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In-season N Fertilization Strategies using Active Sensors

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Abstract
The objectives of this project were to measure corn yield response to applied nitrogen (N) fertilizer based on active canopy sensing during the mid-vegetative corn growth stage (V10) and compare yield and N use efficiency between pre-plant N (PP-N), pre-plant + sensor N (PP+S-N), split N strategy (SNS), and rescue N strategy (RNS).

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Introduction

The objectives of this project were to measure corn yield response to applied nitrogen (N) fertilizer based on active canopy sensing during the mid-vegetative corn growth stage (V10) and compare yield and N use efficiency between pre-plant N (PP-N), pre-plant + sensor N (PP+S-N), split N strategy (SNS), and rescue N strategy (RNS).

Materials and Methods

This research was conducted at multiple farm locations in 2012 and 2013 (Table 1) on soybean-corn (SC) or continuous corn (CC). Pest control and corn management practices were typical for the region and crop rotation.

The sensor used was a Holland Scientific, Crop Circle ACS-210, with sensing and N application at the V10 stage. Normalized sensor index readings (NDVI) were calculated at each site using a virtual reference value (plot reading divided by the highest recorded index). The PP-N application was urea broadcast and incorporated or UAN banded sub-surface before planting (0 to 250 lb N/acre in 50 lb increments). The PP+S-N application was broadcast Agrotain-treated urea, with rates determined from normalized sensor values. The SNS was 75 lb N/acre (SC) or 100 lb N/acre (CC) PP-N plus Agrotain-treated urea-N determined by sensing. A minimum application rate was imposed at 75 lb N/acre (SC) or 100 lb N/acre (CC). The RNS was 150 lb N/acre (SC) or 200 lb N/acre (CC) PP-N rate plus Agrotain-treated urea-N determined by sensing. No maximum in-season N rate was imposed for either strategy (sensor determined N rate with no limitations). Corn was harvested with a plot combine, with yields corrected to 15.5 percent moisture.

Results and Discussion

Grain yields were lower than normal in 2012 and 2013 due to low growing season rainfall, which also reduced the need for additional N and response to in-season application (Tables 2 and 3). Yields were especially low for CC.

Corn responded to in-season N when PP-N rates were low, however canopy sensing tended to direct unneeded N application (Table 2) more with RNS than SNS. The across site Economic Optimum N Rate (EONR) was 138 lb N/acre for SC and 139 lb N/acre for CC (Table 3). The three strategies (PP-N, RNS, and SNS) had the same yield within each rotation. However, N use efficiency (agronomic efficiency or AE) was lower with RNS than PP-N and SNS with SC, but not different with CC (Table 2).

The dEONR (differential from EONR) for the PP+S-N (target of 0 dEONR) was the same when PP-N was 0, 50, or 100 lb N/acre, larger with the highest PP-N rates, and too high for all PP-N rates (Table 3). The active sensor system better directed in-season N rate with less PP-N, but still more N than needed. Grain yields for the PP+S-N rates were not different within each rotation, with the exception of lower yield with 0 lb N/acre PP-N.

Overall, active canopy sensor strategies (SNS or RNS) should include user-defined limits (min./max. rates) that reflect a total amount of expected N needed within an agronomic range for a CS or CC rotation.

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Table 1. Crop rotation, corn planting, and in-season (V10 growth stage) N application dates for multiple research farm locations, 2012 and 2013.

Farm Location	Crop rotation*	Corn planting†			In-season N date
		Date	Hybrid	Maturity (days)	
2012					
Ames	CC	Apr. 12	Dekalb 62-97	112	June 25
Kanawha	SC	May 10	Pioneer 0448XR	104	June 26
Nashua	SC	May 10	Dekalb 55-09	105	July 5
Crawfordsville	SC	May 10	Pioneer 0528AM	105	July 1
Lewis	CC	Apr. 25	Dekalb 63-42	113	June 28
Chariton	CC	May 15	Pioneer 0135AM	113	July 3
2013					
Ames	SC	June 1	AgriGold 6225	112	July 15
Ames	CC	May 16	Dekalb 62-54	112	July 11
Kanawha	SC	May 13	Pioneer 36V51	102	July 5
Nashua	SC	May 15	Pioneer 0297XR	102	July 5
Crawfordsville	SC	May 15	Dekalb 61-89	111	July 8
Greenfield	SC	May 16	Pioneer 1151AM	111	July 10

†Planting rate for all sites were 35,000 seeds/acre.
*CC=continuous corn, SC = soybean/corn rotation.

Table 2. Grain yield and N use efficiency comparison of pre-plant N (PP-N), rescue N (RNS), and split N (SNS) at multiple research farm locations, 2012 and 2013.

N Strategy	Pre-plant N Rate		Mean Sensor N Rate		Mean Total N Applied		Grain Yield		N Use Efficiency AE†	
	SC	CC	SC	CC	SC	CC	SC	CC	SC	CC
	- - - - - - - - - - - - - - - lb N/acre - - - - - - - - - - - - - - -						- - bu/acre - -		bu grain/lb N	
PP-N	150	200	0	0	150	200	168	94	0.37a	0.19
RNS	150	200	70	84	220	284	175	96	0.28b	0.14
SNS	75	100	100	126	175	226	171	95	0.33a	0.17
							Statistics			
							- - - - - - - - - p > F - - - - - - - - - -			
							0.389	0.951	0.012	0.304

†Agronomic efficiency (AE) calculated as [(N rate yield – zero N yield)/total N applied].
*CC = continuous corn, SC = soybean/corn rotation.

Table 3. Performance of active canopy sensor strategy with variable rates of pre-plant N (PP-N) at multiple research farm locations, 2012 and 2013.

PP-N Rate	PP-N Grain Yield		Pre-plant + Sensor-based N (PP+S-N) Mean Sensor N Rate		Mean Total N Applied		dEONR†		Grain Yield	
	SC	CC	SC	CC	SC	CC	SC	CC	SC	CC
lb N/acre	- - bu/acre - -		- - - - - - - - - - - - - - - lb N/acre - - - - - - - - - - - - - - -						- - bu/acre - -	
0	113	56	168	207	168	207	61de	79c	152b	84
50	146	80	114	158	164	208	57e	79c	168a	90
100	162	93	87	121	187	222	79d	93c	170a	96
150	168	102	87	93	237	243	130c	115c	170a	99
200	173	94	73	86	272	286	165b	157b	174a	102
250	172	109	67	95	317	345	210a	216a	170a	108
	Mean EONR						Statistics			
	- lb N/acre -						- - - - - - - - - p > F - - - - - - - - - -			
	138	139					<0.001	<0.001	<0.001	0.147

†dEONR, differential from the economic optimum N rate (EONR) is each site total applied N minus the site EONR from the PP-N strategy. The target dEONR was 0 lb N/acre at each site (no deficient or excess applied N). Letters indicate significant differences at the $P \leq 0.10$ level.
*CC = continuous corn, SC = soybean/corn rotation.