Predicting Grain Protein in Winter Wheat using Sensor and Weather Data

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Abstract

Price deductions related to low grain protein (<11%) are a real concern for United States wheat producers in the Southern Great Plains.The ability to predict grain protein mid-season would enable producers to adjust nitrogen (N) fertilizer rates to achieve desirable protein levels. In this study, linear and non-linear models were tested to predict grain protein in winter wheat using GreenSeeker Normalized Differnce Vegetation Index (NDVI) values, pre-plant N rates, weather data including cumulative rainfall, average ambient temperature, and Fraction of Available Water (FAW).

Objective

The objective of this study was to develop a model for mid-season prediction of grain protein using weather data in addition to NDVI and applied N rates.

Materials and Methods

- Site-Years
  - Altus , OK. (2003-2005, 2007-2008, 2010-2013)
  - Stillwater, OK. (2003-2008, 2010-2013)
  - Lahoma, OK. (2003-2013)

- Model Parameters
  - NDVI (Feekes 3 to Feekes 5 growth stage)
  - Pre-plant N rates
  - Cumulative rainfall
  - Ambient temperature
  - Fraction of Available Water (FAW)
    Calculated as (Θ - Θwp)/(Θfc - Θwp), where Θ is the measured volumetric water content, Θwp is volumetric water content at wilting point , Θfc is volumetric content at field capacity (Hunt *et al*., 2009).
    Values not to exceed 1.0

- Pre-plant N Rates
  Altus: 0, 45, 90, 134, 179 kg N/ ha
  Lahoma: 0, 23, 45, 67, 90, 112 kg N/ ha
  Stillwater: 0, 45, 90, 134 kg N/ ha
  Validation sites
  Lake Carl Blackwell, Hennessey: 0, 28,56,84,112,168,224 kg N/ha

- Weather and Soil Data
  - Weather and soil moisture data from planting to sensing downloaded from Oklahoma Mesonet (www.mesonet.org)
  - Soil hydraulic paremeters based on textural class for each site retrieved from Meso-Soil database version 1.1 (Scott *et al*., 2013)

- Model Development and Validation
  - Grain yield and grain protein data for Stillwater, Lahoma, and Altus, OK., 2003-13
  - R^2 and adjusted R^2 variable selection procedure
  - Models validated using grain yield and grain protein data from two independent studies at Lake Carl Blackwell, and Hennessey OK., 2010- 13

Results

Table 1. Estimates, standard error, and significance levels for parameters in a multiple linear model for grain protein prediction across years and locations

	R^2 =0.42		
Parameter	**Estimate**	**S.E**	**Pr>|t|**
Intercept	13.09	0.659	<0.0001
N rate	0.029	0.002	<0.0001
NDVI	-0.400	0.758	0.5981
Temperature	0.023	0.074	0.7575
Rainfall	-0.006	0.002	<0.0008
FAW	-1.336	0.709	0.060

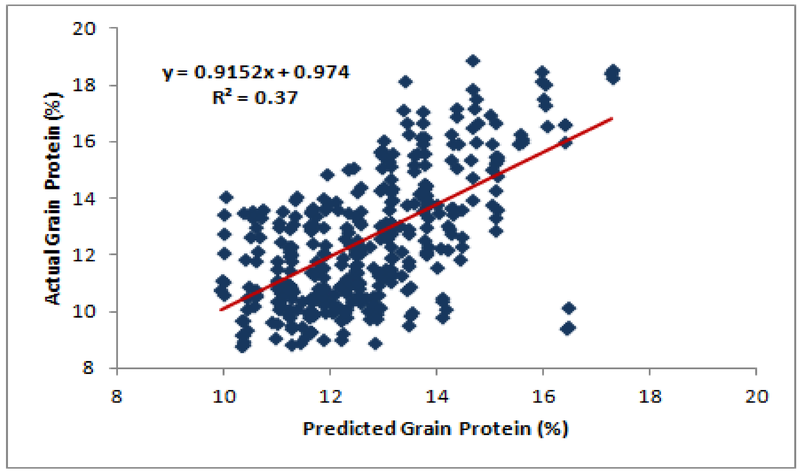

Figure 1. Predicted versus actual grain protein across years (2003-13) and Locations (Altus, Lahoma, Stillwater, OK).

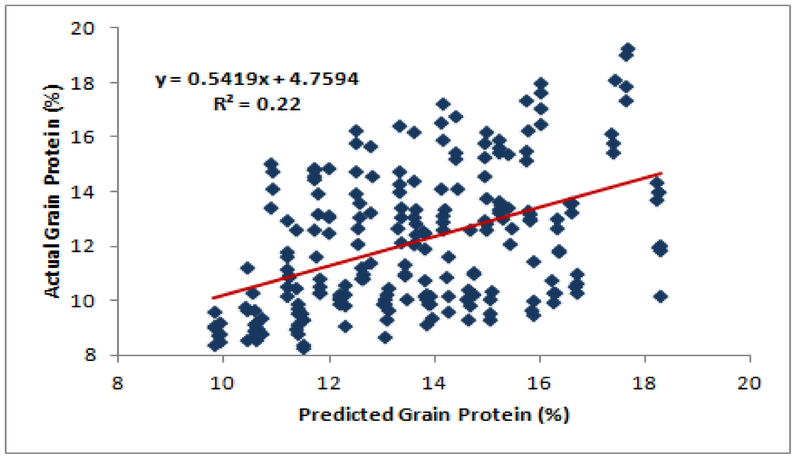

Figure 2. Predicted versus actual grain protein for validation sites Lake Carl Blackwell, and Hennessey, OK. 2010-13.

Table 2. Parameters and coefficient of determination (R^2) values for predicting grain protein at model building and validation sites

Parameters in Model	**Sites in Model**	**Validation Sites**
	R^2	
N rate	0.35	0.12
N rate, NDVI	0.37	0.21
N rate, NDVI, Temperature	0.37	0.21
N rate, NDVI, Temperature, Rainfall	0.42	0.83
N rate, NDVI, Temperature, Rainfall, FAW	0.42	0.83

Conclusions

- Pre-plant N rates had a significant effect on grain protein prediction (Table 1); grain protein increased with increasing N rates.
- Mid-season NDVI from Feekes 3 to Feekes 5, and ambient temperature were not significant as predictors of grain protein (Table 1).
- Decreasing trend in grain protein and increasing trend in grain yield with increasing FAW across sites and years.
- Models that included pre-plant N rates, NDVI, average ambient temperature, cumulative rainfall, and FAW were good predictors of grain protein *(R^2=0. 42, 0.83)* (Table 2).
- Models that included rainfall or FAW outperformed models that included pre-plant N rates, NDVI, and ambient temperature (Table 2).

References

Hunt, E. D, K. G. Hubbard, D. A. Wilhite, T. J. Arkebauer, and A. L. Dutcher. 2009. The development and evaluation of a soil moisture index. Int. J. Climatol. 29: 747-759.

Oklahoma Mesonet (www.mesonet.org)

Scott, B.L., T.E. Ochsner, B.G. Illston, C.A. Fiebrich, J.B. Basara, and A.J. Sutherland. 2013. New soil property database improves Oklahoma mesonet soil moisture estimates. J. Atmos. Ocean. Tech. doi:10.1175/JTECH-D-13-00084.1