Exploring New Technologies for Alfalfa Quality Predictions

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Throughout the alfalfa production season, careful and informed harvest decisions increase the chances of meeting production goals. The growth of a stand, from one cut to the next, will always vary according to stand health as well as a range of environmental factors. Accurate in-field assessment of an alfalfa crop is critical to maximize profitability, in terms of both quality and yield. In the Upper Midwest, where forage demands are driven by the dairy industry, the value of a crop is especially dependent on forage quality. Greater quality means greater milk per ton, which means greater profitability per ton of forage.

Physical measurements of alfalfa maturity and height are currently the most accurate and consistent indicators of quality. As maturity increases, forage quality decreases, enabling the calculation of maturity indices such as mean stage by count (MSC) and mean stage by weight (MSW). The MSC or MSW values can then be interpreted as indicators of forage quality parameters, highlighting the common understanding that forage quality decreases with increasing alfalfa maturity.

The efficacy of these maturity indices may change as alfalfa is harvested earlier for higher quality and as new, novel varieties of alfalfa are being developed with reduced lignin content (i.e., higher digestible fiber). The introduction of these lines will introduce new flexibility into alfalfa harvest management and limit the applications of traditional assessment tools. Although alfalfa maturity will still correlate with quality in these new lines, higher quality will be maintained with greater maturity. Therefore, equal quality can be achieved with higher yields, or higher quality can be achieved with equal (conventional) yields. Precise and intensive management will be critical to optimize the use of these resources and maximize profit margins.

Various new tools and applications in the area of precision agriculture are enabling maximum resource use efficiency and profitability in other major crops (i.e., accounting for in-field variability with variable rate fertilizer application and variable rate planting). Unmanned aerial vehicles (UAVs) are being equipped with GPS technology and a wide array of sensors/cameras to assess crop health, progress, disease/insect pressure, nutrient deficiencies, etc., and are informing management decisions.

One of most widely used technologies in crop remote sensing is the measurement of canopy reflectance. Broadband spectral indices such as NDVI (Normalized Difference Vegetative Index) are valuable indicators of greenness, crop health, or percent ground cover. More specific indices such as MTCI (Meris Terrestrial Chlorophyll Index) are designed for more precise applications. Indices designed for specific purposes utilize the spectral reflectance of particular wavebands (ranges of nanometers in the visible and near-infrared spectrum), and the wavebands of importance can vary depending on the crop and target application. UAVs or ground vehicles equipped with these sensors can travel through the field collecting and mapping data correlating to the current status of the crop across the whole field.

In 2014, a pilot study was conducted at the University of Minnesota Rosemount Research and Outreach Center to determine whether spectral indices could be used to predict alfalfa maturity. A spectrophotometer, measuring reflectance values of 350-2500 nm, was used to periodically scan alfalfa plots throughout the growth of a stand, followed by destructive harvest, sampling and analysis for yield, quality, and maturity. Preliminary analysis indicates there is potential for spectral indices to predict alfalfa maturity; however, alfalfa-specific indices have not yet been developed.

Figure 1. Remote measurement of canopy height using LiDAR technology provides a valuable non-destructive estimate of crop biomass (Rosemount, MN 2015).

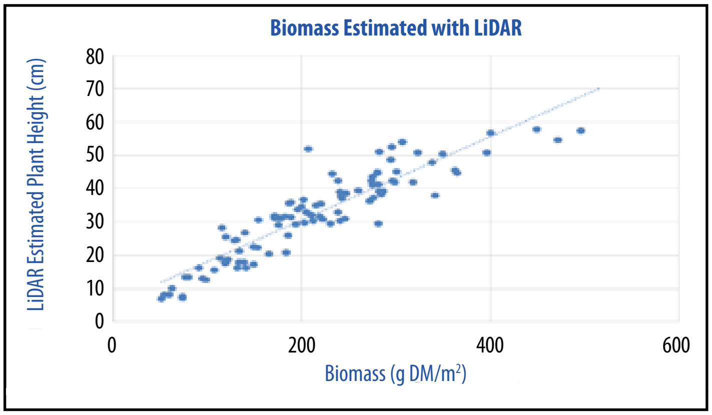
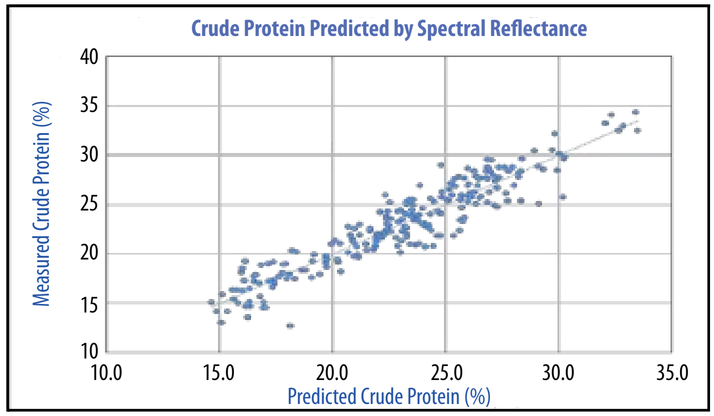


Figure 2. New equation using eight wavebands in a multiple linear regression model to predict alfalfa crude protein (Rosemount, MN 2015).



A follow-up study with similar principles was conducted in 2015. Treatments within a randomized design were mowed periodically to set up a maturity gradient in the field. The resulting stand represented a range of plant maturity, from early vegetative to seed pod development. Then, all plots were scanned with multiple forms of remote sensing instrumentation prior to harvest and analysis. An added technology in 2015 was the use of LiDAR (Light Detection and Ranging) to remotely measure crop height and facilitate yield predictions (Figure 1).

The larger spectral dataset, spanning a wider range of maturity in 2015, was used to identify the most significant wavebands and develop equations using multiple linear regression to predict forage quality parameters such as crude protein (Figure 2). As this project continues, equations are being tested and new technologies are being integrated to develop an alfalfa specific remote sensing platform as a practical tool for optimizing management decisions.