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Estimating Transpiration from Turfgrass Using Stomatal Conductance Values Derived from Infrared Thermometry

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Abstract

Infrared thermometry provides accurate measurements of plant canopy temperature, which, along with basic weather variables, allows estimation of canopy stomatal conductance to water vapor flux (g_c) and transpiration. Using this method we compared modeled estimates of transpiration ($COND_T$) with evapotranspiration (ET) measurements from nearby microlysimeters (LYS_{ET}) in tall fescue (*Schedonorus arundinaceus* Schreb.) turfgrass. Results indicated transpiration may be reliably estimated via calculation of g_c in turfgrass.

Keywords

Evapotranspiration, evapotranspiration models, water

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Estimating Transpiration from Turfgrass Using Stomatal Conductance Values Derived from Infrared Thermometry

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Summary. Infrared thermometry provides accurate measurements of plant canopy temperature, which, along with basic weather variables, allows estimation of canopy stomatal conductance to water vapor flux (g_c) and transpiration. Using this method we compared modeled estimates of transpiration ($COND_T$) with evapotranspiration (ET) measurements from nearby microlysimeters (LYS_{ET}) in tall fescue (*Schedonorus arundinaceus* Schreb.) turfgrass. Results indicated transpiration may be reliably estimated via calculation of g_c in turfgrass.

Rationale. From a landscape and water use perspective, ET is typically of more interest than transpiration alone. However, partitioning between transpiration and soil water evaporation may improve our understanding of the dynamics of water loss from these two components of ET. For example, transpiration and soil water evaporation may respond differently to changing environmental conditions (e.g., soil moisture and weather variables) or canopy characteristics (e.g., density and green leaf area). Additional uses may include evaluation and quantification of turfgrass stress (due to stomatal closure) among treatments, and the study of drought tolerance or water use efficiency of turfgrasses.

Objectives. 1) compare single- versus two-source energy balance approaches for sensible and latent heat flux calculations; 2) use g_c calculated with the method of Blonquist et al. (2009) to estimate transpiration from a dense, well-watered sward of tall fescue (*Schedonorus arundinaceus* Schreb.) turfgrass; and 3) compare calculated canopy transpiration ($COND_T$) with lysimeter evapotranspiration (LYS_{ET}).

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Study Description. The study was conducted from June to October 2012, at the Kansas State University Rocky Ford Turfgrass Research Center near Manhattan, KS. Three microlysimeters containing ambient cores of tall fescue turfgrass were used to measure LYS_{ET}, similar to the method of Bremer (2003). Four infrared radiometers, used to measure canopy temperature, were positioned on a weather station that recorded all data necessary for calculating g_c (Figure 1).

Results. Transpiration calculated from modeled g_c ($COND_T$) averaged 0.07 in./d (29.6 %) less than mean LYS_{ET}, suggesting 29.6% of LYS_{ET} was from soil water evaporation (Table 1). Nighttime LYS_{ET}, which may contribute 5-15% to total daily ET, may have inadvertently contributed to the soil water evaporation component using this method, since our conductance model assumed zero nighttime transpiration. Therefore, assuming 5-15% transpiration during nighttime, mean $COND_T$ would then be 0.17 to 0.19 inches per day, suggesting only 19-26% of LYS_{ET} was from soil water evaporation. Minor errors in both the model estimates and lysimeter measurements also likely affected overall accuracy in the differences between $COND_T$ and LYS_{ET}. Regression analysis of $COND_T$ versus LYS_{ET} resulted in a slope of 0.78 and y-axis intercept of -0.016 (Figure 2). Differences were negligible between the single- and two-source energy balance approaches for sensible and latent heat flux calculations.

References

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Table 1. Comparison of transpiration calculated from canopy stomatal conductance ($COND_T$) and evapotranspiration measured with a lysimeter (LYS_{ET})

Measurement technique	n	Mean daily water loss	RMSE†	MBE‡	%E§
		---------- inches per day ----------			
LYS_{ET}	42	0.230			
$COND_T$	42	0.163	0.074	-0.067	-29.6

†RMSE is the root mean square error calculated as: $RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(ET_{x_i} - LYS_{ET_i}\right)^2}$.

‡MBE is the mean bias error calculated as: $MBE = \frac{1}{n}\sum_{i=1}^{n}\left(ET_{x_i} - LYS_{ET_i}\right)$.

§%E is the mean percent error calculated as: $\%E = \sum\left(\frac{ET_{x_i} - LYS_{ET_i}}{LYS_{ET_i}}\right) \times 100$.

Figure 1. Three infrared radiometers (SI-111, Apogee Instruments, Logan, UT) were installed at 4.92 ft. above the turfgrass and aimed in the compass directions east, west, and south with a view angle of 50° from nadir, yielding a target area of 70 ft². A fourth radiometer, not visible in photo, was pointed straight down (0° from nadir).

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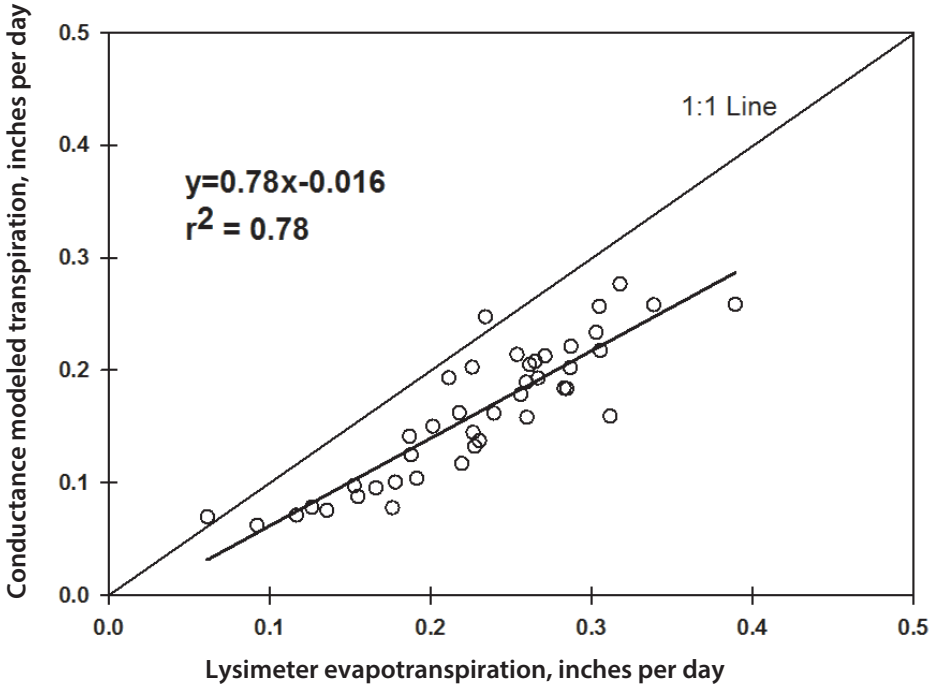

Figure 2. Regression analysis of evapotranspiration measured with a lysimeter (LYSET) and transpiration calculated from canopy stomatal conductance.

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