Using Drone Based Sensors to Direct Variable-Rate, In-Season, Aerial Nitrogen Application on Corn

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Introduction

- Improving nutrient management on farms is a critical issue nationwide.
- Applying a portion of the nitrogen (N) fertilizer during the growing season, alongside the growing corn crop is one way to improve N management.
  - In-season N applications allow N fertilizer availability and crop N uptake to more closely match.
  - In-season N applications allow for N management which is responsive to current growing season conditions.
- Active crop canopy sensors have been used during the growing season to direct in-season N application and have been found to reduce N application and increase profit. This sensor technology is most commonly used on high clearance applicators, where sensing and application take place simultaneously.
- In southeast Nebraska and other regions of the corn-belt, in-season N application by ground-based applicators is not common due to rolling land, and contour and terrace farming. Some farmers in these landscapes rely on airplanes for in-season N applications.
- Small, passive, multi-spectral sensors which can be carried on drones enable crop sensing to occur from the air.
- Sensing N need and applying N from the air can eliminate ground-based field applications which

Objective

The goal of this research project is to:

1. **Evaluate the use of a passive crop canopy sensor to direct variable-rate, in-season N fertilizer recommendation rates on corn and apply this recommendation using variable-rate aerial technology.**
2. **Evaluate different nitrogen base-rates for use in an in-season, variable-rate fertilizer system.**

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Materials and Methods

1. Site Description

- Soil series: Nodaway silt loam, Wabash silty clay loam, and Zook silty clay loam, all occasionally flooded.
- Grid samples (1.0 ha grids in 2015):
  - OM = 1.7-3.6%
  - pH = 6.2-7.3
  - CEC = 12.5-19.6 meq/100 g

2. Experimental design and treatments

- Randomized complete-block with 4 blocks
- Three treatments:

1. Farmer Management – 179 kg/ha N pre-plant as anhydrous ammonia + in-season if needed

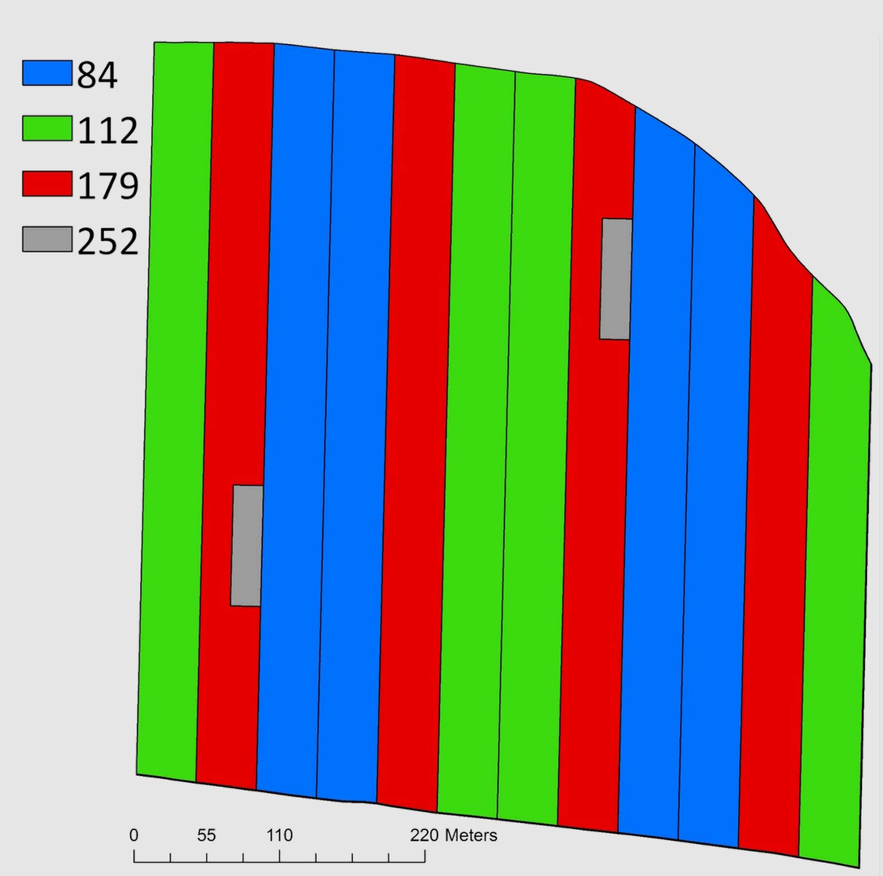
2. 84 kg/ha N pre-plant as anhydrous ammonia + in-season, variable-rate N application based on sensor data

3. 112 kg/ha N pre-plant as anhydrous ammonia + in-season, variable-rate N application based on sensor data

Two high N reference blocks were also applied so that imagery could compare to "ideal" looking corn.

3. Pre-plant N Rate (kg/ha)

Pre-plant N applied on Feb. 15.



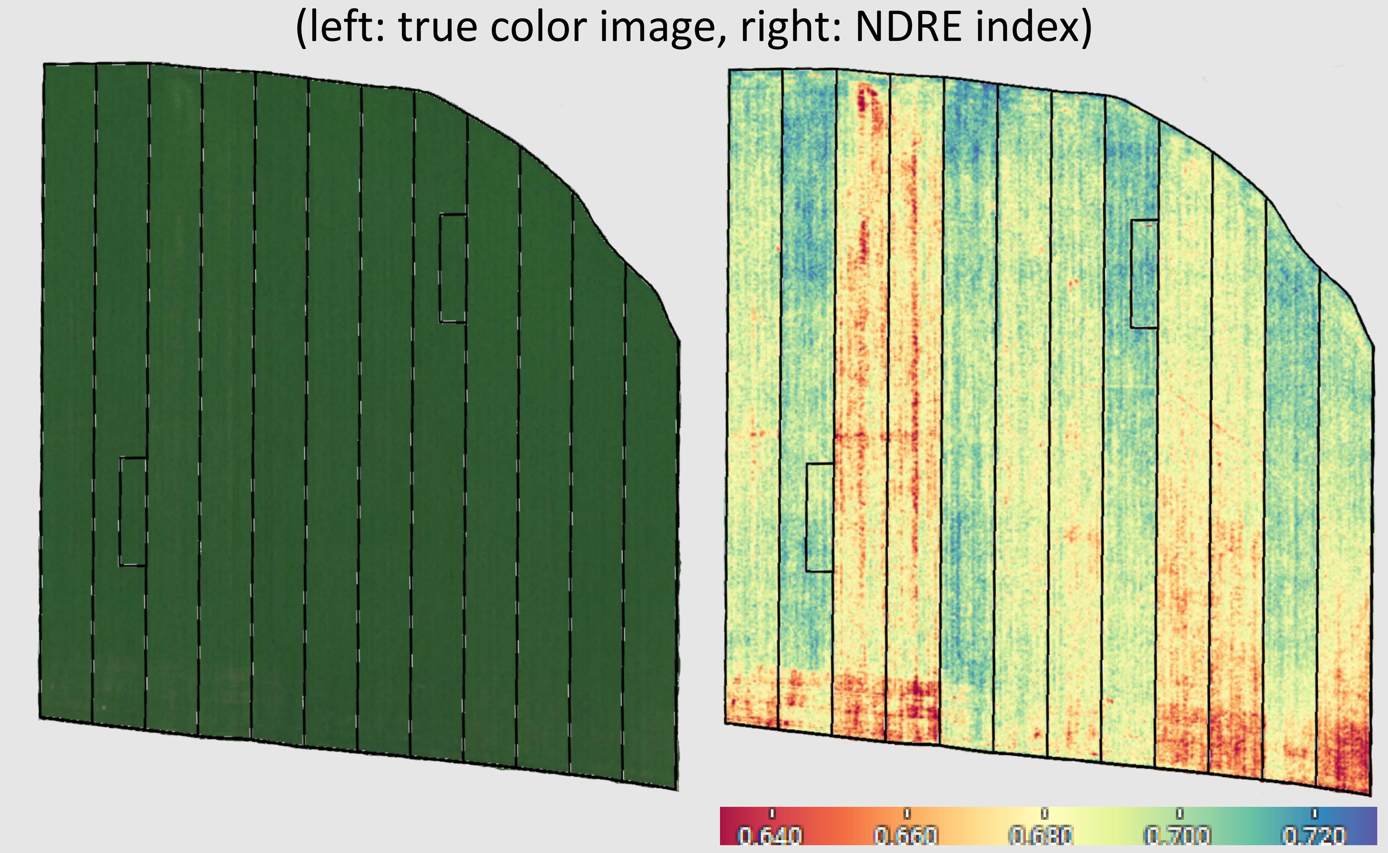
4. Imagery Acquisition

- Sensor: MicaSense RedEdge, 5 band sensor with wavelength centers of 475, 560, 668, 717, and 840 nm.
- Vegetation indices: NDVI and NDRE
- Each flight was calibrated with reflectance panels and downwelling light sensor data so that images can be compared across dates.
- Imagery was obtained on 6/5, 6/15, 6/24, 7/14, and 9/4.

5. Imagery processing

- Approximately 4,500 images were captured each flight. Imagery was stitched together into a composite using MicaSense Atlas cloud based software.
- True color and Normalized Difference Red Edge (NDRE) index were produced for each flight. Imagery from June 24 (below) were used to develop the in-season N prescription.

(left: true color image, right: NDRE index)



- For the NDRE map, unsupervised classification was used to remove pixels which are shadows and soil so that only plant pixels remain.
- A sufficiency index (SI) was calculated by dividing the NDRE of each pixel by the NDRE value of the top 5% of the field. This allows each portion of the field to be compared to non-N limiting corn.

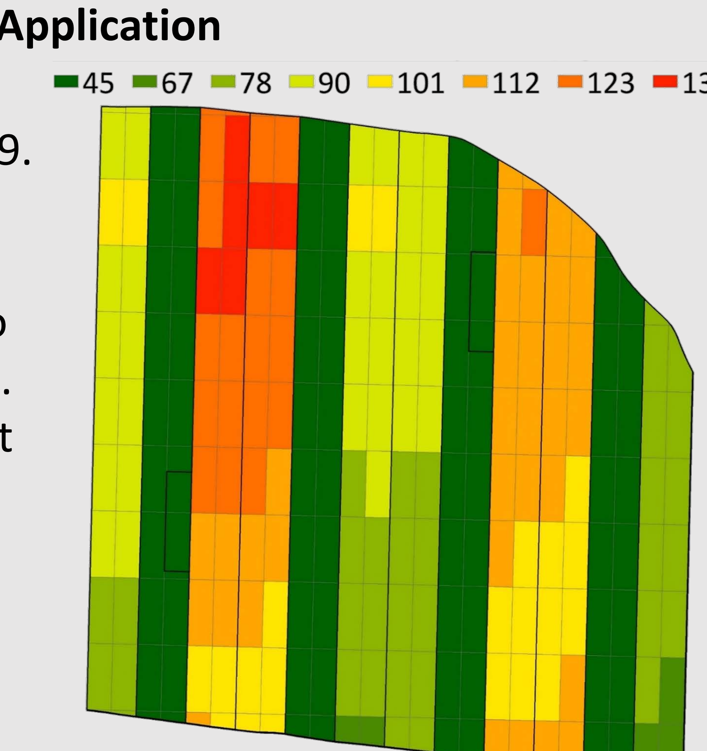
6. Determining In-season N Rates

The simplified Holland and Schepers (2010) algorithm was used to convert SI from June 24 to a N recommendation. For the 84 kg/ha, 112 kg/ha, and farmer management treatments, SI values were 0.86, 0.87, and 0.88 respectively. The algorithm requires an optimum N rate (ONR). A spatially varying ONR was calculated as follows:

a) 15 data layers were fused together to create management zones using Management Zone Analyst (USDA-ARS).
b) Yield goals were assigned to each zone based on past yield.
c) ONR was calculated spatially with the University of Nebraska – Lincoln nitrogen recommendation equation using the yield and interpolated organic matter.

7. Rx and Application

- In-season N was applied as stabilized Urea (46% N) on June 29.
- Variable rate capabilities of the airplane dictated the length of a given rate be at least 61 m and no more than 10 rates could be used.
- Prescription map used is shown at right.
- The farmer selected in-season rates of 45 kg/ha flat rate for the farmer management treatment.



Results and Discussion

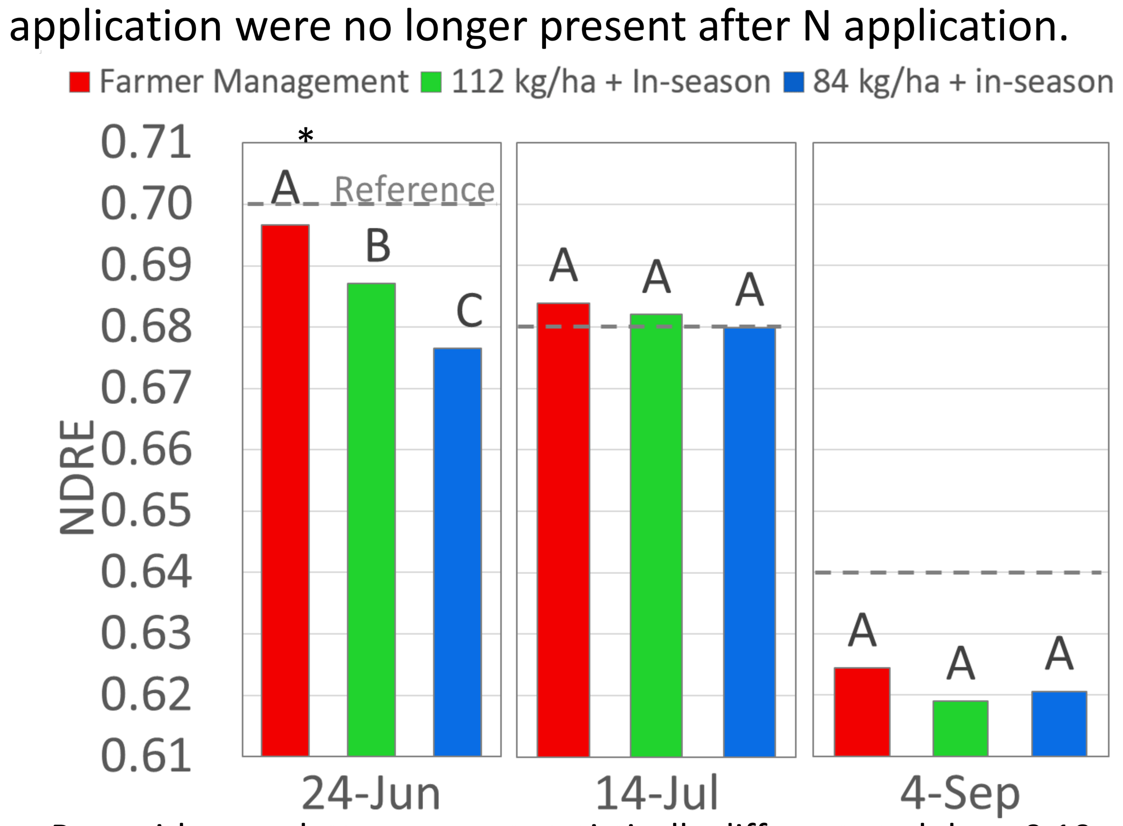
Total N Applied and Costs

Treatment	Base N Rate	Average In-season N Rate	Total N	Cost*
	----------------	kg/ha	--------------	$/ha
Farmer Management	179	45	224	$211.44
84 kg/ha base + in-season	84	114	198	$210.57
112 kg/ha base + in-season	112	84	196	$204.30

*Product costs: $0.625/kg N as anhydrous, $34.59/ha anhydrous application, $0.783/kg N as coated urea, $29.65/ha urea flat rate application, $33.98/ha urea variable rate application.

Imagery Pre- and Post- Application

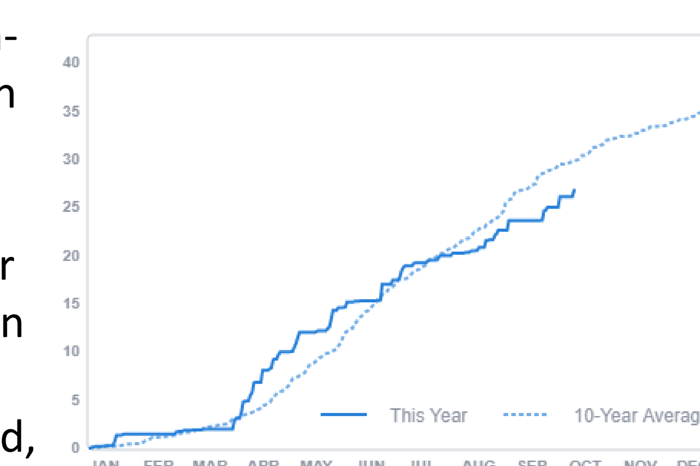
Imagery before and after in-season N application shows the differences in NDRE values which existed prior to application were no longer present after N application.



Bars with same letters are not statistically different at alpha = 0.10.

Weather Variables

While one goal of in-season N application is to better assess crop need, below average rainfall after the date of in-season N application severely limited yield, likely resulting in over application of N.



Rainfall graph from interpolated radar data from FarmLogs

Future Research Questions

- In a non-irrigated environment, incorporation of predictive weather models may help inform N application.
- Unlike applications with a high clearance applicator where the crop is only sensed once and applied at that time, this study collected imagery data over many dates leading up to the in-season N application. More work is needed to identify indicators in imagery of when to apply in-season N application.