Correlations of Leaf Relative Water Content, Canopy Temperature, and Spectral Reflectance in Perennial Ryegrass Under Water Deficit Conditions

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Objectives:

Identify changes and correlations among the canopy reflectance, canopy temperature, and leaf relative water content (RWC) of perennial ryegrass (*Lolium perenne* L.) under water deficit conditions.

Rationale: The decreasing availability of water has become more of a problem for turf management as a result of regional and localized drought, population growth, and a growing demand for water from competing uses. Improved irrigation management is important for enhancing turf performance during periods of drought stress and for conserving water. Determining plant and soil water content in response to water deficit conditions is beneficial for turfgrass site-specific irrigation management, particularly for locations that show large spatial and temporal variability in drought symptoms. Therefore, rapid and accurate assessment of turfgrass water status along with visual observation is essential for timely and proper irrigation as well as for drought stress management in turfgrass.

Laboratory assessment of leaf relative water content is a time consuming process, especially when a large number of samples are needed. Due to the potential variations in drought response of turfgrass in the field, the use of multiple remote sensors to detect changes in canopy temperature and reflectance patterns may allow turfgrass performance under water deficit conditions to be more precisely assessed and spatially characterized. But to date, the potential use of canopy temperature to predict leaf water content and its correlation with reflectance indices under water deficit conditions are not well understood in turfgrass species or cultivars.

Materials and methods:

The experiment was conducted at the Turfgrass Research and Diagnostic Center at Purdue University, West Lafayette, IN from 10 May to 11 Aug. 2007 and from 1 June to 29 Aug. 2008. Six cultivars (BrightStar SLT, Catalina II, Divine, Inspire, Manhattan 4, Silver Dollar) of perennial ryegrass were established from seed in Sep. 2005 on silt loam soil with a pH of 6.8. Each cultivar was seeded into four plots (four replications) of 9.3 m^2 (3.05 m by 3.05 m) each. All the grasses were mowed three times a week at 2.54 cm until drought stress occurred. All the plots received nitrogen at a rate of 146 N ha^{-1} each year. Irrigation was applied as necessary to maintain healthy turfgrass before the initiation of drought stress through dry-down.

The dry-down was initiated after bringing all the grasses to well-watered conditions and then withholding water. Data collection began before the initiation of the drought and continued throughout the dry-down period when there was little or no precipitation. After the end of each dry-down (volumetric soil moisture below 20 % and turf quality below 6.0 in the end), grasses were re-watered to a non-stress level before the next dry-down started.

Canopy spectral reflectance was collected with a Crop Circle ACS-210. A reflectance at wavelengths 880 and 650 nm was used to calculate the normalized difference vegetative index (NDVI) (R880-R650)/(R880+R650). The canopy and air temperature

differential (ΔT) was taken using a handheld infrared thermometer in full sun, and at least two readings for each plot were measured and the means were calculated. The reflectance and canopy temperature readings were taken at 1300 h, along with turf quality, leaf relative water content, and soil moisture readings.

The experiment was a completely randomized design with four replications for each cultivar. Correlation coefficients (*r*) were determined using the Statistical Analysis System (SAS Institute, 9.1 edition, N.C.)

Results:

Turf quality (TQ) was positively correlated with soil moisture (SM), leaf relative water content (RWC), and normalized difference vegetation index (NDVI), but negatively correlated with canopy and ambient temperature differentials (ΔT). ΔT was well correlated with RWC (r = -0.77 to -0.78) and SM (r = -0.66 to -0.74), while SM was correlated with RWC (r = 0.64 to 0.74) across seasons in both years. When a wide range of stress symptoms occurred in July and Aug., RWCs became highly correlated with ΔT (r = -0.80 to -0.89) and NDVI (r = 0.77 to 0.81), while ΔT was correlated with NDVI (r = -0.70 to -0.80) in both years. SM was well correlated with RWC (r = 0.71 to 0.80), NDVI (r =0.70 to 0.73), and ΔT (r = -0.76 to -0.78) in July and Aug. in both years. These results suggest that changes in ΔT can be used to predict well the leaf water and soil moisture content of perennial ryegrass under water deficit conditions. Combined with NDVI, the correlations can be used to direct mapping of the variability in grass water status, thus improving irrigation management.

Acknowledgements

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Table 1. Correlations among turf quality (TQ), soil moisture (SM), leaf relative water content (RWC), normalized difference vegetative index (NDVI), and canopy and air temperature differential (ΔT) across all cultivars from July to Aug. trial in both 2007 and 2008

Correlations	2007 (N = 48)			
	SM	RWC	NDVI	ΔT
TQ	0.91***	0.79***	0.72**	-0.90***
SM		0.71***	0.70***	-0.76***
RWC			0.81***	-0.89***
NDVI				-0.80***

Correlations	2008 (N = 48)			
	SM	RWC	NDVI	ΔT
TQ	0.73***	0.76***	0.94***	-0.76***
SM		0.80***	0.73***	-0.78***
RWC			0.77**	-0.80***
NDVI				-0.70***

,* Significant at 0.01 and 0.001 probability level, respectively.