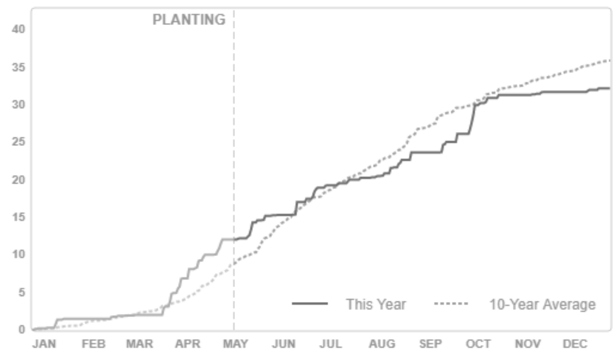
EXTENSION
On-Farm Research

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

**Study ID:** 416147201701
**County:** Richardson
**Soil Type:** Nodaway silt loam occasionally flooded; Zook silty clay loam occasionally flooded; Wabash silty clay loam occasionally flooded
**Planting Date:** 5/8/17
**Harvest Date:** 10/20/17 and 10/26/17
**Population:** 32,800
**Row Spacing (in):** 30
**Hybrid:** P1197
**Reps:** 4
**Previous Crop:** Soybean
**Tillage:** No-Till

**Irrigation:** None
**Rainfall (in):**




**Soil Tests (2015 – averaged over study area):**

| OM % | CEC | pH | P | K | S | Zn | B | Fe | Mg | Mn | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ----------------------------------------------- | | | | *(ppm)* | | | | ----------------------------------------------- |
| 2.5 | 14.8 | 6.6 | 45 | 134 | 9.0 | 3.3 | 0.45 | 149.3 | 231.5 | 103.7 | 11.5 |

**Introduction:** Applying a portion of the 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 and allows 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 topography, and contour and terrace farming practices. Some farmers in these landscapes rely on airplanes for in-season N applications. Additionally, small, passive, multi-spectral sensors can be carried on drones, enabling crop sensing to occur from the air. This study uses drone based sensing and aerial N application to demonstrate in-season N management, which is conducted without vehicles on the ground in the field.

The goal of this research project is to 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. Determining the correct amount of N to apply as a base rate to provide the crop with enough N to reach the in-season N application is also critical. This study evaluated two different N base rates to attempt to identify the optimum base rate for in-season sensing and application.

There were three treatments (*Figure 1*):

1. Farmer management: 160 lb N/ac + flat rate in-season N application if needed

2. 75 lb/ac N base rate + in-season N management directed by drone

3. 100 lb/ac N base rate + in-season N management directed by drone.

A high N reference received 225 lb N/ac in two smaller blocks.

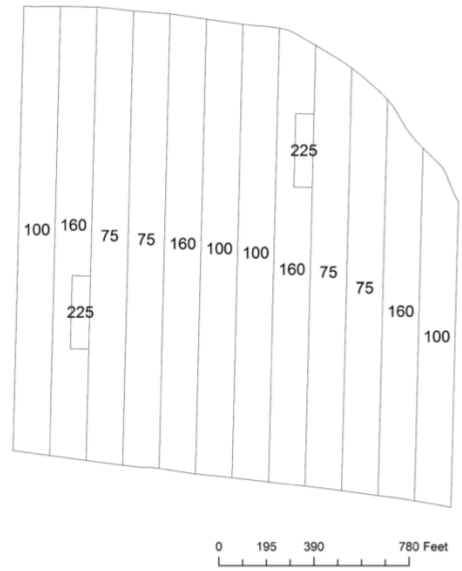



**Figure 1.** Treatment layout for study with base N rates labeled (lb/ac).

Pre-plant N was applied on February 15 as anhydrous ammonia. During the growing season, the field was flown with a DJI Inspire drone equipped with a MicaSense Red Edge 5 band sensor. Imagery was obtained on June 5, June 15, June 24, July 14, and September 4. The normalized difference red edge (NDRE) index was calculated for each flight. The NDRE index uses the near-infrared portion of the spectrum and allows differences in crop vegetation to be apparent, even when not visible in regular, true-color imagery *(Figure 2)*. NDRE data was processed with unsupervised classification 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 percent of the field (virtual reference method). This allows each portion of the field to be compared with non-N limiting corn. NDRE data from the June 24 flight *(Figure 2)* was used to create an in-season, variable-rate prescription.

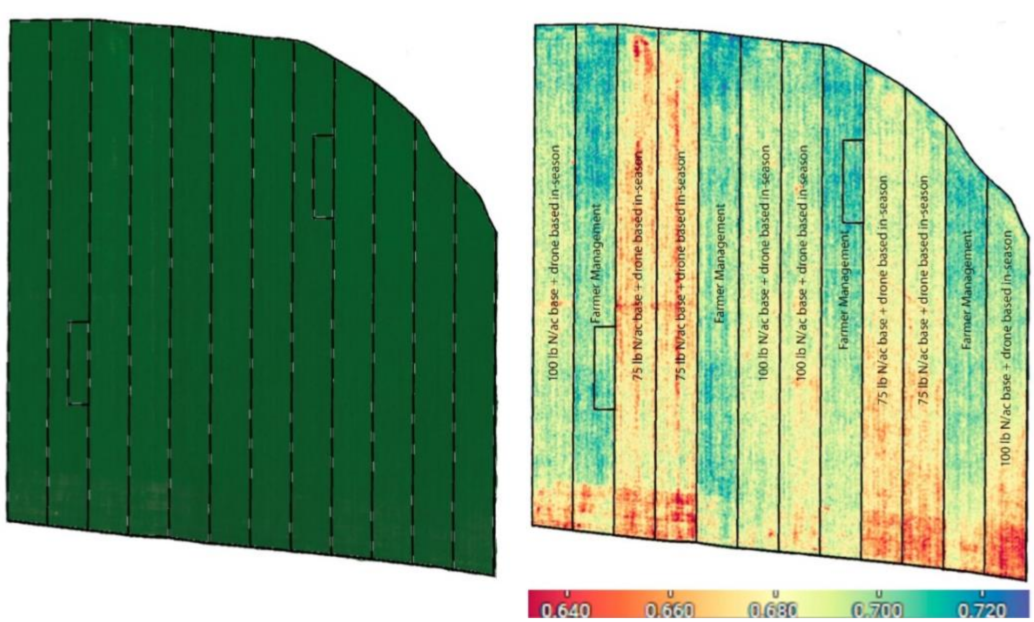



**Figure 2.** True color image (left) and NDRE (normalized difference red edge index) (right) of the study area on June 24, 2017 at V12.

In-season N application was applied as stablized urea (46% N) on June 29. Variable rate capabilities of the airplane dictated the length of a given rate be at least 200 ft and no more than 10 rates could be used. The in-season, variable-rate prescription is shown in *Figure 3*. The farmer elected to apply 40 lb N/ac to the farmer managed strips at this time.

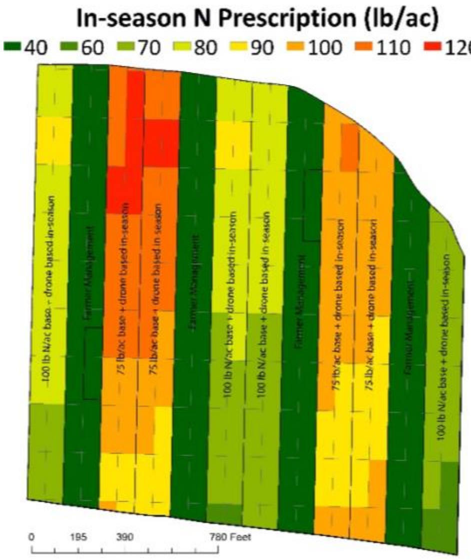



**Figure 3.** In-season N prescription applied on June 29 at V13 to V14.

NDRE values from imagery prior to and after in-season N application were collected as well as final crop yield and net return.

**Results:**

The imagery collected before and after the in-season N application revealed that differences which existed prior to application were no longer present after N application. This suggests that following the in-season N application, the crop was able to recover from any N deficiency *(Figure 4).*

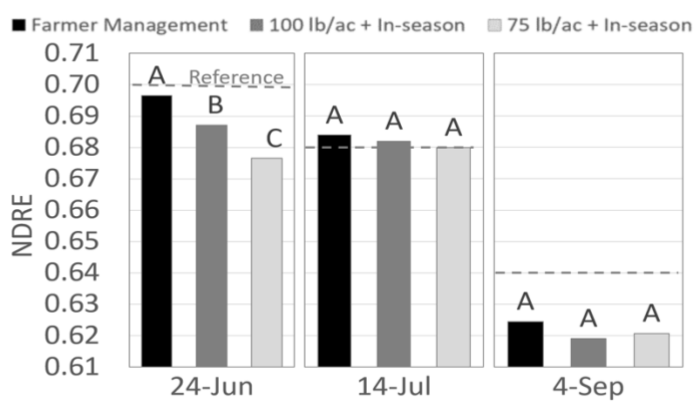



**Figure 4.** NDRE from the three treatments prior to and after N application. Reference is values from the high N rate blocks.

| | Total N rate (lb/ac) | Moisture (%) | Test Weight | Yield (bu/ac)† | NUE (lb N/bu grain) | Marginal Net Return‡ ($/ac) |
|---|---|---|---|---|---|---|
| Grower N Management | 200 | 15.2 A* | 60 A | 246 A | 0.81 A | 689.86 A |
| Drone Management with 75 lb Base | 177 | 15.3 A | 60 A | 247 A | 0.72 B | 692.51 A |
| Drone Management with 100 lb Base | 175 | 15.4 A | 60 A | 246 A | 0.71 B | 692.64 A |
| P-Value | N/A | 0.473 | 0.345 | 0.971 | 0.002 | 0.962 |

*Values with the same letter are not significantly different at a 90% confidence level.

†Yield values are from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

‡Marginal net return based on $3.15/bu corn, $465/ton anhydrous, $326.67/ton coated urea, $14/ac anhydrous application, $12/ac flat rate airplane application of urea, and $13.75/ac variable rate airplane application of urea.

**Summary:**

- There was no yield difference between the farmer managed strips and drone managed strips.
- Both the 75 and 100 lb/ac pre-plant rates resulted in less total N application than the farmer rate. This resulted in higher N use efficiency for the drone managed strips.
- Costs for N fertilizer and application were comparable between the three treatments.
- In order to optimize sensor-based in-season N application, it is necessary to time the N application to when the crop is expressing N deficiency, but prior to non-recoverable yield loss. A drone is one platform that allows the field to be sensed multiple times throughout the growing season with the goal of identifying the ideal timing for in-season N application. Further work is needed to develop guidelines for the ideal threshold for triggering in-season N application based on sensor readings.
- This study will be continued on two farms in 2018.

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**Sponsored by:** **In Partnership with:**

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