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

Study ID: 0416147201801
County: Richardson
Soil Type: Kennebec silt loam rarely flooded; Zook silty clay loam occasionally flooded
Planting Date: 5/1/18
Harvest Date: 10/2/18
Population: 33,000
Row Spacing (in): 30
Hybrid: Pioneer® P1197
Reps: 4
Previous Crop: Soybean
Tillage: Strip-Till

Irrigation: None
Rainfall (in):

Soil Test (2017 – 17 samples, averaged over study area):

Soil pH	Buffer	CEC	OM	Bray P1	K	Ca	Mg	Mn	Fe	Na	Cu	B	Zn	H	Ca	Mg	K	Na
1:1	pH	*mg/100g*	*%*	*ppm*	*(ppm)*									*% Base Saturation*				
6.6	6.8	14.4	3.2	46	211	2190	229	101.6	151	19.2	1.5	0.44	2.5	6.1	76.4	13.3	3.8	0.6

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 regions with rolling topography, contour, and terrace farming practices, some farmers 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: 180 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 December 1, 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 (virtual reference method). 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 53 lb/ac. In-season N application was applied as urea (46% N) with Gavilon Nitrolock Technology™ NBPT stabilizer on June 28. On June 30, the field received a 0.45” 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:

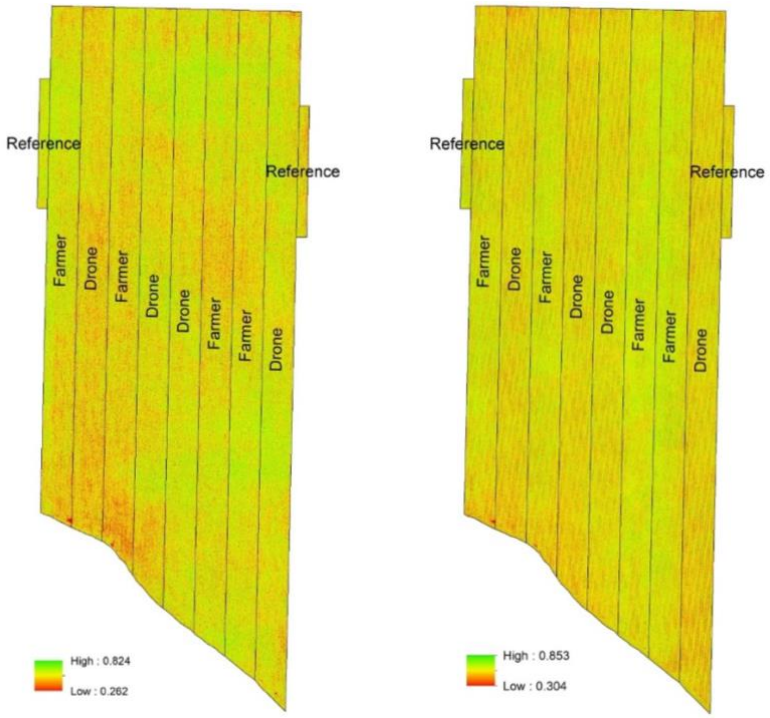

Figure 1. Normalized difference red edge index (NDRE) for June 27, prior to N application on June 28 (left) and July 8, following N application (right).

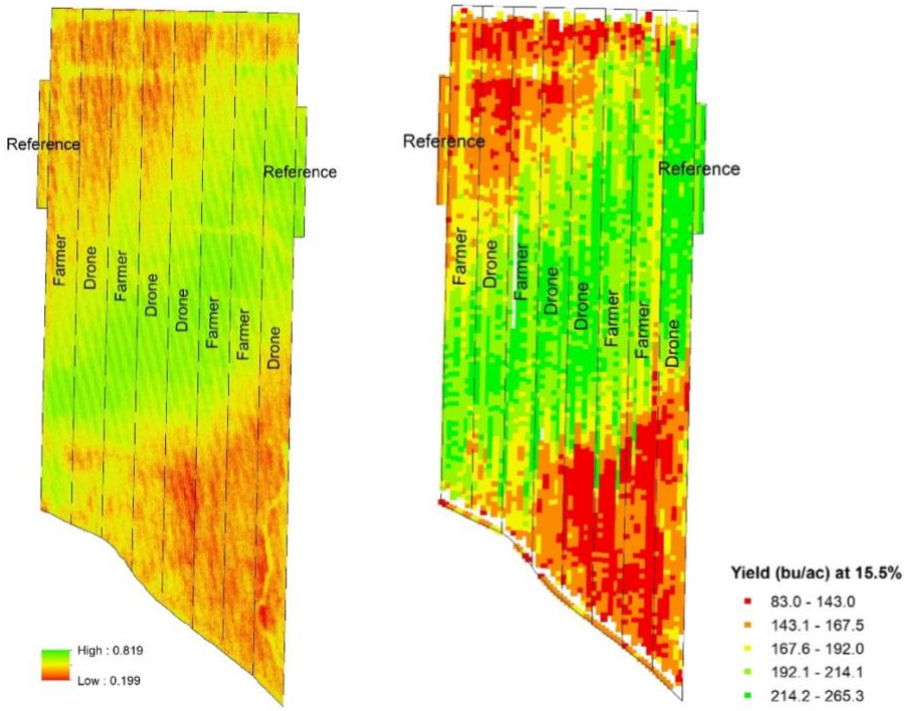

Figure 2. Normalized difference red edge index (NDRE) for August 9 (left) and yield map from October 2 (right).

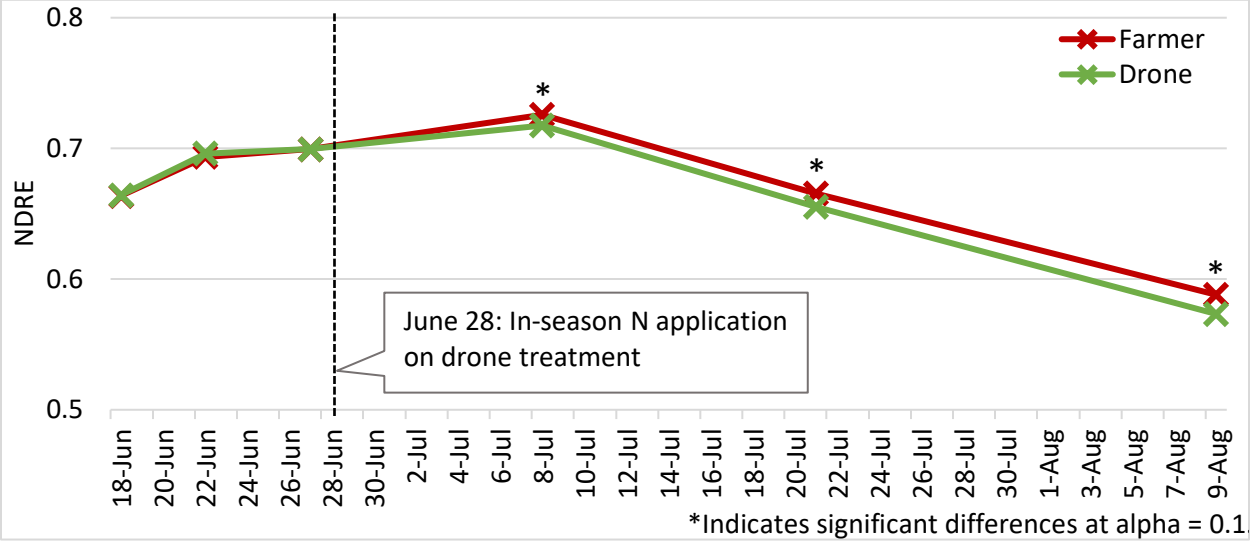

Figure 3. Normalized difference red edge index (NDRE) values for the farmer's N management versus the drone and sensor N management for flights on June 18, June 22, June 27, July 8, July 21, and August 9.

	Total N (lb/ac)	Moisture (%)	Test Weight	Yield† (bu/ac)	NUE (lb N/bu grain)	Marginal Net Return‡ ($/ac)
Farmer N Management	180	17.1 A*	58 A	183 A	0.99 A	538.89 A
Drone N Management	153	16.7 A	58 A	183 A	0.84 B	520.67 A
P-Value	-	0.205	0.231	0.947	0.002	0.128

*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, 53 lb/ac was applied in-season. If the high N reference had been used in place of the virtual reference, very little to no N would have been applied in-season (the sufficiency index calculated with the high N reference did not go below 0.97 through July 21); this is a potential area for future research.
- The drone N management method saved 27 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 0.84 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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