Measurement of Turfgrass Quality, Leaf Area Index, and Aboveground Biomass with Multi-spectral Radiometry

Hyeonju Lee and Dale J. Bremer

Dept. of Horticulture, Forestry, and Recreation Resources, Kansas State University, Manhattan, Kansas

Introduction

Turfgrass quality is typically evaluated by visual observations of color, uniformity, density, and texture. Visual evaluations, however, are subjective and may vary among people. Alternatively, 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). Furthermore, normalized difference vegetation index (NDVI) and the ratio of infrared to red (IR/R) may be good predictors of green leaf area index (LAI) and aboveground biomass although this has not been evaluated in turfgrasses.

Objectives

- Compare correlations between canopy reflectance and visual ratings in four cool-season grasses
- Measure relationships between reflectance data and green LAI and biomass in seven turfgrass species
- Develop models to predict visual quality and green LAI and aboveground biomass using MSR

Material and Methods

Study 1 : Canopy reflectance

- Research was conducted under a rainout shelter (12 x 12 m) at the Rocky Ford Turfgrass Research Center in Manhattan, KS summer, 2005 and 2006 (Fig. 1)
- 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 hand-held multi-spectral radiometer (CropScan16, Inc., Rochester, MN) (Fig. 1)
- 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$[R_{935}-R_{661}]$ / $[R_{935}+R_{661}]$), *IR/R* (R_{935}/R_{661}), *Stress 1* (R_{706}/R_{760}), and *Stress 2* (R_{706}/R_{935})

Study 2 : Leaf area index & Biomass

- 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

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

Table 1. Spectral characteristics of the MSR16

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

Table 2. Correlation coefficients for reflectance vs. turfgrass quality in 4 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

Results

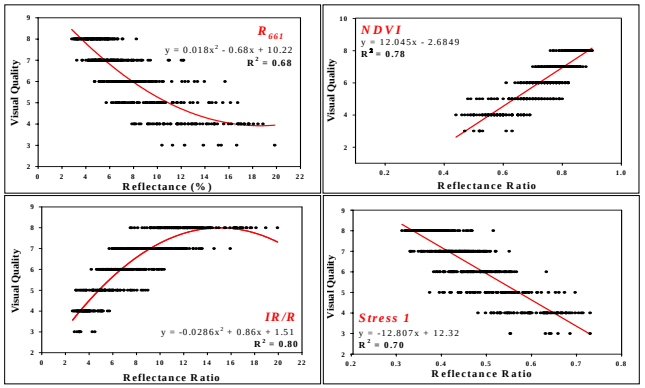

Fig 2. Relationships between visual quality ratings and percent reflectance at 661nm, reflectance ratio of the *NDVI*, *IR/R*, and *Stress 1* in four cool-season turfgrass

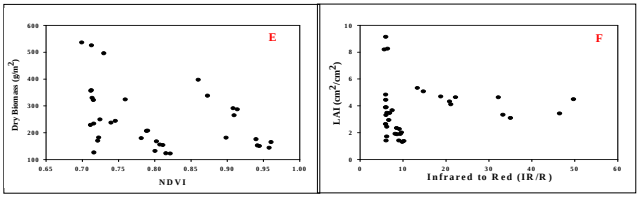

Fig 3. Relation between dry biomass and calculated *NDVI* (E) as well as LAI and *IR/R* (F) on seven turfgrass cultivas

Conclusions

Study 1 : Canopy reflectance

- Relationships between turfgrass quality and MSR data were significant at R_{661} *NDVI*, *IR/R* and *Stress1* showed strong correlations in cool-season grasses (Table 2, Fig. 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 will be conducted to develop predictive models and determine the minimum number of measurements with the MSR to accurately estimate turfgrass visual quality.

Study 2 : Leaf area index & Biomass

- No relationships were evident between green LAI or biomass and reflectance data (Fig. 3)
- 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

Acknowledgements

We gratefully acknowledge funding by The Scotts Company, Golf Course Superintendents Association of America (GCSAA), and Kansas Turfgrass Foundation.

References

- L. E. Trenholm, R. N. Carrow, and R. R. Duncan, 1999 Crop Sci. 39:763-769
- D. Haboudane, J. R. Miller, E. Rattey, P. J. Zarco-Tejada and I. B. Strachan, 2004 Remote Sensing of Environment, 337-352