Efficient Use of Manure Nitrogen by Corn with Canopy Reflectance Guidance of Sidedress Application

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Objectives

Research was conducted to adapt corn canopy sensor technology for manured corn fields. The objectives were to:

- Determine the fertilizer N substitution value of organic N in feedlot manure
- Calibrate the algorithm for corn canopy sensor technology for manured fields.

Introduction

Nebraska finishes ~5,000,000 beef cattle yr^{-1} excreting about 35 kg head^{-1} N. Much N is lost to volatilization, but about 16 kg yr^{-1} head^{-1} of organic N is land applied. This totals ~80,000 Mg yr^{-1}, equal to the fertilizer N need of about 450,000 ha of corn. However, low predictability of manure organic N availability often causes farmers to apply more fertilizer N to manured fields than is needed resulting in low N use efficiency (NUE). Use of crop canopy sensors to quantify light reflectance from the crop leaves, assess leaf N level, and guide variable rate side-dress application of fertilizer N is well developed for corn production in Nebraska but not for manured fields. Variable rate side dress N application in response to canopy reflectance for manured fields has a great potential for improved NUE.

Materials and Methods

Experimental and treatments design

- Irrigated, no till, continuous corn in eastern Nebraska.
- Split-split plot organized on blocks with four replications
  - Whole plot: 0, 15 and 30 Mg ha^{-1} feedlot manure surface applied without incorporation. The manure N content was 0.09 and 5.45 kg Mg^{-1} of NH_4-N and organic N, respectively
  - Split plot: 0, 30, 60, 90 and 120 kg ha^{-1} N
  - Split-split plot: with or without sensor guided in-season N application

Measurements

- V8 to R6 measurements:
  - Normalized Difference Red Edge Index (NDRE) (Holland Scientific CS-45)
  - Leaf Area Index (Li-Cor Plant Canopy Analyzer-2200C)
- Grain yield, N uptake, and residual soil nitrate to 1.2 m depth)

In-season N application

- Based on NDRE at V12.
- N rate = 317 $\sqrt{0.97 - SI}$
- SI= $\frac{\text{NDRE}}{\text{NDRE (Non limiting plot=200 kgha}^{-1}\text{ N)}}$
- Agronomic efficiency = grain yield gained (kg) per kg fertilizer N applied

Yield response and fertilizer N substitution values

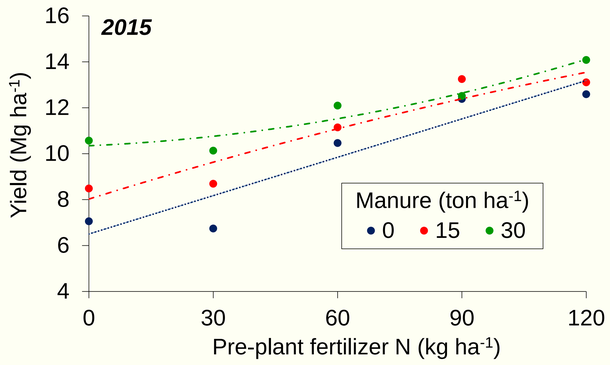


Fig. 1

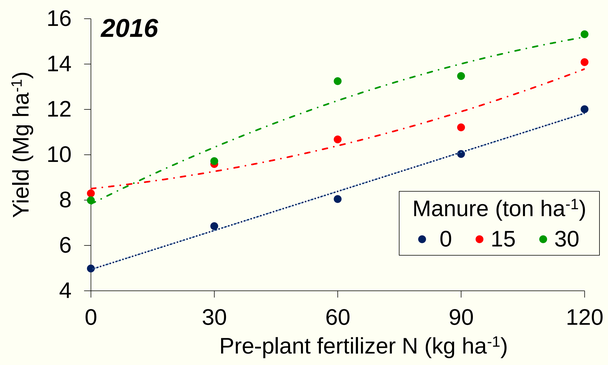
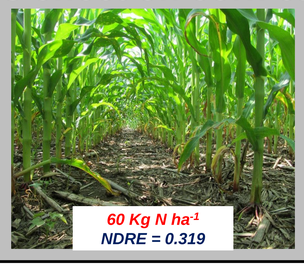


Fig. 2

Manure (ton ha^{-1})	15	30
Total Organic N applied (kg ha^{-1})	81.7	163.5
N substituted 2015 (kg N per kg N organic)	0.40	0.27
N substituted 2016 (kg N per kg N organic)	0.47	0.39

Table 1

Nitrogen rates effect on corn canopy at V-12



Results

- The fertilizer N substitution value of manure was 0.33 and 0.43 kg kg^{-1} of organic N applied for the first and second crop, respectively, following application. Manure and N rates did not affect the N substitution value except for a generally greater value with 0N compared to with fertilizer N applied for the 2015 crop (Table 1; Fig. 1 and 2)
- The residual N effect of manure application was greater during the second year compared with the first year (Table 1)
- NDRE at V12 was increased with manure application and for pre-plant N rate up to 90 kg ha^{-1} N (Table 3 and Fig. 3 and 4)
- For both years, in season N application based on sensor reading at V12 was reduced by increased pre-plant N or manure rates (Fig. 3 and 4)
- NDRE and sufficiency index values were affected by manure application and for pre plant N rates of 90 and 120 kg ha^{-1} (Fig. 3 and 4)
- Yield was no affected by manure x N interaction. Yields were similar for in-season N application for all preplant N rates except for higher yield with the 120 kg N preplant N rate in 2015 (Table 3; Fig. 6)
- For in season N application treatments, manure application and preplant N rate did not affect N AE (Fig. 5; Table 3)
- Similar yield and AE across treatments indicate good performance of the algorithm.

Treatments effect on NDRE and Sufficiency Index at V12 (2015-2016)

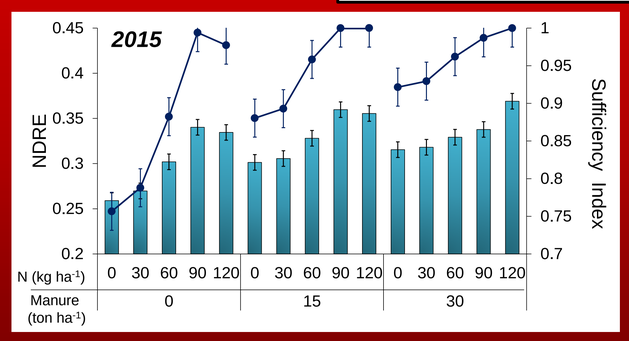


Fig. 3 NDRE Sufficiency Index

Table 2		NDRE 2015 Estimate	NDRE 2015 Pr > f	NDRE 2016 Estimate	NDRE 2016 Pr > f
Year		0.322 A	<.0001	0.3625 B	<.0001
Manure (ton ha^{-1})	0	0.301 C	0.0029	0.355 B	0.003
	15	0.330 AB		0.360 AB	
	30	0.334 A		0.372 A	
Nitrogen (kg ha^{-1})	0	0.292 c	<.0001	0.316 c	<.0001
	30	0.298 c		0.339 c	
	60	0.319 b		0.376 b	
	90	0.346 a		0.391 ab	
	120	0.353 a		0.395 a	
Manure*Nitrogen		0.075			0.783
Year * Manure		0.006			
Year*Nitrogen		0.017			

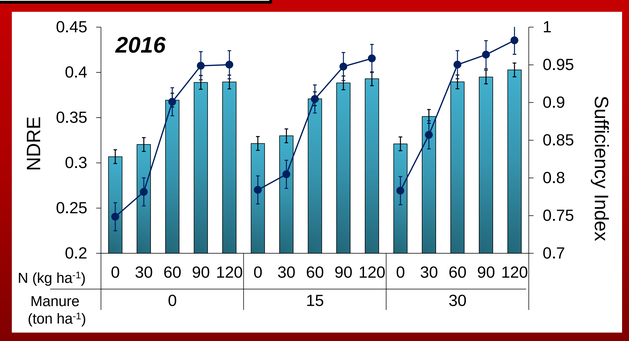


Fig. 4 NDRE Sufficiency Index

In-season N effects on yield and agronomic efficiency (2015-2016)

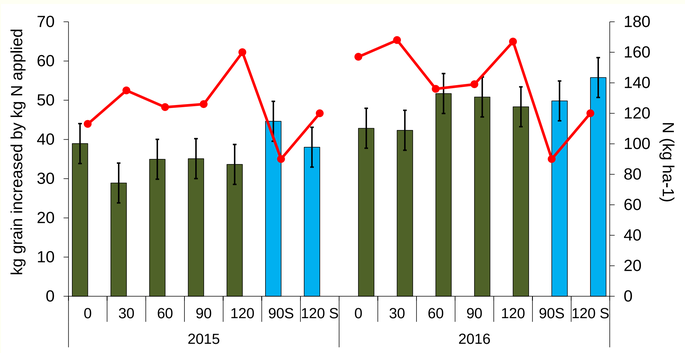


Fig. 5

Table 3			Yield Mg ha^{-1}	Yield Pr > f	Agronomic efficiency kg grain increased by kg N applied	Agronomic efficiency Pr > f
Year	2015		12.9 b	0.003	36.3 b	<.0001
	2016		13.7 a		48.8 a	
Manure (Mg ha^{-1})	0		12.5 B	<.0001	46.8	0.060
	15		13.6 A		42.1	
	30		13.9 A		38.8	
	Pre plant	In season				
Nitrogen (kg ha^{-1})	0	135	13.0 B	<.0001	40.9	0.306
	30	132	13.2 B		35.6	
	60	70	13.3 B		43.3	
	90	42	13.6 B		42.9	
	120	32	14.6 A		41.0	
	90	0	12.1 C		47.2	
	120	0	13.5 B		46.9	
Year * Manure			0.001		<.0001	
Year * Nitrogen			0.012		0.726	
Manure * Nitrogen			0.687		0.585	
Year * Manure * Nitrogen			0.494		0.446	

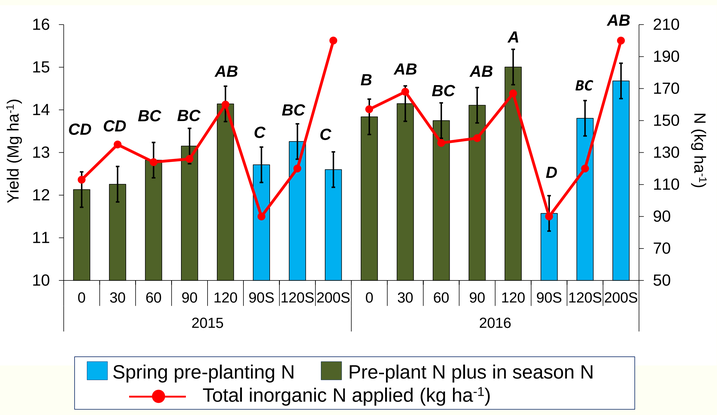


Fig. 6

Conclusions

- Feedlot manure and pre-plant fertilizer N rates do not affect the N substitution values for manure organic N during the two years after manure application
- The current algorithm for sensor guided in-season N application at V12 that was developed for unmanured fields worked well for manured fields in both years