Determining In-Season Nitrogen Requirements for Maize Using Model and Sensor Based Approaches

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Introduction

There is great value in determining the optimum quantity and timing of nitrogen (N) application to meet crop needs while minimizing losses. Applying a portion of the total N during the growing season allows for adjustments which can be responsive to actual field conditions which result in varying N needs. A crop model-based approach and a crop canopy sensor-based approach have been proposed as ways to determine in-season N need.

Objectives

The objective of this study was to evaluate these two approaches for determining in-season N rates: model and sensor. Utility in predicting N need is evaluated for both approaches over a 3-state region, including sites in Missouri, Nebraska, and North Dakota. Additionally, the study investigated effects of maize hybrid and population on the efficacy of the two N recommendation strategies.

Methods

- The study was conducted over 12 site years, located in 3 states (Missouri, Nebraska, and North Dakota), with 2 sites per state. Soil test data for all site years is shown in Table 1.
- The experimental design was a RCBD with four replications per site.
- The treatment design was a 2x2x4 factorial with: 2 hybrids, 2 populations, and 4 N strategies (unfertilized check, N-rich reference ranging from 224 – 280 kg ha⁻¹, sensor-based, and model-based).
- The sensor-based and model-based N treatments had a base N rate applied at planting, and an in-season N application at V9-V11.
- For the sensor-based treatments, the normalized difference red edge index (NDRE) and sufficiency index (SI) were obtained using a RapidSCAN CS-45 Handheld Crop Sensor (Hollander Scientific, Lincoln, NE). The modified Holland-Schepers algorithm used SI values to determine in-season N application rates (Hollander and Schepers, 2010).
- For model-based treatments, Maize-N: Nitrogen Rate Recommendation for Maize tool (Setiyono, et al., 2011) was used to determine in-season N application rates.
- All treatments were scanned to obtain NDRE and SI values at the time of in-season N application and ~2 weeks following N application.
- Grain yield, grain N content, partial factor productivity of N, and agronomic efficiency were obtained.

Results and Discussion

Nebraska

- For all site years, the sensor approach called for less in-season N than the model approach (Figure 1).
- Yields were not statistically different between the model, sensor, and reference treatments for 3 of 4 site years (Figure 2). Yield of the differing site year, NE- MC-13, is shown in Figure 3.
- For all site years the sensor approach had a statistically higher partial factor productivity of N (PPPₚ) than the model approach (Figure 4).
- For all sites, the sensor approach had a significantly greater agronomic efficiency than the model approach and reference (Figure 5). For one site the model approach was significantly greater than the reference in agronomic efficiency.
- No N was recommended by the sensor approach for site NE-CC in 2012 where high mineralization occurred, therefore the sensor approach appears more responsive to in-season growing conditions.

Missouri

- Both 2012 sites had lower N recommendations using the sensor-based approach than the model-based approach (Figure 1).
- The MO-LT site showed no significant yield differences between the model, sensor, and reference N strategies and the sensor had a higher PPPₚ (P<0.05). The 2012 MO-RO site was lost due to water stress.
- In 2013, at the MO-BY site, the sensor approach recommended a higher N application than the model approach; at the MO-TR site, the sensor approach recommended a lower N application than the model approach (Figure 1). Yield data is not yet available for these sites.

North Dakota

- For all site years, no initial N was applied prior to in-season N application. In 2012, both sites had lower N applications using the sensor approach than the model approach; in 2013, the sensor approach recommended higher N application at the ND-VC site, and lower N application at the ND-AR site (Figure 1).
- For 2012, the sensor strategy had a higher PPPₚ (Figure 6), but lower N rate resulted in yield values for the sensor treatment which were significantly lower than the reference (Figure 7). The model approach estimated N needs that reduced overall N application from the reference amount, without significantly reducing yield.
- In 2012, there was no significant economic advantage to either the model or sensor strategy, given $5 corn prices and $0.50 fertilizer N price (P>0.05).
- In 2013, no significant yield differences were seen at either site for any N strategy, including between the check which received 0 kg ha⁻¹ and the reference which received 224 kg ha⁻¹ (P>0.05). It is believed that there were other factors which limited yield potential and masked N treatment differences.