TITLE: Evaluation of Turfgrass Quality and Green Leaf Area Index and Aboveground Biomass with Multispectral Radiometry

OBJECTIVES: 1. Compare correlations between canopy reflectance and visual ratings in four cool-season grasses; and 2. measure relationships between reflectance data and green leaf area index and biomass in seven turfgrass species.

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INTRODUCTION:
Turfgrass quality is typically evaluated by visual observations of color, uniformity, density, and texture. Visual evaluations, however, are subjective and may vary among observers. Multispectral radiometry (MSR) may provide quantitative and objective evaluations of turfgrass quality and its responses to various stresses by measuring the reflectance of turfgrasses in the visible and near infrared part of the spectrum (Table 1). Normalized difference vegetation index (NDVI) and the ratio of near infrared to red (NIR/R) may be good predictors of green leaf area index (LAI) and aboveground biomass, although this has not been evaluated in turfgrasses.

METHODS:
*Study 1: Correlations between visual ratings of turfgrass quality and canopy reflectance. measurements*Research was conducted under a rainout shelter (12 x 12 m) at the Rocky Ford Turfgrass Research Center, Manhattan, KS, summer, 2005 and 2006 (Fig. 1A). Four cool-season turfgrasses were evaluated: Kentucky bluegrass (*Poa pratensis* L., 'Apollo'), tall fescue (*Festuca arundinacea* Schreb., 'Dynasty') and two hybrid bluegrasses, genetic crosses between *Poa arachnifera* Torr. and Kentucky bluegrass ('Thermal Blue' and 'Reveille'). Spectral reflectance was measured once weekly with a handheld multispectral radiometer (CropScan16, Inc., Rochester, MN) (Fig. 1B-1D). Turfgrass quality was rated visually on a scale from 1 to 9 (6=minimally acceptable for use in home lawns) and was compared with reflectance at each of 8 wavelengths as well as with the ratios NDVI (computed as [*R935-R661*] / [*R935+R661*]), *NIR/R* (*R935/R661*), *Stress 1* (*R706/R760*), and *Stress 2* (*R706/R935*).

Study 2: Predicting green leaf area index and aboveground biomass with NDVI and NIR/R.
Aboveground biomass samples (three 7.62 cm diam. PVC rings) were harvested from turfgrass canopies immediately after measurements with MSR on seven turfgrass cultivars. Green leaf area was measured with an area scanner and software (WinRhizo 2002C Reg). Green biomass was then dried and weighed separately from dead biomass at 78°C for 12 hours. Measurements of green LAI and aboveground biomass were correlated with NDVI and NIR/R to determine relationships between spectral reflectance and canopy properties.

RESULTS:
Study 1: Correlations between visual ratings of turfgrass quality and canopy reflectance measurements.
Relationships between turfgrass quality and MSR data were significant at ***R661*** *NDVI, IR/R* and *Stress1* showed strong correlations in cool-season grasses (Table 2). Our results indicated that reflectance measurements in these wavebands and ratios may be a good method for assessing turfgrass quality. Further research and data analyses are being conducted to develop predictive models to accurately estimate turfgrass visual quality using multispectral radiometry.

Study 2:Predicting green leaf area index and aboveground biomass with NDVI and NIR/R.
No relationships were evident between green LAI or biomass and reflectance data (Fig. 2). Data indicated that LAI in established turfgrasses may be above the "saturation point" of reflectance-based vegetation indices, suggesting limited use of MSR data in predicting LAI. Further research is needed to develop adequate models to predict LAI from reflectance data – e.g., hyperspectral radiometry or the refinement of vegetation indices from our MSR data may result in improved predictions from reflectance data of green LAI and biomass in turfgrasses.

Table 1. Wavelengths measured by Cropscan multispectral radiometer and the associated color and function in plant tissue at each wavelength.

Wavebands	Color	Properties
R_{507} R_{559}	Green	Low absorbance by chlorophyll
R_{613} R_{661} R_{706}	Red	High absorbance by chlorophyll
R_{760} R_{813} R_{935}	Near infrared	High reflectance by air -water interfaces in leaf

Table 2. Correlation coefficients for reflectance vs. turfgrass quality in four cool-season turfgrasses in 2005 and 2006.

Wavelength or Ratio	Correlation	
	2005	2006
R_{507}	-0.48	-0.70
R_{559}	-0.64	-0.61
R_{613}	-0.74	-0.09
R_{661}	-0.80	-0.73
R_{706}	-0.54	-0.37
R_{760}	0.76	0.55
R_{813}	0.38	0.62
R_{935}	0.40	0.54
NDVI	0.88	0.77
IR/R	0.83	0.68
Stress1	-0.84	-0.68
Stress2	-0.70	-0.70

Figure 1. (A) The rainout shelter shields turf plots from rainfall and allows for precise irrigation application. (B) Reflectance was measured using a Cropscan MSR 16. The sensor head of MSR 16 radiometer (C) and keypad (D) are shown.

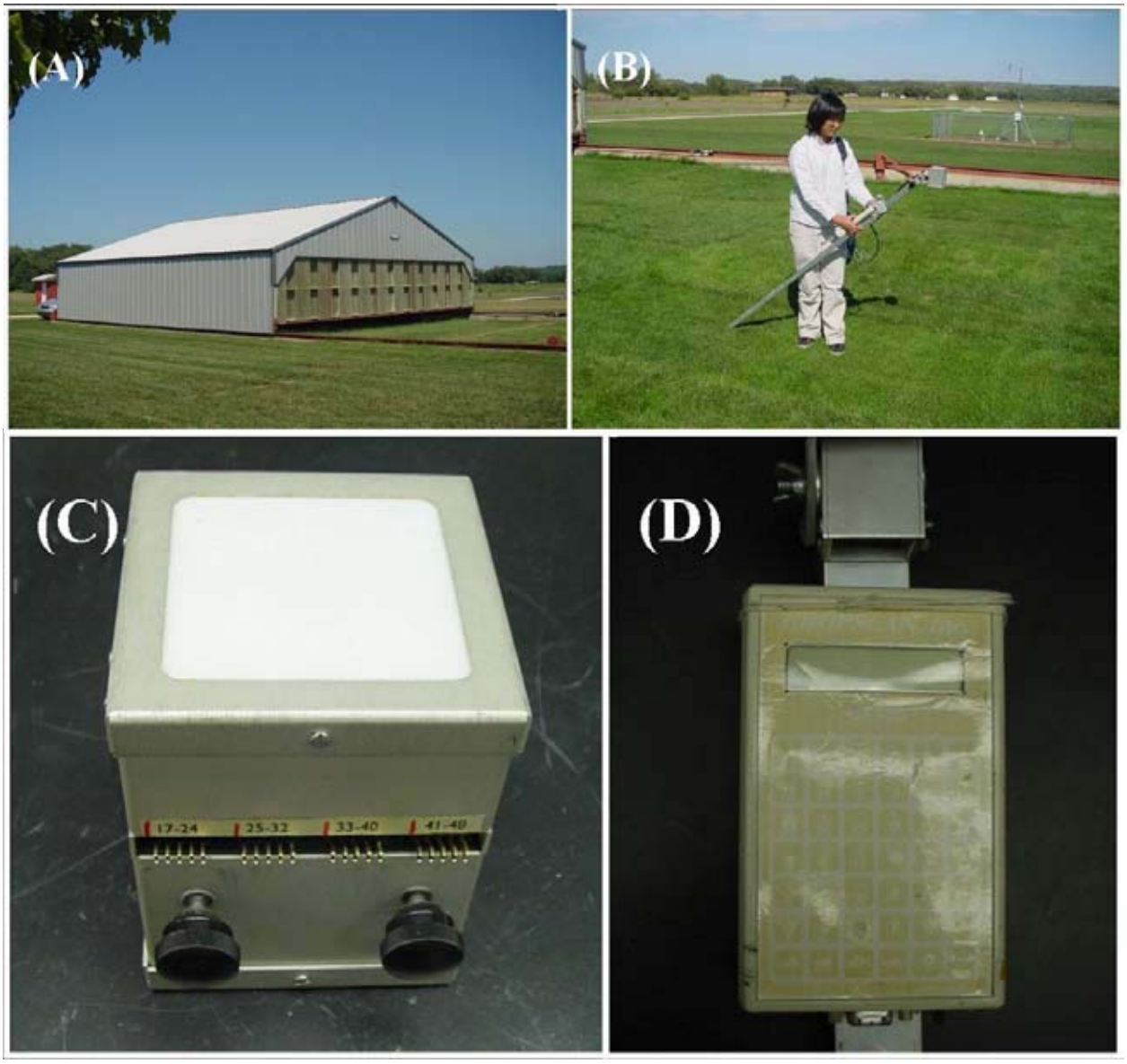

Figure 2. Relationship between IR/R and green LAI (left) and NDVI and green aboveground dry biomass and (right) in seven turfgrass cultivars.