SECOND YEAR PROGRESS REPORT

for

I. Influence of Soil Moisture Level on Turfgrass Water Use and Growth

II. Cultivation Methods on Turfgrass Water Relationships and Growth Under Soil Compaction

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I. INTRODUCTION

The projects reported on were initiated on February 1, 1986 and this report covers the period from November 1, 1986 to November 1, 1987. The first year was for implementation and included site preparation, establishment, equipment acquisition, and hiring of personnel. In the current year (second), we concentrated on acclimating the grasses to irrigation or cultivation treatments and intensive measurement periods. Included in this report is information on status, budget summary, and publicity concerning this research.

II. STATUS OF SECOND YEAR ANNUAL PLAN OF WORK

A. OBJECTIVES FOR INFLUENCE OF SOIL MOISTURE LEVEL ON TURFGRASS WATER USE AND GROWTH

1. To determine the annual and seasonal water requirements of major turfgrass species in the Southeast under non-limiting to moderate moisture stress conditions.

2. To evaluate turfgrass performance -- quality, shoot responses, root alterations -- under non-limiting to moderate moisture stress conditions.

Three warm-season grasses (Tifway bermudagrass, Meyer zoysiagrass, common centipedegrass) were each irrigated at three irrigation regimes based on soil water content readings at 15 cm depth. Irrigation regimes were (a) 18.7% H_2O_{vol} = -0.1 MPa = 25% soil water depletion (SWD), (b) 14.3% H_2O_{vol} = -0.4 MPa = 50% SWD, and (c) 10.0% H_2O_{vol} = -0.7 MPa = 75% SWD. These will be referred to as well watered, moderate stress, and severe stress, respectively.

Well-watered turf would be typical for tees and well maintained fairways. Under well watered conditions, bermudagrass used the least water (Table 1). Meyer zoysia used 10, 30, and 5% more water for July, August, and October, while centipedegrass used 4, 23, and 13% more, respectively, than bermudagrass.

The moderate stress treatment would be representative of many fairways. During a prolonged dry period in August, comparative water use rates revealed that zoysiagrass and centipedegrass used 39 and 11% more water than bermudagrass.

Except for golf course rough situations, most turfgrasses would not be under the severe stress irrigation regime. However, this regime provides insight into how these grasses may respond to prolonged drought. Zoysiagrass exhibited the lowest water use, 4% lower than bermudagrass. However, zoysiagrass quality markedly declined under this irrigation program with severe wilting and leaf firing (Table 2). Bermudagrass exhibited very little decline in quality. Centipedegrass was intermediate and the reduced quality was due to moderate wilting but no leaf firing occurred.

Greater water use by centipedegrass at the -0.7 MPa versus -0.4 MPa irrigation appeared to be due to a proliferation of root growth into the subsoil at the -0.7 MPa treatment. Rooting data are currently being determined but the increase in percent of water extracted data (Table 2) illustrates that at the -0.7 MPa irrigation treatment, centipedegrass did obtain a higher percentage of water from the 8 to 24-inch depth.

Another measure of turfgrass water needs is to compare irrigation events based on TDR soil water content measurements over a dry period. Such a comparison is presented in Table 3 for a 23-day period in August 1987.

Other data were obtained in the August period, such as verdure, leaf angles, wilting, leaf firing, root length and weight by depth, canopy temperatures, and environmental data. These will be used to relate different plant morphological or physiological responses to water use at different irrigation regimes.

The above reported information relates to the specific objectives of this project. However, due to the nature of the data collected to achieve these objectives, important additional information can be obtained from this project that may help reduce turfgrass water use (this was pointed out in the original project). The additional information concerns comparing different irrigation scheduling methods - i.e. procedures that aid a grower in when to irrigate.

Water use data in this project has been measured by daily monitoring of soil water content at three depths during periods when no leaching or runoff occurs. Time-domain reflectrometry (TDR) has been used to measure soil water content. We can then compare other methods to the TDR procedure. Currenty we are comparing:

Method	Basis for Scheduling Irrigation
TDR	Soil based to estimate ET
CWSI[1]	Plant based to estimate degree of drought stress
ΣSDD[2]	Plant based to estimate degree of drought stress
Weather pan	Climate based to estimate ET
Penman equation	Climate based to estimate ET

[1]Crop water stress index

[2]Summation of stress degree days between irrigations

Results to data include these observations;

(a) The TDR procedure is very accurate but requires daily measurement and it cannot be automated at this time.

(b) CWSI is based on determining canopy temperatures (T_c) minus air temperatures (T_a) on days when water is not limiting. This provides a lower baseline that is also influenced by humidity. From this, an upper baseline (T_c - T_a for non-transpiring conditions), can be calculated. For any particular day that we know the humidity at the time T_c and T_a are measured, the theoretical CWSI can range from 0 (on the lower baseline) to 1 (on the upper baseline). If a particular CWSI value could be consistently correlated to a known soil water content, then the CWSI would be useful for indicating to a grower when to irrigate. We determined baselines for each species and calculated CWSI values just prior to irrigation (Table 4). These were very inconsistent for all three species in contrast to more consistent CWSI indices reported by Throssell and Carrow (1987, Agron. J. 27:126-131) for Kentucky bluegrass. One contributing factor was the scattering of data for the lower baseline which may be due to a humid climate versus semi-arid or arid conditions for most CWSI literature.

(c) The ΣSDD is based on summing T_c - T_a values for each day after an irrigation until a critical value is reached that would suggest the need for irrigation. ΣSDD values were much more consistent than CWSI indices (Table 4), except for zoysiagrass at -0.4 MPa irrigation regime. This may be due to the tendency of zoysiagrass to lose considerable water on the first day after irrigation, especially on days with low humidity. An upright leaf structure may contribute to this water loss.

(d) Crop coefficients were calculated for a U.S. Weather Bureau pan (Table 5). With additional data from 1988, these should be useful guidelines for any growers using weather pan evaporation to guide irrigation.

(e) Penman values have not been calculated as of this date. They will be compared to daily ET estimates by the weather pan and TDR procedures.

Table 1. Drought Tolerance Study 1987[1]

Treatment	Water Use (ET)[2] July 9-14	Aug. 10-27	Oct. 5-7
	----------------inches/day----------------		
Tifway bermuda			
-0.1 MPa (25% dep.)	0.166 (100%)	0.145 (100%)	0.099 (100%)
-0.4 MPa (50% dep.)	-	0.116	-
-0.7 MPa (75% dep.)	-	0.115	-
Meyer zoysia			
-0.1 MPa	0.183 (110)	0.189 (130)	0.104 (105)
-0.4 MPa	-	0.161	-
-0.7 MPa	-	0.110	-
Common centipede			
-0.1 MPa	0.172 (104)	0.179 (123)	0.112 (113)
-0.4 MPa	-	0.129	-
-0.7 MPa	-	0.165	-

[1]Funded by USGA Green Section

[2]Measured by soil water depletion

Table 2. Drought Tolerance Study - 1987[1]

Treatment	% Water Extracted by Soil Depth		Visual Quality			
	0-8"	8-24"	D-11 Aug 18	D-15 Aug 22	D-18 Aug 25	D-22 Aug 29
	------%-------		---9 = ideal, 1 = no live turf--			
Tifway bermuda						
-0.1 MPa	61	40	7.9	7.9	7.9	7.9
-0.4 MPa	46	54	8.0	8.1	7.8	8.0
-0.7 MPa	51	49	7.8	7.6	7.3	7.4
Meyer zoysia						
-0.1 MPa	69	31	7.6	7.2	8.0	8.2
-0.4 MPa	55	45	7.6	8.1	8.2	8.4
-0.7 MPa	64	36	7.3	4.7	3.7	6.6
Common centipede						
-0.1 MPa	61	39	7.9	8.5	8.6	8.5
-0.4 MPa	59	40	7.9	8.2	8.2	8.2
-0.7 MPa	41	59	8.0	7.8	6.1	8.1

[1]Funded by USGA Green Section.

Table 3. Drought Tolerance Study 1987[1]

Treatment	D-0 Aug. 7	D-9 16	D-12 19	D-15 22	D-16 23	D-18 25	D-19 26	D-23 30	Irr. Total
	Irrigation Events								
	inches water applied								
Tifway bermuda									
-0.1 MPa	2.58[2]	1.10				1.10		1.10	3.30
-0.4 MPa	2.58							1.40	1.40
-0.7 MPa	2.58								0
Meyer zoysia									
-0.1 MPa	2.58	1.10			1.10		1.10		3.30
-0.4 MPa	2.58		1.40		1.40				2.80
-0.7 MPa	2.58						1.87		1.87
Common centipede									
-0.1 MPa	2.58	1.10		1.10			1.10		3.30
-0.4 MPa	2.58			1.40				1.40	2.80
-0.7 MPa	2.58						1.87		1.87

[1]Funded by USGA Green Section

[2]Rain - all others are irrigation events

Table 4. CWSI and ΣSDD Irrigation Scheduling Indices on Three Warm-Season Turfgrasses

Turfgrass and Soil Water Status for Irrigation	CWSI Just Prior To A Scheduled Irrigation Event					ΣSDD Between Irrigation Events				
Tifway bermuda										
-0.1 MPa (18.7% H_2O_v)	0.58	0.16	0.62	0.25	-	29	15	14	26	-
-0.4 MPa (14.3% H_2O_v)	0.80	-	-	-	-	54	-	-	-	
-0.7 MPa (10.0% H_2O_v)	did not reach - 0.7 MPa					>63	-	-	-	
Meyer zoysiagrass										
-0.1 MPa	0.26	0.15	0.70	0.41	0.29	21	19	14	17[+]	14
-0.4 MPa	0.28	0.10	0.15	0.05	0.90	28	6	22	7	28
-0.7 MPa	1.34	-	-	-	-	87	-	-	-	-
Common centipede										
-0.1 MPa	0.78	1.41	0.12	0.48	-	24	9	13	9	-
-0.4 MPa	0.30	0.06	0.88	-	-	33	24	22	-	-
-0.7 MPa	0.88	-	-	-	-	46	-	-	-	-

[+]Zoysiagrass tended to evaporate/transpire substantially more water on the first day or two after irrigation than bermudagrass or centipedegrass.

Table 5. Drought Tolerance Study 1987

Treatment	Crop Coefficients[1] July 9-14	Aug 10-27
Tifway bermuda		
-0.1 MPa	0.50	0.54
-0.4 MPa	-	0.44
Meyer zoysia		
-0.1 MPa	0.55	0.58
-0.4 MPa	-	0.52
Common centipede		
-0.1 MPa	0.47	0.50
-0.4 MPa	-	0.50

[1]Crop Coefficient = ET/weather pan evaporation

B. OBJECTIVES FOR CULTIVATION METHODS ON TURFGRASS WATER RELATIONSHIPS AND GROWTH UNDER SOIL COMPACTION

1. To determine on a compacted soil the effects of different cultivation methods on turfgrass - soil - water relationships, particularly water use.

2. To identify any important acclimation responses of the turf to compaction and how cultivation may alter such responses.

Tifway bermudagrass was used in this study to investigate the influence of different cultivation procedures to alleviate soil compaction. Treatments are listed in Table 6.

Rooting lengths were determined in three soil zones in August. All compacted treatments reduced rooting compared to the uncompacted - noncultivated check (Table 7). In the surface 0 to 4 inches root lengths were enhanced by 53, 12, and 12% for the Ryan slicer, deep drill, and Aerway slicer, respectively, compared to the compacted control (with no cultivation). More important would be increased deep rooting. At the 8 to 16-inch depth, rooting was increased by 120 and 55% by the Aerway slicer and deep drill, respectively, relative to the compacted control.

Water use was also improved by all cultivation procedures (Table 8) compared to the uncompacted check. In this case, higher water use would be beneficial because it indicates that the plant is able to better extract moisture in the soil. Turfgrasses on compacted soils often require light, frequent irrigation because of low infiltration rates and poor root growth/viability. If cultivation improves the ability of a plant to use existing soil moisture, then less frequent, deeper irrigation could be used - the net effect being conservation of water.

While all cultivation techniques improved water use (Table 8), the ones most effective in extracting water in the 8 to 24-inch zone were the Aerway slicer, hollow tine, and deep drill with 9, 8, and 4% greater water extraction than the uncompacted chedk (data not presented). Least effective was the Ryan slicer with 6% less water from this zone than the check.

An indication of the improvement in shoot growth can be illustrated by the clipping yield data (Table 9). All compacted treatments exhibited lower clipping yields than the uncompacted control, but several cultivation methods did improve growth when compared to the compacted check. The deep drill aerifier and Aerway slicer were particularly effective, especially in day 14-17 of the dry-down period (all plots were saturated on day 1). Why the Ryan slicer treatment caused low clipping yields is not readily apparent from current data.

Additional data were obtained such as verdure, canopy temperature, leaf water potential status, and soil physical properties. These plots will be severely compacted in fall, 1987, cultivation treatments applied in early May 1988, and data obtained after the grasses have time to acclimate to the treatments.

From this study, we will be able to (a) determine specifically how effective each cultivation method is in improving water use, root growth, and shoot growth when applied to a compacted turfgrass, (b) quantify the effects of soil compaction on Tifway bermudagrass - the most common golf course grass in the South. This has not been done before, and (c) determine whether soil compaction influences CWSI baselines, CWSI indices, ΣSDD, and crop coefficients for weather pan evaporation. Items (b) and (c) are not specific objectives of this study but additional information that relates to water relations of bermudagrass. The information listed in items (b) and (c) will be obtained by comparison of the two controls - one compacted and one not compacted.

Table 6. Cultivation Study

Cultivation Method[a]	Depth	Spacing	Size
	---------inches-------		
1. None, not compacted	-	-	-
2. None, compacted	-	-	-
3. Deep drill aerofier Floyd McKay	10	5	5/8
4. Aerway slicer	6	7	1/3x4
5. Hollow tine core, Ryan	3	2	5/8
6. Shattercoring, Ryan	3	2	5/8
7. Ryan slicer	6	6	1/4x4

[a]1. Not compacted
2-7. Compacted

Table 7. Cultivation Study: August 13-25, 1987 (Wiecko, Carrow)

Treatment		Root Length			
Cultivation	Compaction	0-4"	4-8"	8-16"	Total
		---------cm cm^{-3} of soil-----------			
None	No	44.0	16.6	5.5	70.5
None	Yes	34.5	3.8	2.0	40.3
Deep Drill	Yes	42.6	3.7	3.1	49.4
Hollow tine	Yes	33.8	3.4	2.4	39.6
Shattercore	Yes	38.1	8.3	1.7	48.1
Aerway slicer	Yes	42.4	2.8	4.4	49.6
Ryan slicer	Yes	52.8	3.1	2.6	58.5

Table 8. Cultivation Study: August 13-25, 1987 (Wiecko, Carrow)

Treatment		Water Use (ET)[a]					
Cultivation	Compaction	Day 1-3	Day 4-6	Day 7-9	Day 10-13	Total	
		cm					
None	No	0.89	0.90	1.35	4.54	7.68	(98)
None	Yes	1.07	0.72	1.30	4.72	7.81	(100%)
Deep drill	Yes	1.48	0.92	1.51	4.82	8.73	(112)
Hollow tine	Yes	1.43	0.80	1.21	5.06	8.49	(109)
Shattercore	Yes	1.96	0.85	1.30	4.78	8.89	(114)
Aerway slicer	Yes	1.23	1.12	1.18	5.02	8.55	(109)
Ryan slicer	Yes	1.17	0.81	1.44	4.53	7.95	(102)

[a]Based on soil water depletion to 60 cm depth.

Table 9. Cultivation Study: August 11-28, 1987 (Wiecko, Carrow)

Treatment		Clipping Yield				
Cultivation	Compaction	Day 1-5	Day 6-13	Day 14-17	Total	
		---------g/15 ft^2-------------				
None	No	33.5	36.3	19.7	89.5	(169%)
None	Yes	9.7	31.2	12.2	53.1	(100)
Deep drill	Yes	16.2	35.7	24.3	76.2	(144)
Hollowtine	Yes	16.9	29.7	19.5	66.1	(124)
Shattercore	Yes	20.2	26.2	14.1	60.5	(114)
Aerway slicer	Yes	23.3	27.1	22.1	72.5	(137)
Ryan slicer	Yes	7.9	14.9	6.6	29.4	(55)

III BUDGET

Expenditures to date have been very close to budget estimates with salaries of an Agricultural Technician III and temporary position accounting for 95% of the funding.

IV PUBLICITY

Several opportunities have occurred during the period of this report to discuss these two research projects to audiences concerned with water conservation in the turfgrass industry. In each instance, we have credited the USGA for their support and noted their overall goal of water conservation on turfgrasses. Talks and papers presented were:

National Conferences:

Carrow, R. N. 1986. Turfgrass root growth: an overview. Root Growth Symposia. ASA meetings, New Orleans. Dec. 3.

Regional or State Conferences:

Carrow, R. N. 1986. Irrigation scheduling for efficient water use. Clemson Turf Conf., Clemson, SC. Nov. 10-12.

Carrow, R. N. 1986. Soil compaction and water use. Clemson Turf Conference, Clemson, SC. Nov. 10-12.

Carrow, R. N. 1987. Irrigation scheduling - the old and new. Mich. State Turfgrass Conf. and Show. E. Lansing, MI. Jan. 12-14. (talk and paper).

Carrow, R. N. 1987. How compaction effects your management of turf. Mich. State Turfgrass Conf. and Show. E. Lansing, MI. Jan. 12-14. (talk and paper).

Carrow, R. N. 1987. Water research. Southern Turf Research Inform. Exchange Group-16. Blacksburg, VI. June 24.

Carrow, R. N. 1987. Overview of turfgrass research. Georgia Agric. Leg. Comm. Griffin, GA. Sept. 2.