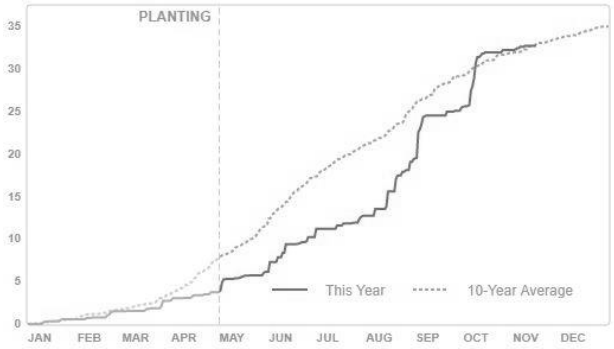
Using Drone Based Sensors to Direct Variable-Rate In-Season Aerial Nitrogen Application on Corn

Study ID: 0810147201801
County: Richardson
Soil Type: Monona silt loam 1-6% slopes
Planting Date: 5/1/18
Harvest Date: 9/28/18
Population: 29,500
Row Spacing (in): 30
Hybrid: MOEWS 3751
Reps: 4
Previous Crop: Soybean
Tillage: Strip-Till

Irrigation: None
Rainfall (in):



Soil Test (Nov. 2017 – 7 samples, averaged over study area):

Soil pH 1:1	Buffer pH	CEC	OM	Nitrate-N	Bray P1	Bray P2	K	S	Mg	Mn	Cu	B	Zn
		mg/100g	*%*	*ppm*	*ppm*	*ppm*	*(ppm)*						
6.5	6.9	16.52	3.0	6.7	29	38	165	22	185	6.4	0.74	0.76	4.7

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 that 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 that 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.

There were two treatments:

1. Farmer management: 160 lb N/ac
2. Drone management: 100 lb/ac N base rate + in-season N directed by drone and applied by airplane.

Pre-plant N was applied on November 30, 2017, as anhydrous ammonia. During the growing season, the field was flown with a DJI™ Inspire 2 drone equipped with a MicaSense® RedEdge® 5 band sensor. Imagery was obtained on June 3, June 10, June 18, June 22, June 27, July 8, July 21, and August 9. The normalized difference vegetation index (NDVI) was calculated for the June 3 and June 10 flights. For the remaining flights, the normalized difference red edge index (NDRE) was used. 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. A sufficiency index (SI) was calculated by dividing the NDRE of the target N application area to 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. NDRE data from the June 27 flight (Figure 2) was used to create an in-

season prescription. Due to very similar N recommendation rates across the field, only one N rate was applied at a rate of 25 lb/ac. In-season N application was applied as urea (46% N) with Gavilon Nitrolock Technology™ NBPT nitrogen stabilizer on June 28. On June 30, the field received a 1.07" rainfall.

NDRE values from imagery prior to and after in-season N application were collected as well as final crop yield, moisture, test weight, nitrogen use efficiency (NUE), and net return.

Results:

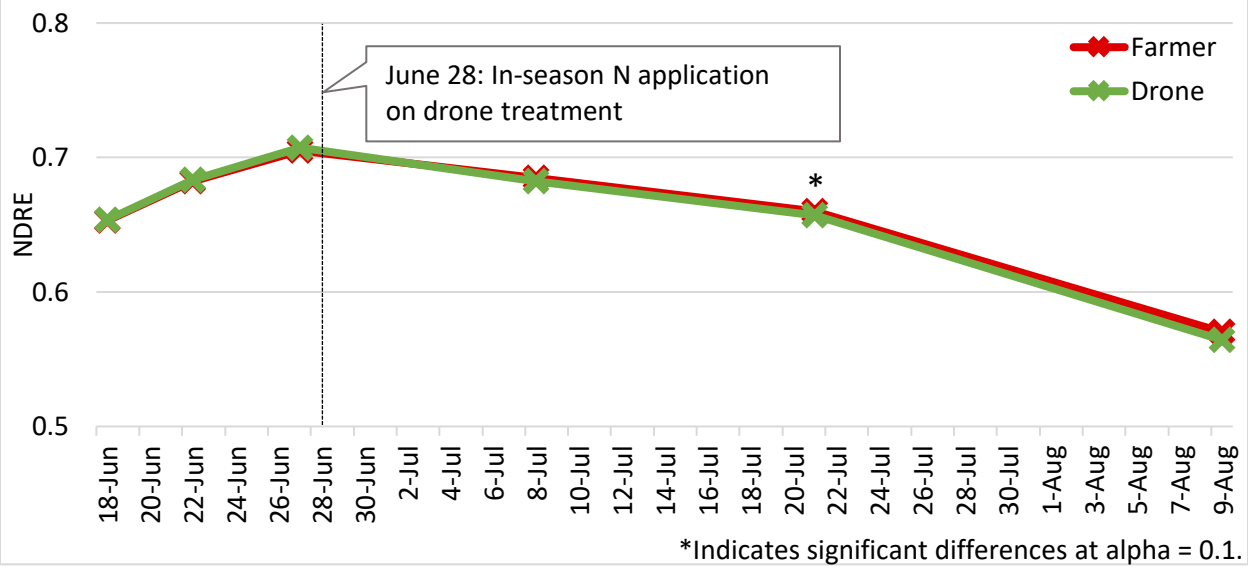


Figure 1. Normalized difference red edge index (NDRE) values for the farmer's N management versus the drone and sensor N management for flights on June 18, June 22, June 27, July 8, July 21, and August 9.

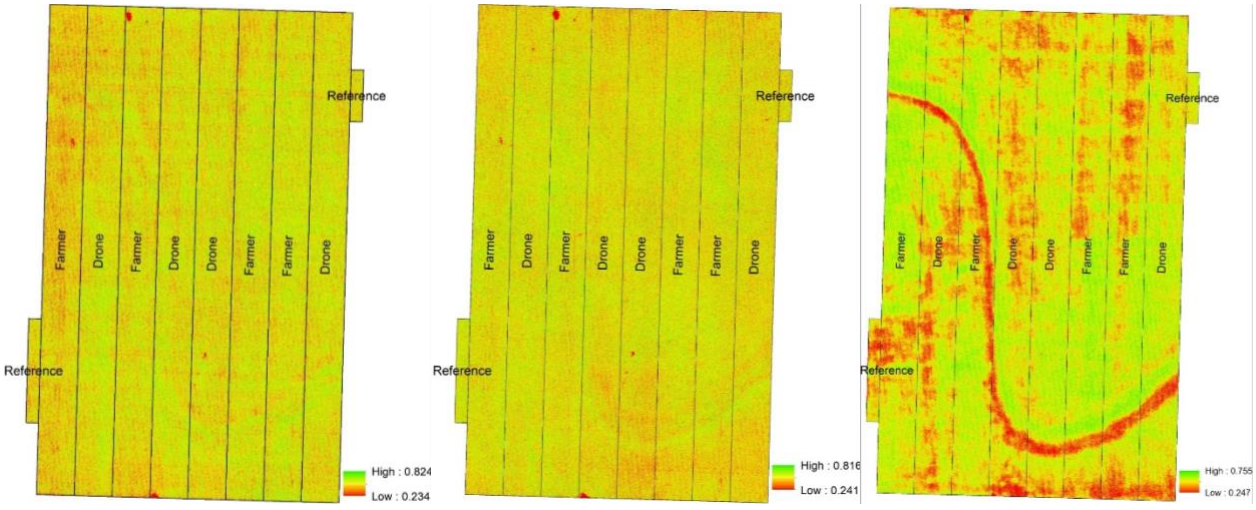


Figure 2. Normalized difference red edge index (NDRE) for June 27, prior to N application on June 28 (left), July 8, following N application (center), and on August 9 (right).

	Total N (lb/ac)	Moisture (%)	Test Weight	Yield† (bu/ac)	NUE (lb N/bu grain)	Marginal Net Return‡ ($/ac)
Farmer N Management	160	15.9 A*	59 A	203 A	0.79 A	606.44 A
Drone N Management	125	15.7 A	60 A	201 A	0.62 B	589.02 A
P-Value	-	0.212	0.295	0.667	0.001	0.175

*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 adjusted to 15.5% moisture.
‡Marginal net return based on $3.23/bu corn, $15/ac anhydrous application, $15.90/ac airplane urea application, $335/ton anhydrous, and $335/ton coated urea.

Summary:

- For the drone N management treatment, only 25 lb/ac was applied in-season. If the high N reference had been used in place of the virtual reference, no in-season N application would have been recommended (the sufficiency index calculated with the high N reference did not go below 0.99 through July 21); this is a potential topic of future research. Furthermore, throughout the season there was little to no difference in NDRE values between the drone N management and the grower N management.
- The drone N management method saved 35 lb/ac N compared to the farmer's traditional management. There was no yield difference between the two treatments. Nitrogen use efficiency was greater for the drone method, using only 0.62 lb N to produce a bushel of grain. Increasing N use efficiency is important in reducing negative environmental impacts of N application.
- Marginal net return was not statistically different; however, the drone N management method had an additional cost of an in-season application that the farmer's N management did not have.
- The field in this study was in D1 (moderate) to D2 (severe) drought throughout the entire growing season. It would be valuable to evaluate this technique for N management in a wet year.

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