Hancock Turfgrass Research Center.

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

METHODS

A 2x2 factorially arranged randomized complete block design with 2 additional non-cored plots, one receiving compaction and the other receiving none, was used in this experiment. There were 4 replications. Treatments utilized were:

1. hollow tine coring in "dry" compacted soil
2. hollow tine coring in "wet" compacted soil
3. solid tine coring in "dry" compacted soil
4. solid tine coring in "wet" compacted soil
5. no coring - compacted soil
6. no coring - non-compacted soil

Compaction treatments consisted of 6 passes of a 600 pound vibrating roller. Treatment applications averaged once a week over a 15 week period. "Dry" coring treatments were applied August 27, 1984 at an average soil moisture of 7.5% (range 6.4 - 9.1%) by weight. "Wet" coring treatments were applied August 30, 1984 at an average soil moisture content of 19.1% (range 17.6 - 20.9%). Fertilizers, fungicides and insecticides were applied as needed to maintain the turf.

Double ring water infiltrometers and a soil penetrometer were used to evaluate soil water infiltration rates and soil resistance to cone penetration. For laboratory analysis, four soil cores (7.5 cm diameter by 7.5 cm high) were taken from each plot. Saturated hydraulic conductivities and oxygen diffusion rate measurements were made on these cores.

RESULTS

Field Measurements

Water Infiltration Rates. No significant differences were found due to the type of tine used in coring (Table 1), although coring under "wet" soil moisture conditions significantly reduced water infiltration rates. The compaction treatment did not influence infiltration rates, possibly because this modified soil already has a high soil density. The coring treatments caused significantly lower infiltration rates compared to the checks. This would support the conclusion of the development of a compacted layer at the bottom of the coring hole.

Penetration Resistance. A penetrometer was used to chart pounds of pressure with depth of penetration. The area under the resulting curves were then calculated and used to analyze the different treatments. All coring treatments significantly reduced the pressure required to penetrate the surface soil with a cone shaped probe when compared to the compacted check. At about 7.5 cm (3 inches), however, all cored plots had a large increase in pressure such that the readings became the same for both cored and untreated plots. This further substantiates the development of a compacted layer at the bottom of the coring hole.

Laboratory Data

Saturated Hydraulic Conductivity. No significant differences were observed between individual coring treatments. Only the two checks differed significantly with the non-compacted plot having higher water conductivity.

Oxygen Diffusion Rates. Oxygen diffusion rates (ODR) were monitored on each core at a 5 cm depth over 3 moisture levels: 20, 30 and 40 centimeters of tension which were controlled with a tension table. A significant difference in oxygen diffusion was found only at the moisture level of 30 cm of tension. The check plots were significantly higher in ODR's when compared to the average of all coring treatments, although the degree of ODR reduction was small.

CONCLUSIONS

Field Measurements

Field Infiltration Rate. Infiltration data suggests that all coring treatments reduce water infiltration. Although, the degree to which infiltration rates are reduced is largely influenced by soil moisture content during coring. Cultivation under high soil moisture contents in this study significantly reduced infiltration rates by 38% compared to treatment under "dry" conditions. No effects could be attributed to the type of tine used for coring.

Penetrometer Readings. All coring treatments reduced the amount of force required to penetrate the soil (Table 2). The actual region of soil being loosened is still vague but appears to be in the surface 2-5 cm (1-2 inches) with an increase in pressure required at about 7.5 cm coinciding with the bottom of the coring hole.

Laboratory Measurements

Saturated Hydraulic Conductivity. No individual coring treatments differed significantly (Table 3), although the solid tine - "wet" treatment does show a tendency to have a lower conductivity in this laboratory evaluation than the other treatments. The checks differed significantly in conductivities, with the compacted check having a 50% reduction in saturated water flow.

Oxygen Diffusion Rates. Oxygen diffusion data (Table 4) show that at the 2 inch (5 cm) depth coring reduces the rate at which oxygen moves through the soil. If soil compaction is occurring at the bottom of the coring hole, lower ODR's would be expected. These reduced ODR's are probably not low enough to create oxygen stress to a turf.

SUMMARY

The data suggests coring will "loosen" the soil surface. To what degree this disturbance is occurring and the associated benefits need to be studied further. The field infiltration rates and oxygen diffusion rates suggest that below this loosening of the surface soil, properties are being affected in an adverse manner. One explanation is that soil compaction is occurring at the bottom of the coring hole. The severity of this compactive effect seems to be enhanced when coring during wet soil conditions. Although not proven statistically, the solid tine - "wet" soil coring treatments show a tendency to be lower than all other coring treatments in water movement and oxygen diffusion rates.

Coring with hollow tines is still considered the standard practice, particularly when there is need to fill the coring holes with topdressing, when larger coring holes are needed to alleviate surface compaction or when the topsoil from the cores is considered an important part of the thatch control program. But there may be a place for the use of solid tines (shattercoring) during the summer when relief from surface compaction is needed, especially when runoff of irrigation water occurs. The use of smaller tines will leave small openings which heal over quickly and do not leave the turf as open to rapid dessication. These holes tend to close up quickly. Further research will provide a clearer picture of the benefits of coring with solid tines.

Table 1. Water infiltration rates of field plots using double ring infiltrometers. Statistical comparisons summarized in Table 5.

Treatment	Infiltration (In/hr)
No compaction - no coring	1.15
Compaction - no coring	.94
Compaction - hollow tine - "dry" soil	.87
Compaction - hollow tine - "wet" soil	.69
Compaction - solid tine - "dry" soil	1.00
Compaction - solid tine - "wet"soil	.46

Table 2. Soil resistance as measured by area under the curve using a cone-shaped penetrometer. Statistical comparisons summarized in Table 5.

Treatments	Area under curve (Resistance vs. Depth)
No compaction - no coring	198.5
Compaction - no coring	255.5
Compaction - hollow tine - "dry" soil	196.3
Compaction - hollow tine - "wet" soil	186.5
Compaction - solid tine - "dry" soil	189.4
Compaction - solid tine - "wet" soil	180.1

Table 3. Saturated hydraulic conductivities on soil cores taken from treated plots. Statistical comparisons summarized in Table 5.

Treatments	Conductivity (In/hr)
No compaction - no coring	1.91
Compaction - no coring	.96
Compaction - hollow tine "dry" soil	1.22
Compaction - hollow tine "wet" soil	1.25
Compaction - solid tine - "dry" soil	1.23
Compaction - solid tine - "wet" soil	.70

Table 4. Oxygen diffusion rates (gm/cm^2 min x 10^{-8}) on soil cores taken from treated plots measured at a depth of 5 cm. Statistical comparisons summarized in Table 5.

Treatments	Moisture Level		
	20 cm	30 cm	40 cm
No compaction - no coring	8.84	42.87	75.77
Compaction - no coring	4.55	47.29	83.10
Compaction - hollow tine - "dry" soil	3.24	30.61	80.15
Compaction - hollow tine - "wet" soil	3.61	32.44	77.86
Compaction - solid tine - "dry" soil	4.45	36.26	83.43
Compaction - solid tine - "wet" soil	3.45	22.98	73.93

Table 5. Statistical Summary for Data in Tables 1-4.

Parameter	Camparisons	Significance
Field Infiltration (Table 1)	Solid vs hollow	NS[a]
	Wet vs dry	*
	Tines X moisture	NS
	Compacted vs noncompacted (checks)	NS
	Checks vs all treatments combined	NS
Penetration Resistance (Table 2)	Solid vs hollow	NS
	Wet vs dry	NS
	Tines X moisture	NS
	Compacted vs noncompacted (checks)	**
	Checks vs all treatments combined	**
Hydraulic Conductivity (Table 3)	Solid vs hollow	NS
	Wet vs dry	NS
	Tines X moisture	NS
	Compacted vs noncompacted (checks)	*
	Checks vs all treatments combined	NS
ODR's at 30 cm tension (Table 4)	Solid vs hollow	NS
	Wet vs dry	NS
	Tine X moisture	NS
	Compacted vs noncompacted (checks)	NS
	Checks vs all treamtents combined	**

[a] NS = no significant diffepences occurred

*, ** = significant differences occurred at the 5% and 1% levels, respectively.