Estimating Crude Protein Concentration of a Grass Sward Using Spectral Measurements

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INTRODUCTION

Forage quality, as indicated by crude protein concentration (CP), along with mass (FM), indicates a sward's forage potential. Normalized difference vegetation index (NDVI) has been related to those characteristics, but is affected by other canopy traits. Further spectroscopic study is needed to suggest how estimates of forage quality, specifically CP concentration, might be improved.

Figure 1. ASD FieldSpec 3 portable spectrometer used to obtain spectral readings from plots.

PROCEDURE

Fifteen tall fescue [*Lolium arundinaceum* (Schreb.) S.J. Darbyshire] plots 12 × 1.5 m were fall-fertilized with N rates of 0 to 224 kg ha^{-1} to stimulate differences in April forage CP. Reflectance readings from 0.3 to 2.5 µm (10/plot) were obtained with an Analytical Spectral Devices (ASD, Boulder, CO, USA) FieldSpec 3 portable spectrometer (Fig. 1). Reflectance data were used with the GRAMS/AI 8.0 software (Thermo Electron Corp., Salem, NH, USA), as in ElMasry et al. (Fig. 2). Partial least square (PLS) regression with cross-validation algorithm were used to select factors with N concentration as the dependent variable. Next, a Greenseeker RT200 sensor (Trimble, Ukiah, CA) on a mobile rising plate unit was used to measure sward NDVI and estimate FM. Those readings were used to separate FM and CP effects on NDVI using multiple regression (Moyer, et al). Plots were harvested, weighed, sampled, dried for FM, and ground for N analysis.

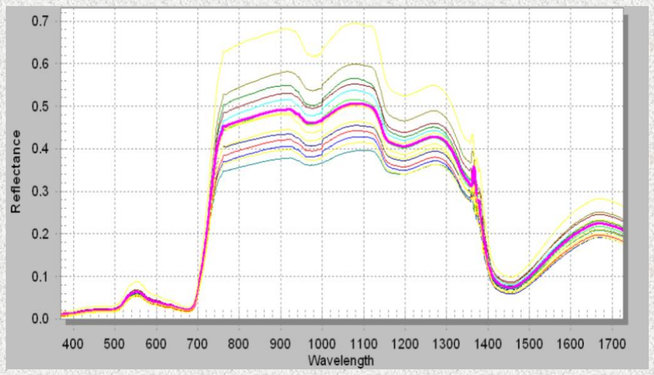

Figure 2. Mean reflectance curves for 15 field plots of tall fescue.

RESULTS

Spectral reflectance curves from field plot samples (Fig. 2) were analysed with the corresponding N (thus CP) concentrations. Principle-factor analysis indicated that the largest amount of variation in N concentrations was explained by 2, or at most 3 spectral factors. Using those two factors, least squares regression resulted in an R^2 value of 72% (Fig. 3). The principal factor loadings (Fig. 4) that occurred in the 1421-1600 nm and 2200-2400 nm regions (NIR range) indicated that those two regions contained the two principle factors that explained the greatest amount of variation in N (thus CP).

Field data from the mobile rising plate apparatus resulted in significant ($P<0.01$) correlation coefficients (r) of NDVI with CP and FM of 0.69 and 0.89, respectively.

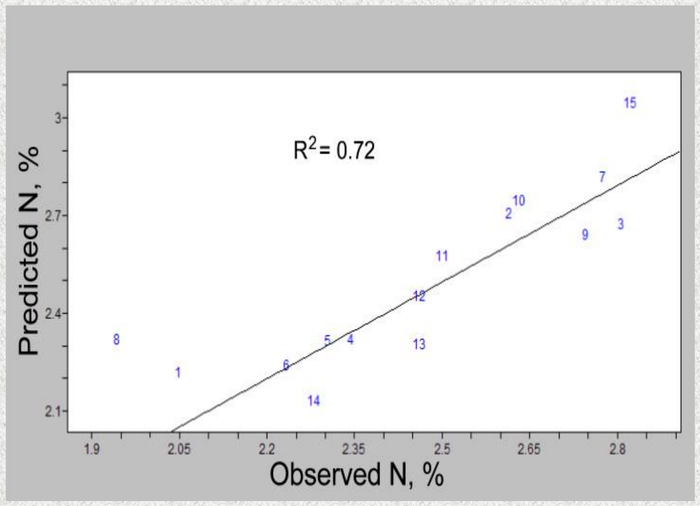

Figure 3. Relationship between % N observed and that predicted from mean reflectance data of plots using partial least square (PLS) regression.

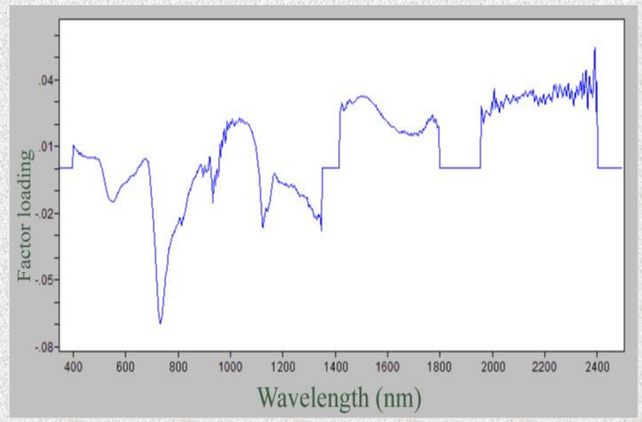

Figure 4. Spectral principal factor loadings in the spectral range related to tall fescue N (CP)concentration.

When an existing tall fescue prediction equation that factored FM and CP effects on NDVI was applied to field data from the rising plate, a prediction coefficient (r) for CP of 0.88 was obtained.

CONCLUSION

The two spectral regions of the tall fescue sward that related best to forage N (thus CP) were in the near-infrared (NIR) range. The spectral region(s) measured by the Greenseeker appears to include wavelengths adequate for detection of CP in tall fescue. However, expression as NDVI includes confounding effects that must be accounted for in any attempt to estimate CP or another specific characteristic.

REFERENCES

ElMasry G, Wang N, ElSayed A and Ngadi M (2007) Hyperspectral imaging for nondestructive determination of some quality attributes for strawberry. Journal of Food Engineering, 81: 98 – 107.

Moyer JL, Price RR, Lomas LW, and Higgins JJ (2010) Estimating forage mass and crude protein with a moving plate and Greenseeker. Proceedings of the 2010 American Forage and Grassland Council, Vol. 19 (CD), June 2010, Springfield, MO, USA.