TURFGRASS SOILS AND FERTILITY RESEARCH REPORT 2000

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It seems hard to believe that my first year at Michigan State University is almost complete. It's certainly been a very busy year as I've focused on establishing a research program and traveling the state to meet those working in the turfgrass industry. Thom Nikolai served as my research technician for my first 9 months but has now taken a teaching position in the two-year turfgrass management program. It will be difficult to replace Thom and I am grateful for his assistance as I strived to establish my program. I have taken on two graduate students working towards a Masters degree. Brian Leach started in June and is concentrating his research on the Sloping Green Research Project. Kevin O'Reilly has recently started graduate school and will be working on the Long Term Nitrogen Fate Research Project.

I look forward to continuing several research projects this year and investigating new areas. I am also eager to continue my explorations of Michigan and establish relationships with those working in the turfgrass industry.

The research results presented in this report are preliminary in nature and additional years of data are necessary to make definitive conclusions.

EFFECTS OF ROOTZONE MATERIAL AND DEPTH ON MOISTURE RETENTION PROBLEMS IN UNDULATING USGA PUTTING GREENS (THE SLOPING GREEN)

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Introduction

The United States Golf Association (USGA) introduced guidelines for constructing putting greens over thirty years ago and since then the USGA green has become the standard for golf course putting greens. The concept behind the USGA recommendations for putting green construction is to build a green that provides a measure of resistance to compaction in the rooting zone and drains quickly to an optimum soil moisture level. If greens lacked slopes there is little doubt that most, if not all, USGA greens would perform well. However with the slopes present on putting greens today, the USGA greens do not always perform ideally. Two problems that have commonly been encountered on greens are "Localized Dry Spot" (LDS) and "Black Layer". These problems are primarily associated with extremes in soil moisture in the rootzone of the green (Wilkinson and Miller, 1978; Tucker et al., 1990; Cullimore et al., 1990; Berndt and Vargas, 1992).

Specifications for a USGA putting green require that the sandy rootzone mixture be placed at a uniform depth of 30 cm (12"), across the entire surface of the green. However, the uniform rootzone mix depth does not account for the lateral flow of water in a sloping rootzone. Lateral flow occurs in sloping soil profiles when gravitational and surface tension forces acting on the water become larger than the attraction of water to the soil. This lateral flow causes lower water contents in high areas of the putting green resulting in dry soil conditions and susceptibility to LDS. Water flows laterally to the lower parts of the green causing higher water contents closer to the surface in the same green. This is the location where Black Layer most frequently occurs.

Research was initiated in 1998 at the Hancock Turfgrass Research Center to investigate whether or not altering the rootzone depth, decreasing it in high areas and increasing it in low areas, will increase the water content near the soil surface in high areas and decrease the water content of the rootzone mix in low areas.

Materials and Methods

In 1998, a 950 m^2 (10,000 ft^2) research putting green was constructed at the Hancock Turfgrass Research Center at Michigan State University. The entire putting green is subdivided into 12 sloping plots. The profile of the green (from North to South) consists of a 2.3 m (8') long flat portion (toeslope North), followed by a seven percent 5.3 m (17.3') long slope (backslope North) to the summit, followed by a more gradual three percent 12.2 m (40') long downward slope (backslope South), followed by a final 4.5 m (14.7') long flat portion (toeslope South) (Figure 1). Barriers in the form of particle board dividing walls and PVC liners were placed along the length of each plot to prevent lateral movement of water between plots. Each plot received one of three rootzone mixes; sand/peat, sand/soil, or straight sand. Three plots (one of each rootzone type) have a rootzone mix with a uniform 30 cm (12") depth (standard USGA type) and three have a rootzone mix depth varying from 20 cm (8") at higher elevations to 40 cm (16") at lower elevations (modified USGA type). Drainage tiles were placed in trenches at strategic locations across the plots: at the extreme ends of each plot as well as at the end of each slope, and in the middle of the backslope of the 3% slope (Figure 1). The trenches were filled with gravel to cover the tiles and each tile was connected to a solid pipe that discharges at the lower end of each slope to a rain tipping bucket. A series of 120 Time Domain Reflectometry (TDR) probes and cables were buried in the soil to measure soil moisture in 10 cm (4") increments at several locations in every plot. The plots are arranged in a two factor complete randomized split-block design and are replicated twice. A Rainbird irrigation system was installed to provide uniform irrigation coverage for the entire green. The green was seeded with creeping bentgrass (*Agrostis palustris*) cultivar 'L-93' in June of 1998.

In 2000, data were collected on soil moisture, leaf surface temperature, turfgrass quality and color, root weights, and quantity of drainage water from various regions of the green.

Turfgrass quality, color, and leaf surface temperatures were taken from five locations per green (toeslope North, backslope North, summit, backslope South, and toeslope South). Soil moisture readings were collected for four different 'dry down cycles' during the summer using a TRIME portable TDR unit for the 0 to 10 cm depth. A TDR100 and a series of multiplexers were used to measure soil moisture with the permanently installed probes at depths of 10-20 cm, 20-30 cm and 30-40 cm. Soil moisture measurements were taken in the Northfacing toeslope (TDR location 1), summit (TDR location 2), and at two locations in the Southfacing toeslope (TDR locations 3 and 4) (Figure 1). Root samples are in the process of being washed and weighed and results will be presented in future reports. Thirty-six rain tipping buckets were installed at the south end of the green to quantify the amount of water draining from three locations on the south slope of the green (Figure 1). Data from the rain tipping buckets were collected continuously throughout 2000.

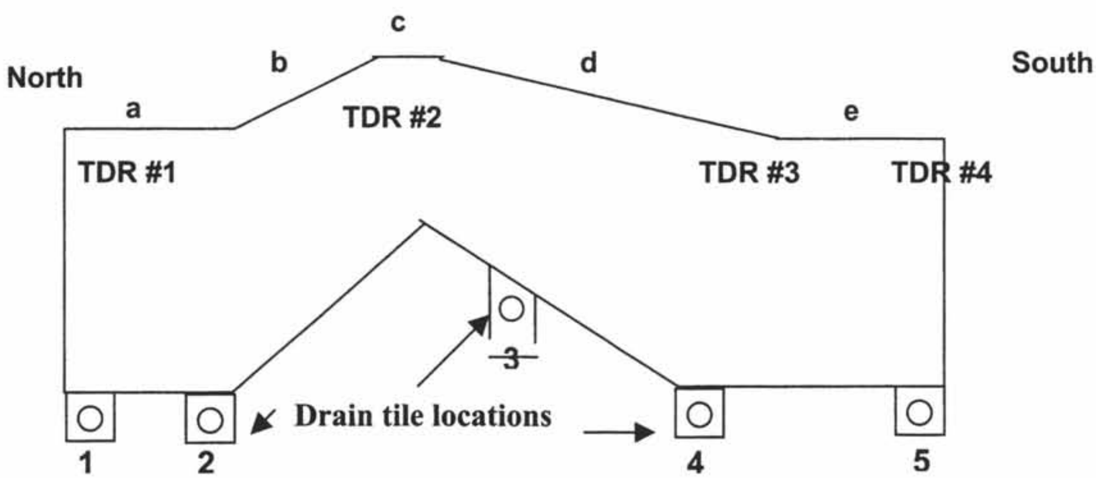

Figure 1. Cross section through plots with variable rootzone depth and different locations for measurements: (a) toeslope North, (b) backslope north, (c) summit, (d) backslope South, (e) toeslope south.

Results and Discussion

Turfgrass quality, color, and leaf surface temperatures

There were no consistently significant differences observed in quality, color, or leaf surface temperatures among the treatments in 2000. At several sampling times, there were location x construction type x rootzone mix interactions for turfgrass quality but analysis of the three way interaction revealed no important differences among the treatments. The abundant rainfall received throughout the spring and summer of 2000 in East Lansing resulted in few differences in turfgrass quality and color on the green.

Soil Moisture

During the summer of 2000 there were five different 'dry down' cycles during which volumetric soil moisture measurements were taken using TDR probes. Data were analyzed separately by depth for the 0-10 and 10-20 cm depths. Since the 20-30 and 30-40 cm depths are not present for both construction methods at all locations on the green, statistical comparisons of these depths was not conducted. The location x construction type and location x rootzone mix interaction were significant throughout the dry down cycles.

Location x Construction Type Interaction 0-10 cm depth

At the 0-10 cm depth there was a significant location x construction type interaction at almost all measurement times. At the beginning of a dry down cycle on August 31, when the rootzone is near field capacity, the location x construction type interaction revealed that at TDR locations 1 and 3 the modified USGA construction type had lower volumetric soil moisture content than the standard USGA construction type (Table 1). There were no differences in volumetric soil moisture content between the construction types at TDR locations 2 and 4. Furthermore, it was evident that there were no differences in volumetric soil moisture content among TDR locations for the modified USGA construction type. However, for the standard USGA construction type the peak of the slope, TDR location 2, had significantly lower soil moisture content values than TDR locations 1 and 3.

Table 1. Volumetric soil moisture for the location x construction type interaction at the 0-10 cm depth on August 31, 2000.

	Construction Type	
TDR Location	Modified USGA	Standard USGA
1	17.5 B†a‡	24.2 Aa
2	20.8 Aa	17.5 Ab
3	16.2 Ba	23.4 Aa
4	17.6 Aa	22.5 Aab

† Means in a row followed by the same capital letter are not significantly different according to Fischer's protected LSD (p=0.05)

‡ Means in a column followed by the same small case letter are not significantly different according to Fischer's protected LSD (p=0.05)

On September 3, 4 days after an irrigation event, the location x construction type interaction was still significant for volumetric soil moisture content. The modified USGA construction type had lower volumetric soil moisture content values at TDR locations 1, 3, and 4 (Table 2). As on August 31, there were no differences in soil moisture content among the locations for the modified USGA construction type, indicating that the modified USGA construction type had uniform soil moisture across the entire slope of the green. Across the slope of the standard USGA construction type green, volumetric soil moisture content values were lower at the peak of the slope, TDR location 2.

Table 2. Volumetric soil moisture for the location x construction type interaction at the 0-10 cm depth on Septmeber 3, 2000.

	Construction Type	
TDR Location	Modified USGA	Standard USGA
1	14.1 B†a‡	21.2 Aa
2	14.5 Aa	11.3 Ab
3	14.8 Ba	20.8 Aa
4	13.6 Ba	19.1 Aa

† Means in a row followed by the same capital letter are not significantly different according to Fischer's protected LSD (p=0.05)

‡ Means in a column followed by the same small case letter are not significantly different according to Fischer's protected LSD (p=0.05)

Analysis of the location x construction type interaction at the 0-10 cm depth indicated that the modified USGA construction type had lower volumetric soil moisture content than the standard USGA construction type at TDR locations 1, 3, and 4. Although the differences were not statistically significant at this time, volumetric soil moisture content was greater at the peak of the slope, TDR location 2, for the modified USGA construction type. The results confirm our initial hypothesis that altering the rootzone depth will decrease moisture content in lower regions and increase moisture content on elevated areas of greens.

Location x Construction Type Interaction 10-20 cm depth

Statistical analysis of volumetric soil moisture content for the 10-20 cm depth revealed a significant location x construction type interaction. The location x construction type interaction results were similar to those observed for the 0-10 cm depth. On August 31, day 1 of the dry down, the modified USGA construction type had lower volumetric soil moisture content values than the standard USGA construction type at TDR locations 1, 3, and 4 and higher volumetric soil moisture content values at TDR location 2 (Table 3). In contrast to the moisture contents at the 0-10 cm depth, for the 10-20 cm depth there were no differences in moisture content among locations for the standard USGA construction type. Among locations for the modified USGA construction type, soil moisture content was higher at TDR location 2 than at the other locations. On September 2, three days after an irrigation event, the modified USGA construction type had lower soil moisture content at TDR locations 1 and 4 and was not different from the standard USGA construction type at TDR locations 2 and 3 (Table 4).

Table 3. Volumetric soil moisture for the location x construction type interaction at the 10-20 cm depth on August 31, 2000.

	Construction Type	
TDR Location	Modified USGA	Standard USGA
1	17.0 B†b‡	22.7 Aa
2	23.2 Aa	17.8 Ba
3	17.3 Bb	21.7 Aa
4	16.4 Bb	22.3 Aa

† Means in a row followed by the same capital letter are not significantly different according to Fischer's protected LSD (p=0.05)

‡ Means in a column followed by the same small case letter are not significantly different according to Fischer's protected LSD (p=0.05)

Table 4. Volumetric soil moisture for the location x construction type interaction at the 10-20 cm depth on September 2, 2000.

	Construction Type	
TDR Location	Modified USGA	Standard USGA
1	15.9 B[†]a[‡]	21.1 Aa
2	20.3 Aa	16.5 Aa
3	16.6 Aa	20.4 Aa
4	15.7 Ba	21.0 Aa

† Means in a row followed by the same capital letter are not significantly different according to Fischer's protected LSD (p=0.05)

‡ Means in a column followed by the same small case letter are not significantly different according to Fischer's protected LSD (p=0.05)

Location x Rootzone Mix Interaction

The location x rootzone mix interaction was also significant throughout most of the dry down cycles. Volumetric soil moisture content values are reported for the location x rootzone mix interaction observed on August 14 and 16, day 2 and 4 of a dry down cycle, respectively (Tables 5 and 6). The results indicate that the sand rootzone mix was drier than the sand/peat and sand/soil rootzone mixes at TDR locations 1, 2, and 3 on August 14 and at TDR locations 1 and 2 on August 16. There were no differences in volumetric soil moisture content among locations for the sand/peat and sand/soil rootzone mixes on both dates. On both August 14 and 16 within the sand rootzone mix plots, the lowest volumetric soil moisture content was at TDR location 2. The results indicate that when volumetric soil moisture content is averaged across the construction types, the sand/peat and sand/soil rootzone mixes do not have differences in soil moisture content across the slope of the green while the sand rootzone mix is consistently drier at the peak of the slope.

Table 5. Volumetric soil moisture for the location x rootzone mix interaction at the 0-10 cm depth on August 14, 2000.

	TDR Location			
Rootzone Mix	1	2	3	4
Sand	11.1 BC†b‡	7.05 Cc	16.6 Ab	15.2 Ab
Sand/Peat	23.2 Aa	23.8 Aa	23.9 Aa	19.9 Aa
Sand/Soil	21.4 Aa	17.8 Ab	20.2 Aa	18.4 Aab

† Means in a row followed by the same capital letter are not significantly different according to Fischer's protected LSD (p=0.05)

‡ Means in a column followed by the same small case letter are not significantly different according to Fischer's protected LSD (p=0.05)

Table 6. Volumetric soil moisture for the location x rootzone mix interaction at the 0-10 cm depth on August 16, 2000.

	TDR Location			
Rootzone Mix	1	2	3	4
Sand	11.0 A†c‡	6.0 Bc	14.5 Ab	13.6 Ab
Sand/Peat	23.4 Aa	20.4 Aa	21.9 Aa	21.0 Aa
Sand/Soil	19.2 Ab	16.4 Ab	17.1 Ab	16.0 Ab

† Means in a row followed by the same capital letter are not significantly different according to Fischer's protected LSD (p=0.05)

‡ Means in a column followed by the same small case letter are not significantly different according to Fischer's protected LSD (p=0.05)

Drainage Water

The quantity of drainage water from three different locations on the south slope of the green was collected continuously throughout 2000. Water was collected from drain tiles located approximately 2.3 m (8') south of the peak of the slope (drain tile #3), at the base of the south backslope (drain tile #4), and at the south end of the south toeslope (drain tile #5) (Figure 1). A total of 1.25 cm (0.5") of water was applied at 10:00 a.m. uniformly across the entire green on September 3. No irrigation had been applied for the previous 4 days. The amount of water collected from the three drain tiles and the time over which it was collected are presented in Figures 2-4. Drain tile number three collected the smallest amount of water and only four of the rootzone mix/construction type greens had any water collected at this drain tile (Figure 2). All three of the modified USGA construction type greens had water draining from drain tile number 3 and only one of the standard USGA construction type greens, the USGA sand/peat rootzone mix, had water draining from drain tile number 3. Drain tiles number 4 and 5 had larger amounts of water draining from them and all greens had water draining from these tiles (Figures 3 and 4). For drain tile number 4, all of the standard USGA construction type greens had water draining from the tile before the modified USGA construction type greens (Figure 3). For drain tile number 5 the results are not as clear (Figure 4). The time order of water draining from drain tile #5 is as follows: standard USGA sand rootzone mix, modified USGA sand rootzone mix, standard USGA sand/soil rootzone mix, standard USGA sand/peat rootzone mix, modified USGA sand/soil rootzone mix, and finally the modified USGA sand/peat rootzone mix.

The percent of the total water collected from the south slope of the green that drained from each individual drain tile is presented in Table 7. Drain tile number 3 had a maximum value of 8.5% of the total water collected from tiles 3, 4, and 5. For the standard USGA construction type, the highest percentage of water drained from tile number 4. For the modified USGA construction type, the highest percentage of water drained from tile number 5.

Although preliminary in nature, these results seem to indicate that by altering the rootzone depth more water is collected off the peak of the slope and less drains to the lower regions of the green. Further replication of irrigation events in 2001 and complete installation of tipping buckets on the north side of the green will enable more definitive conclusions with respect to the amounts of water draining from various regions of a sloped putting green.

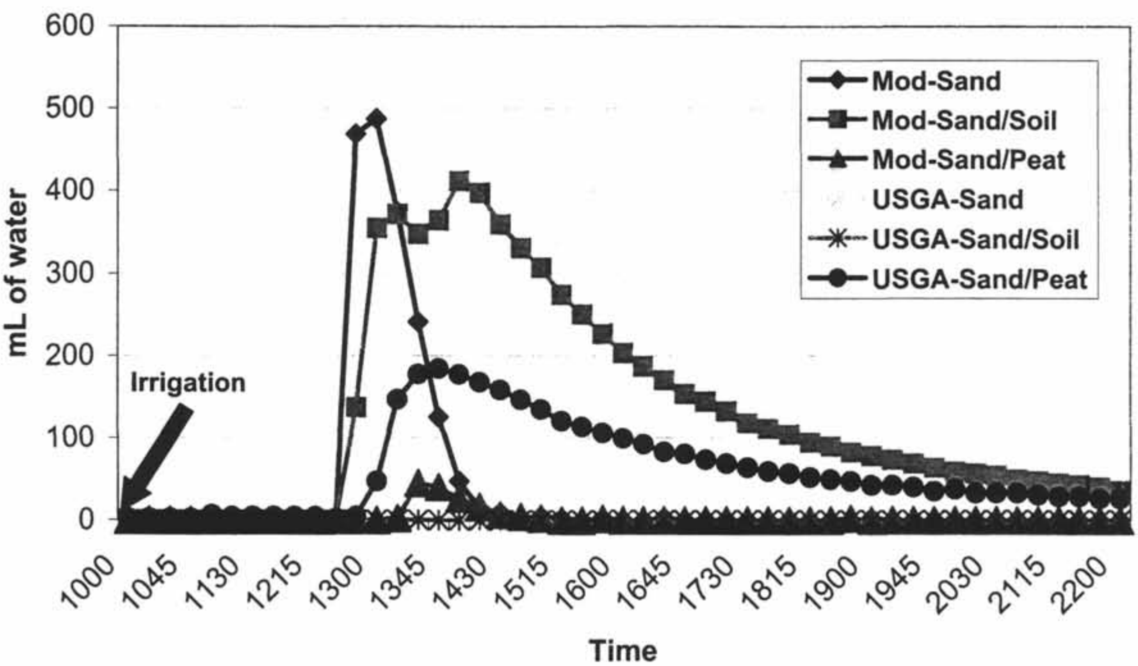

Figure 2. Amount of water collected from drain tile number three after an irrigation event on September 3.

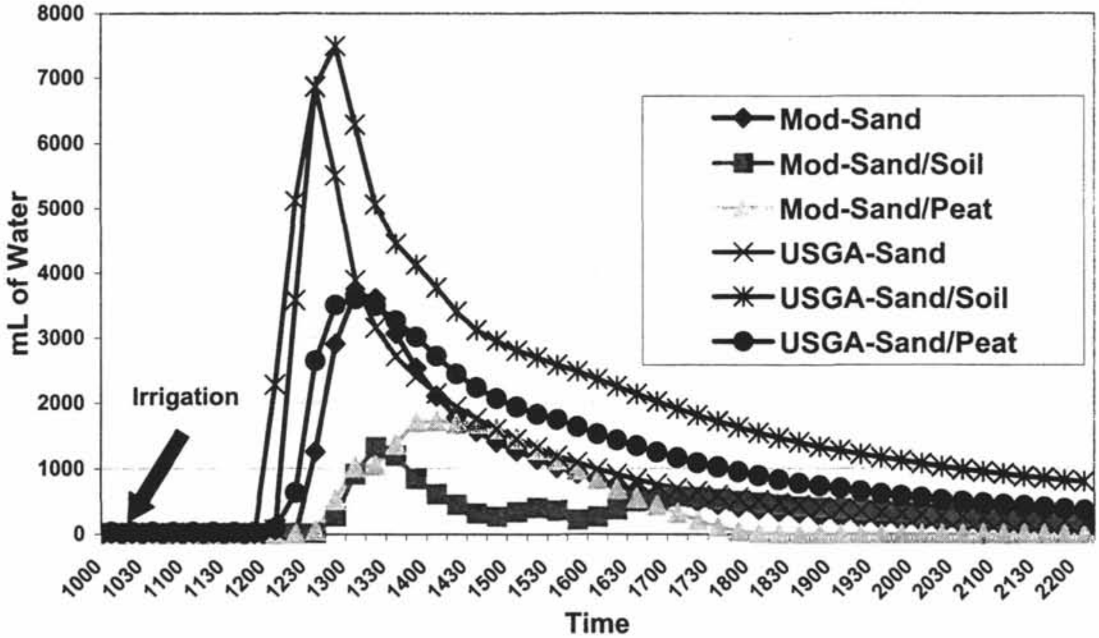

Figure 3. Amount of water collected from drain tile number four after an irrigation event on September 3.

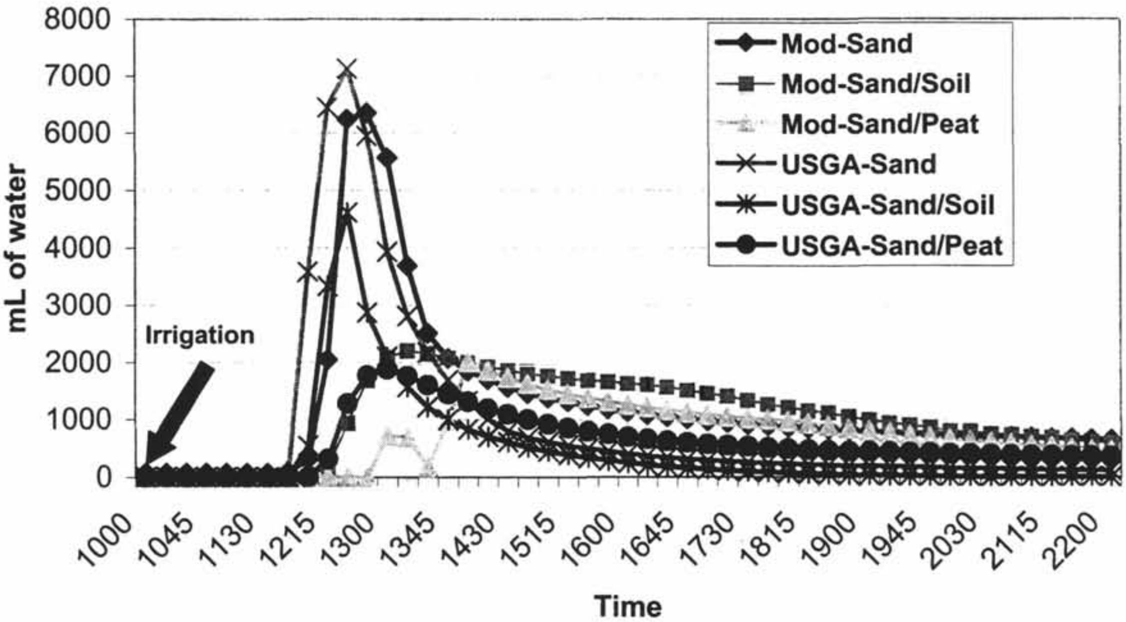

Figure 4. Amount of water collected from drain tile number five after an irrigation event on September 3.

Table 7. The percent of the total drainage water collected from the south slope of the green that drained from each drain tile.

	Drain Tile		
Construction Method/Mix	3	4	5
Modified Sand	1.79†	36.3	61.9
Modified Sand/Peat	8.53	22.6	68.9
Modified Sand/Soil	0.26	36.3	63.4
USGA Sand	0.00	55.4	44.6
USGA Sand/Peat	0.00	80.9	19.2
USGA Sand/Soil	3.34	63.5	33.2

† Percent of water collected

Conclusions

The results from 2000 confirm our initial hypothesis that altering the rootzone depth decreases soil moisture content near the putting green surface in lower regions of the green and increases soil moisture content near the putting green surface in higher areas of greens. The concern that was raised in the 1999 report that lower moisture content in the lower regions of the green could lead to greater susceptibility to drought stress still needs to be considered. Analysis of rooting depth in these areas should provide valuable information to help determine the relevancy of this concern.

Future Directions for 2001

Research will continue to investigate soil moisture content using TDR probes throughout the entire season of 2001. Rain tipping buckets will be installed on the north side of the green so an entire balance of water applied to the green will be able to be accounted for through the drainage water. A soil gas analyzer has been acquired this fall and will be used in 2001 to measure gas concentration at different locations and depths in the green.

Acknowledgements

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