Integration of Sensor Based Fertigation Management

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Introduction

- Groundwater contamination from nitrate in Nebraska is mostly from nitrogen (N) applied to row crop production (Frank, 1991). Figure 1 illustrates the scope of the problem.
- There is evidence in Nebraska of a plateau in gains in nitrogen use efficiency (NUE) in corn production. (Ferguson, 2015)
- Applying nitrogen (N) fertilizer before or early in the growing season exposes N to losses due to little to no crop N demand.
- Determining efficient rates prior to the growing season may result in excessive N rates from lack of synchrony between N supply and crop demand.
- Crop canopy sensors, used to direct in season applications, may help in increasing NUE while maintaining yields. (Samborski, 2009)
- Sensor research has focused on one-time in season application due to logistical considerations of corn management. Adoption of sensor based management is low.
- Fertigation offers the potential to monitor crop N status via sensors and react with a targeted dose of N only when the crop needs it, which eliminates uncertainty of a predetermined N rate.
- In Nebraska, 78 percent of all corn production (48 percent of all crop acres) for grain is irrigated, and of that percent, 22 percent has some fertilizer applied through irrigation water ("NASS," 2015).

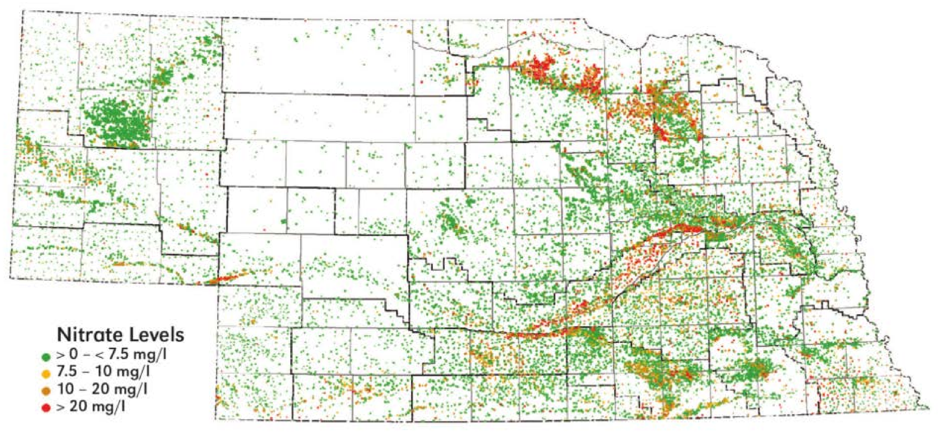

Figure 1: (Left) Nebraska map presenting recorded concentration of nitrate from 1974 - 2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013). Empty areas indicate no data reported, not the absence of nitrate in groundwater.

Research Objectives

- Demonstrate the potential for improving NUE while optimizing profitability through canopy sensor-based, reactive fertigation.

Methods

- Treatments were chosen to represent the current BMPs recommended in Nebraska for N management in corn and to develop new BMPs that utilize sensor guided fertigation.

Treatments:

1. Check
2. High N Reference (used for sensor to detect relative deficiencies)
3. UNL algorithm (non sensor-BMP, one time in-season sidedress)
4. Holland-Schepers (H-S) algorithm (sensor-BMP, one time in-season sidedress) (Holland and Schepers, 2010)
5. Reactive-fixed fertigation (sensor guided, reactive rate is fixed)
6. Reactive-model fertigation (sensor guided, reactive rate is informed by crop model)
7. Slow release reactive-model fertigation (sensor guided, reactive rate is informed by crop model, initial N applied as polymer coated urea (slow release))
8. Model-fertigation (not sensor informed, proactive rate is informed by crop model)

- All but Check received an initial base rate of N to maintain N sufficiency until sensors become reliably effective at V8
  - N was applied as UAN with exception of the slow release treatment that received slow release nitrogen as the initial base rate.
- Sensor uses sufficiency index (SI) to compare treatment vegetation index vs. High N Reference.
- Application Go/No Go logic depends on
  - 0.95 SI Threshold (Sensor informed)
  - Past SI (current growing season)
  - Depending on treatment, predicted N uptake from crop model
- Proc GLM (SAS 9.4). Means were separated using Fisher's LSD.
- Research conducted in 2016 and 2017 at location SCAL under sprinkler irrigation/fertigation

Results and Discussion

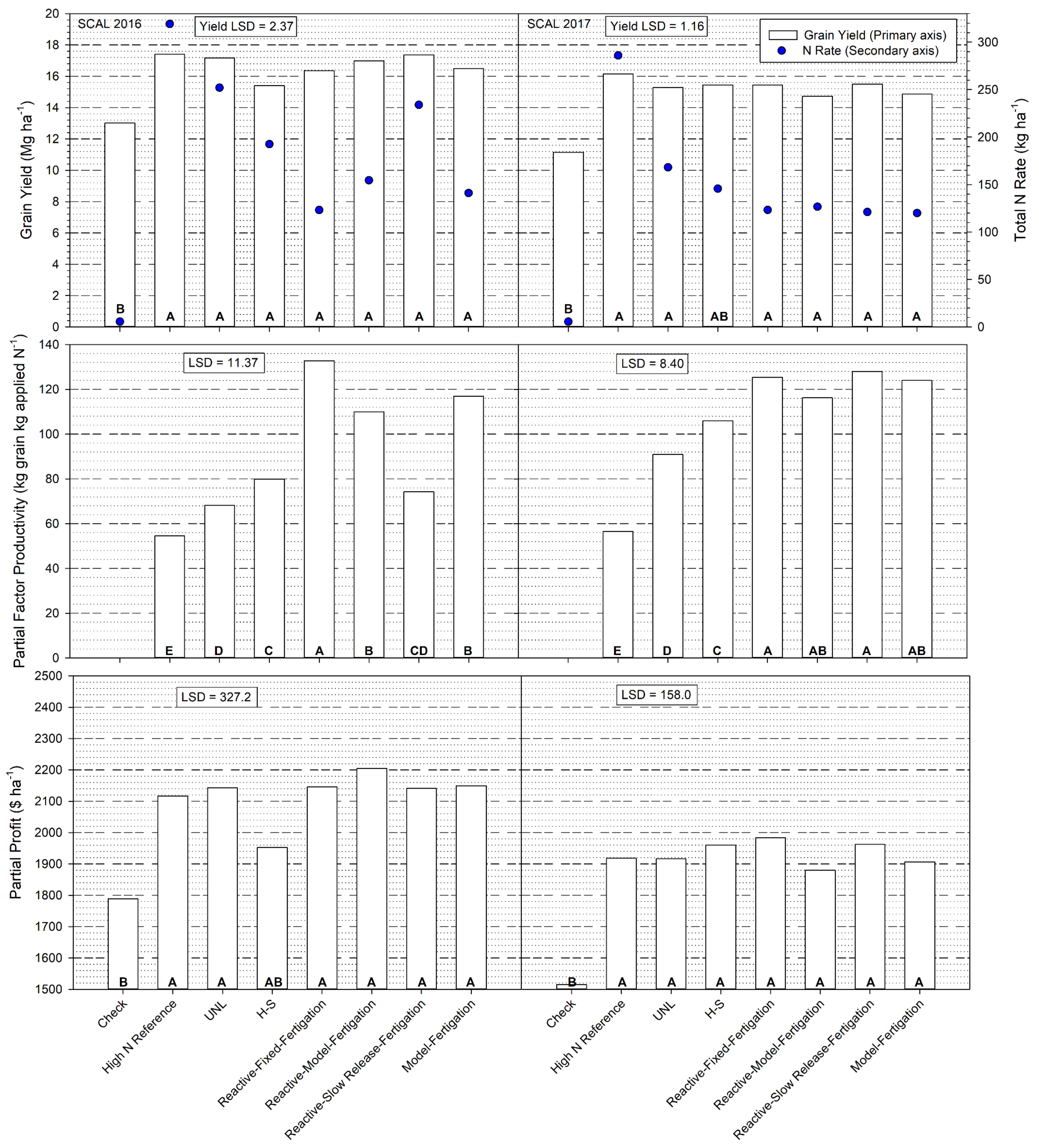

Figure 2: (Top) Grain yield and applied N rate, (Middle) partial factor productivity, a measure of nitrogen use efficiency (NUE), and (Bottom) partial profit for 2016 and 2017 at location SCAL. An alpha level of 0.05 was used for LSD mean comparison and is reported on each respective chart. Treatments with the same letter are not significantly different. Partial profit was calculated using grain prices and N costs specific to each year.

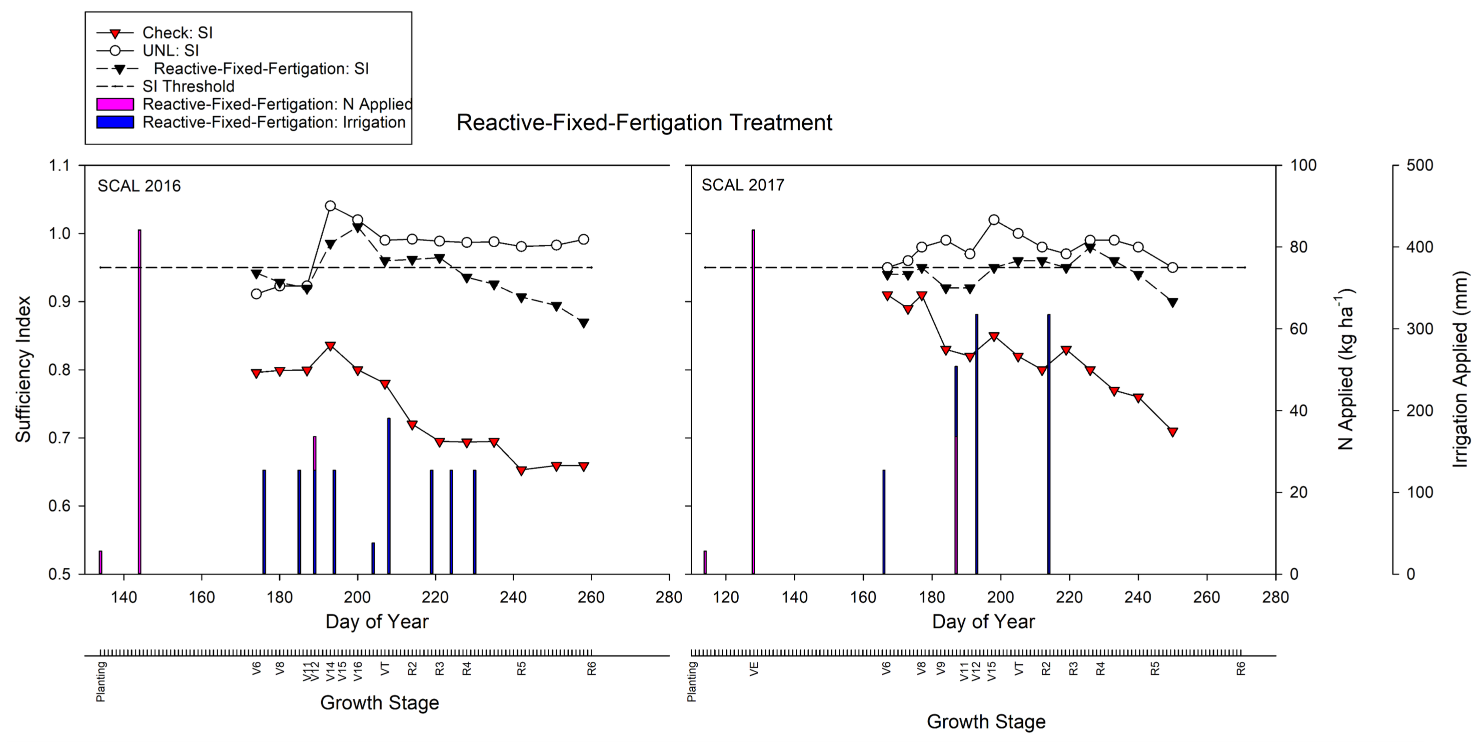

Figure 3: A timeline view of SI values for the reactive-fixed fertigation treatment with the Check and UNL treatments used as comparisons. All irrigation and N application rates are associated only with the reactive-fixed fertigation treatment.

- Reactive-fixed fertigation treatment grain yield was not significantly different from that of the High N reference, but used considerably less nitrogen in both site years.
- Differentiation among N applied by fertigation treatments was limited to that of the reactive-model fertigation treatment that used polymer coated urea (slow release).
- The one time in-season sidedress application treatments (UNL, H-S) recommended more N compared to reactive-fixed fertigation treatment, but no accompanying gain in grain yield.
- Nitrogen use efficiency (NUE) reported as partial factor productivity (PFP) was highest for the reactive fixed fertigation treatment in both site years.
- Partial profit varied slightly by year. There was no significant difference between the treatment with highest partial profit and that of the reactive fixed fertigation treatment in both site years.
- Decision logic had little affect on the total N rate for the fertigation treatments.

Conclusions

- More years and environments are needed to investigate and identify robust decision logic for when to apply N and the amount of N to apply
- However, the current application decision logic proved to be resilient in the site years tested.
- No evidence to suggest use of 0.95 SI as the threshold for application is detrimental to yield.
- In 2016 and 2017 at location SCAL, the reactive-fixed fertigation treatment:
  - Had the highest nitrogen use efficiency (partial factor productivity)
  - Was among the highest yielding treatments (not significantly lower than any other)
  - Had the highest partial profit
- On-farm research is needed to test the feasibility of this potential BMP on a production scale
- Sensor based fertigation shows potential to be a new BMP that increases nitrogen use efficiency while maintaining or increasing profit

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