TURFGRASS IRRIGATION SCHEDULING BY INFRARED THERMOMETRY

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INTRODUCTION

Careful irrigation scheduling is one means of conserving water for turfgrass situations. When to irrigate a turfgrass site can be determined in three ways (Carrow, 1985): (a) by monitoring soil moisture status with soil moisture sensors, (b) by using atmospheric-based indices such as weather pan evaporation or formula to calculate turfgrass evapotranspiration (ET) from climatic data, and (c) from plant-based indices such as visual symptoms of wilt or canopy temperatures. Infrared thermometry uses canopy temperature data to schedule irrigation events. This is theoretically attractive since canopy temperatures should integrate all factors that cause drought stress on the plant, thereby causing canopy temperatures to increase. Examples of such factors are dry soils, limited root system, closed stomata, and hot, dry weather.

Canopy temperatures for estimating when to irrigate can be used in three major ways (Jackson, 1982): (a) summation of stress degree days (ΣSDD), where the SDD for a particular day is the degrees (°C) that canopy temperatures (Tc) are warmer than ambient air temperature (Ta). If canopy temperatures are cooler, then the SDD is considered zero. After a rainfall or irrigation event, the SDD values are added each day from a reading made between 11:30 a.m. to 2:00 p.m. When the ΣSDD total a particular value, irrigation is applied. This value must be determined experimentally and adjusted by the grower for his site. The ΣSDD approach requires daily monitoring but the only data needed are canopy temperature and air temperature, and calculations are minimal; (b) the second method is a crop water stress index (CWSI) that should theoretically range from 0 (no stress) to 1 (no transpiration). This approach requires well-watered (full transpiration) and dry (no transpiration) baselines to be determined for each species by researchers. Once these baselines are known, a grower collects daily canopy temperature, air (dry and wet bulb) temperature, relative humidity, and solar radiation measurements. From these, he can calculate the CWSI using the graph of the baselines or a computer program. This CWSI method only requires the grower to take measurements when he anticipates stress, but errors are more likely to occur than by the ΣSDD procedure. This is true because the baselines are estimates and baselines for semi-arid or arid regions may prove more accurate than for more humid climates. Also, errors in any of the measurements will give an erroneous CWSI value. The particular CWSI value to irrigate depends on what degree of turfgrass stress the grower wishes to allow; (c) a third approach is for canopy temperature data to be used to estimate plant evapotranspiration (ET) either directly or by factoring canopy temperatures into climatic based equations used to estimate ET. While the procedures for using ΣSDD and CWSI data for turfgrass irrigation have received research attention (Throssell et al., 1987), the use of canopy temperatures for estimating ET on turfgrasses is less developed.

The objective was to determine the potential of using CWSI and ΣSDD canopy temperature indices to schedule irrigation of three warm-season turfgrasses.

MATERIALS AND METHODS

Infrared thermometry was used to measure canopy temperatures of 'Tifway' bermudagrass (Cynodon dactylon L. Pers.), 'Meyer' zoysiagrass (Zoysia japonica), and common centipedegrass (Eremochloa ophiuroides) under three irrigation regimes. Irrigation was based on soil water potential (Ψs) at the 15 cm depth with irrigation occurring whenever Ψs reached (a) -0.10 MPa (well irrigated), (b) -0.40 MPa (moderate stress), or (c) -0.70 MPa (severe stress). The study was carried out at Griffin, GA on a Cecil sandy loam soil during 1986 and 1987. Soil water content was determined by time domain reflectrometry (Topp and Davis 1985) and Ψs estimated from soil moisture retention curves. Data from the well irrigated (-0.10 MPa) treatment were used to develop the CWSI baselines (Idso et al., 1981). Soil moisture dry-down periods allowed comparison of ΣSDD and CWSI data to actual soil water content.

RESULTS AND DISCUSSION

CWSI baselines. Figure 1 contains the CWSI upper and lower baselines for Tifway bermudagrass. Linear regression for ΔT, where $\Delta T = Tc - Ta$, and correlation coefficients for the three grasses were:

Bermudagrass $\Delta T = 5.74-1.25$ VPD
$r = -0.50^{**}$, $n = 37$
Zoysiagrass $\Delta T = 6.26-1.41$ VPD
$r = -0.55^{**}$, $n = 39$
Centipedegrass $\Delta T = 4.69-0.86$ VPD
$r = -0.40^{**}$, $n = 38$

where, VPD = vapor pressure deficit (KPa)
n = number of observations
** = significant at 0.001%

Thus, each species exhibited unique baselines, which would suggest that computer software packages for irrigation scheduling by CWSI should account for unique baselines for each turfgrass species. Also, the linear regression lines were significant at $P < 0.001$ but the r was not high. This is in contrast to a $r = 0.82^{**}$ observed by Throssell et al. (1987) on Kentucky bluegrass (Poa pratensis L.) under semi-arid conditions. Data scatter on the well water baselines would contribute to significant error in use of the CWSI index for irrigation scheduling since a specific CWSI (between 0 and 1) must be calculated using the baselines.

ΣSDD and CWSI indices. Table 1 contains CWSI and ΣSDD indices observed for each grass for each irrigation regime. These data were obtained during August 1987 dry-down periods.

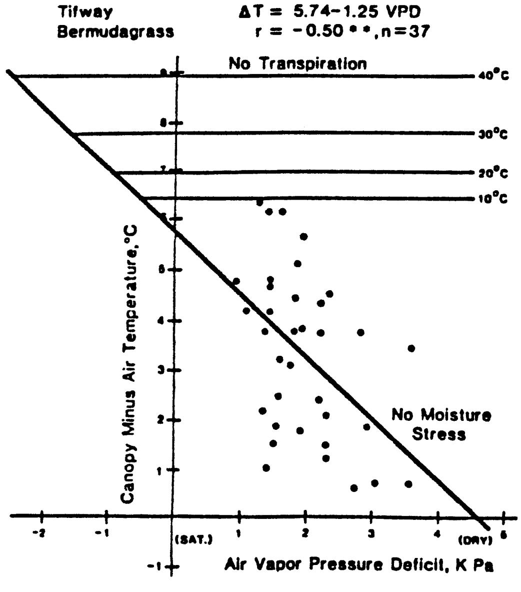

Figure 1. CWSI upper and lower baselines.

CWSI indices varied considerably for each grass under well irrigated and moderate stress conditions. When canopy temperature responses were presented in ΣSDD form, there were more consistent values for SDD than observed for CWSI. However, ΣSDD for moderate stress (-0.40 MPa) on zoysiagrass still exhibited an unacceptable range. These results reveal that CWSI or ΣSDD indices were not well correlated to actual soil moisture conditions. This would introduce considerable error in use of either of these indices for irrigation scheduling.

Table 1. CWSI and SDD 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	15	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.

With Kentucky bluegrass, a cool-season species, Throssell et al. (1987) reported much more consistent CWSI and ΣSDD indices, which correlated to soil moisture conditions. Further research data will be necessary to determine whether differences observed by Throssell et al. (1987) versus the present study are due to: a) grass, cool-season versus warm-season species; b) climate, semiarid versus arid conditions; or c) some other factor. Until these differences are resolved and well defined indices can be determined on warm-season turfgrasses in the Southeast, the CWSI and ΣSDD approaches to scheduling turfgrass irrigation are not recommended. Since infrared thermometers, however, can accurately measure canopy temperatures, they will be useful in identifying "hot" spots on golf greens and other sites before actual turf injury is observed. Identifying and correcting the cause of such "hot" spots will aid in more efficient water use.

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