Use of Remote Sensors to Predict Grain Protein and Yield of Wheat Response to N

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Introduction

Remote sensors are useful decision support tools that can accurately, rapidly, and non-destructively monitor crop growth indicators using light reflectance data off of the crop canopy, producing numbers (indices) that may be related to final yields and grain protein. Promising results have shown that unmanned aerial vehicles (UAVs), and ground-based sensors such as the GreenSeeker (GS) and Crop Circle (CC), produce indices like the Normalized Difference Vegetation Index (NDVI) and Red Edge (RE) as indicators of crop health/vigor and N status. Field studies were conducted to determine the relationship between NDVI and RE to final grain protein of wheat following data collection on multiple sensing dates.

Materials and methods

Spring wheat was planted at the Carrington Research Extension Center in spring 2018 on dryland and under irrigation. Available soil test N at the irrigated site was 75 lbs N. The trial received N fertilizer (treatments 1 to 6) at rates of 0, 40, 80, 120, 160, and 200 lbs N. Treatments 7 to 10 (0, 40, 80, 120 lbs N) received post-anthesis N as 28% UAN that was premixed with equal amounts of water before spraying at the rate of 30 lbs N. Treatments 11 and 12 received the same N rates (0 and 40 lbs N) as 13 and 14. These last four treatments were to receive mid-season N at the five-leaf stage based on sensor data from the GS and CC.

Results

Based on the response indices given by the NDVIs of N-fertilized plots divided by NDVIs of the check (unfertilized) plots, midseason N fertilizer was not recommended for both sites.

However, the effect of N became more pronounced later in the growing season, which affected yields and grain protein.

At the dryland site, grain protein was significantly different between N rates; meanwhile, yields were marginally different (Figure 1). At the irrigated site, grain protein and grain yield improved significantly from N application (Figure 2).

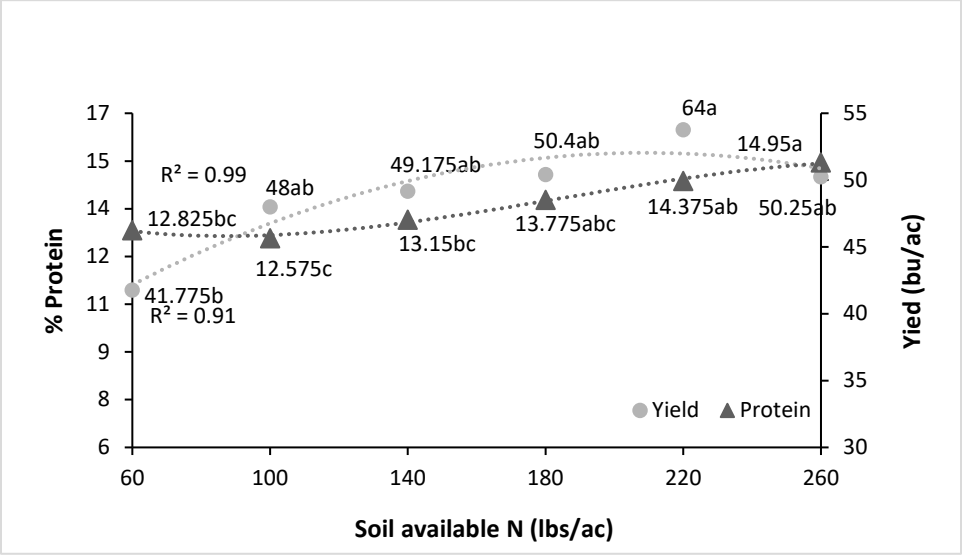

Figure 1. Grain protein and yield response of wheat to N rates (dryland).

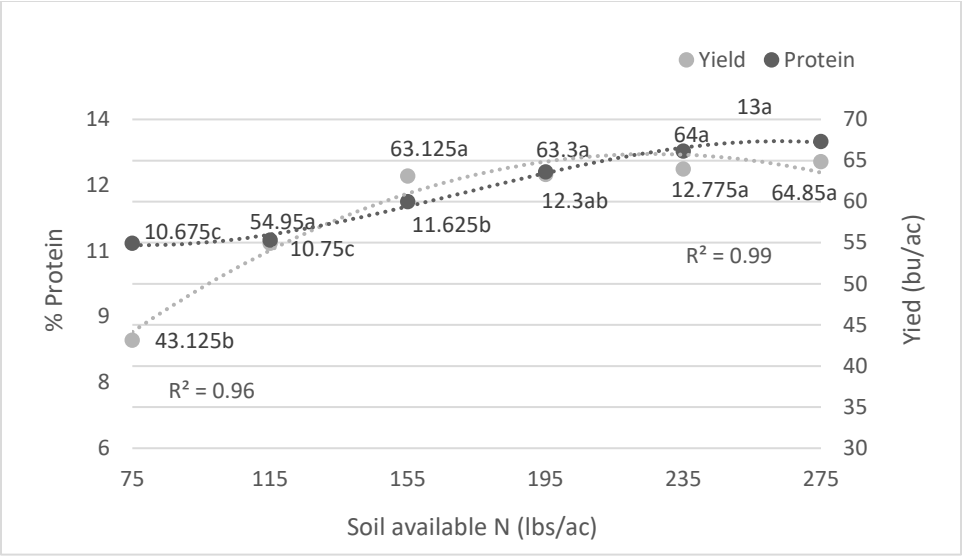

Figure 2. Grain protein and yield response of wheat to N rates (Irrigated)

Under dryland, where planting was on May 11, GS NDVI data collected on June 8 (≈ 4 to 5-leaf growth stage), June 13, and 25, did not correlate well with grain protein (Figure 3). But on July 6 (about the watery ripe stage) a significant correlation was observed, where about 57% (R^2 = 56.67) of the variation in grain protein could be explained by the NDVI. Grain protein relationship to either UAV-RE or UAV-NDVI was weak for all the three sensing dates starting on June 13, and again on June 26, and July 2.

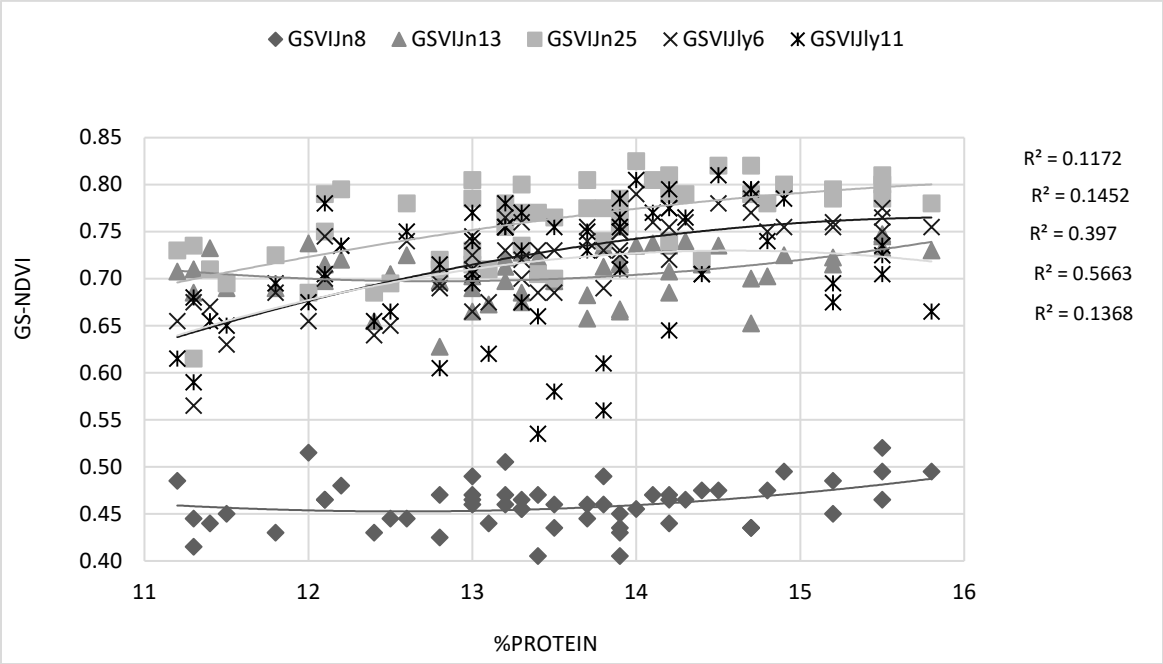

Figure 3. Relationship between wheat grain protein and GS NDVI at different sensing dates (dryland)

At the irrigated site, where planting was on May 24, GS NDVI taken on July 6 (at boot swelling) had a good correlation with grain protein, explaining 59% of variation in protein. NDVI and protein relationship was weak on June 25 (6 leaves), and July 11. Meanwhile, protein correlated well with NDVI and NDRE from Crop Circle (CC) at the watery ripe stage on July 11 and two days later, with the UAV NDVI and NDRE (all giving R^2 values between 0.56 and 0.59).

Dryland wheat flag leaf N was not different between the check and higher N rates, but increased with N rates under irrigation. Grain protein was enhanced by N application at post-anthesis.

Summary

NDVI or NDRE from the sensors showed some positive correlation with grain protein of wheat. Good correlations between protein and sensor indices were observed only after the 5-leaf stage, when it is recommended for any practical mid-season application of N to boost yield of spring wheat. The strength of the relationship was not different between grain protein and Red Edge or between grain protein and NDVI.