Integrated remote sensing tools for timely predictions of alfalfa nutritive value

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Accurate, in-field assessment of alfalfa nutritive value is critical to optimize cutting management and meet production goals. However, acquisition of timely information at the field scale is limited using traditional assessment techniques (i.e. destructive sampling and predictions of nutritive value based on maturity and canopy height). Remote sensing technologies (e.g. measurement of canopy reflectance) have potential to facilitate rapid and accurate predictions across entire fields, enabling the precise timing of harvest based on forage needs. Such applications will become especially important as management strategies change with the development of new alfalfa cultivars (e.g. reduced lignin), yet efficient and accurate remote sensing tools for alfalfa management have not been developed. A study was initiated in 2014 at the University of Minnesota Rosemount Research and Outreach Center to determine the viability of published spectral vegetative indices, and develop new indices, to remotely predict alfalfa maturity and forage nutritive value. A wide range of spectral reflectance (350-2500 nm) was measured in conjunction with destructive sampling of alfalfa (measured maturity, biomass, and forage nutritive value) every 3-4 days throughout the growth of a stand. The same parameters were measured in 2015 under a more controlled sampling environment (consistent light and weather conditions on the day of sampling) achieved by regular cutting intervals to establish a maturity gradient in the field.

Red Edge Inflection Point (REIP) showed the strongest correlation with alfalfa maturity (R^2 = 0.76) of several published vegetative indices tested, although direct predictions of forage nutritive status were less accurate (e.g. REIP was also the best predictor of crude protein (CP) (R^2 = 0.57). The full range of reflectance data was processed using stepwise regression, as well as an alternative assessment using the Akaike Information Criterion (AIC) to identify individual wavebands most correlated with alfalfa nutritive value. Using spectral data alone, 8 wavebands were selected to build linear models for predicting CP (R^2 = 0.88) and Neutral Detergent Fiber Digestibility (NDFD, 48 hour in-vitro)) (R^2 = 0.84). Cumulative Growing Degree Units since last harvest (GDUbase) was used as a covariate for improved model fit, and enabled the inclusion of fewer wavebands while improving predictability. Using 3 wavebands and GDUbase as the model inputs, strong predictions of CP (R^2= 0.91) and NDFD (R^2 = 0.89) were maintained. Cross-validation was performed applying the same model (trained on 2015 data) to the 2014 alfalfa CP (R^2 = 0.87). These results identify new remote sensing tools capable of providing rapid and accurate predictions of forage nutritive value at the field scale for timely and precise cutting management.