NC STATE UNIVERSITY

DEPARTMENT of SOIL SCIENCE

Evaluation of a Ground-Based N Sensor For Corn in North Carolina

C.R. Crozier, R.W. Heiniger, G.T. Roberson, R. Austin, R. Silva Santos, and R. Nogueira de Sousa; carl_crozier@ncsu.edu

Introduction

The Trimble Greenseeker is an active, light-based crop sensor currently available as a means of prescribing sidedress N rates to corn (*Zea mays* L.), but available calibration algorithms have not been evaluated for North Carolina conditions. This study attempts to quantify relationships between sensor NDVI values and corn plant N status and responses to additional N.

Objectives

- Evaluate specific assumptions inherent to the application of a crop sensor algorithm in predicting optimum sidedress N rates:

1) Does the sensor identify corn stands with suboptimal N rates? And is sensor efficacy sensitive to:
   - Growth stages (V5, V7, V10, V12)?
   - Sensor height above canopy?
   - Different ambient light conditions?
2) Do sensor NDVI values correlate with grain yields for stands receiving no additional N fertilizer?
3) Do sensor NDVI values correlate with the magnitude of grain yield response to additional N?

Methods & Materials

- 10 corn N response experiments 2013-2015
- Pioneer P1690HR (2013 & '14) or P1637AM (2015); at 88,900 seed ha^{-1}; 60-100 cm row spacing; all had 2-6 kg N ha^{-1} banded starter
- Experimental design – RCBD, 4 reps (approximately 3 x 15 m plots, 60-100 cm row spacing)
  - N Rate & timing variables; 20 combinations in 2013, 30 combinations in 2014, 2015:
    - N rates (all surface dribbled UAN 30 or 32%N)
      - At plant: 0, 56, 112, 168, 224, 280 kg N ha^{-1}
      - V7: 0, 84, 168 kg N ha^{-1}
      - V12: 0, 84, 168 kg N ha^{-1}
    - Trimble Greenseeker Sensor normalized difference vegetation index (NDVI)
      - Measurements at vegetative growth stages V5, 7, 10, 12 (not all sites/stages analyzed yet)
  - Yield: 2-4-row mechanized or 6.1 m row segment manual harvest
  - 1 site (adjacent to #10): 8 replicates with repeated sensor readings of the same plot row segments
    - 3 sensor heights above the canopy (61, 91, and 122 cm)
    - 2 relative ambient light conditions (greater intensity at mid-day, lesser intensity early morning or late afternoon)
    - 3 different N rate treatments
- Data analysis
  - SAS Proc GLM, F-protected LSD for N treatment comparisons (separately for each site)
  - SAS Proc CORR for linear correlation coefficient calculations (based on individual plot results and based on N treatment means). Correlations based on relative values when pooled across sites.
  - SAS Proc MIXED for factorial analysis of sensor efficacy; with fixed effects of light, N rate, sensor height; and random effect of replication.

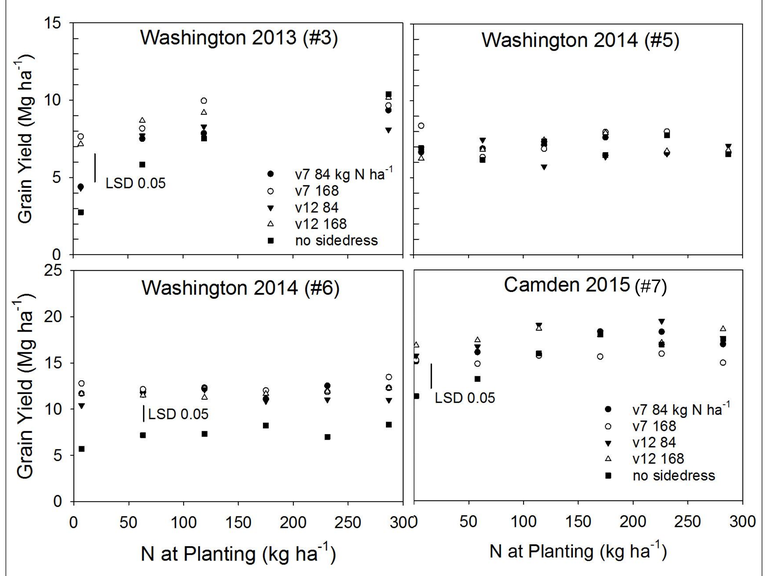
Sensor readings collected at V5, V7, and V10 growth stages with height adjusted to approximately 100 cm above canopy.

Table 1. Site characterization. Sites 6 & 10 were irrigated.

#	County	Soil†	Yield levels (Mg ha^{-1})		Sensor response to N (treatment means)				Sensor correlation with yield (individual plots) §				Sensor correlation with yield increase after sidedress††			
			0 N ‡	Max.	V5	V7	V10	V12	V5	V7	V10	V12	V5	V7	V10	V12
2013																
1	Beaufort	Cape Fear	8.0	10.3	ns	ns	ns	ns	ns	ns	***	ns	--	--	ns	ns
2	Washington	Portsmouth	4.6	11.0	ns	+	ns	+	ns	+	***	***	--	--	+,+	ns,+
3	Washington	Portsmouth	2.8	10.4	ns	+	**	***	ns	+	***	**	--	--	ns	ns,+
2014																
4	Henderson	Comus	8.0	15.6	--	--	--	ns	--	--	--	--	--	--	--	+
5	Washington	Cape Fear	6.9	8.4 ns	ns	ns	ns	ns	*	**	***	***	ns	*,+	ns,+	+,ns
6	Washington	Portsmouth	5.7	13.5	ns	+	ns	*	+	*	ns	***	ns	ns	ns	+,ns
2015																
7	Camden	Perquimans	11.3	19.5	ns	+	***	***	ns	ns	+	***	ns	ns	ns	+,ns
8	Henderson	Comus	6.2	19.5	--	--	--	--	--	--	--	--	--	--	--	--
9	Washington	Cape Fear	2.1	6.3	*	***	***	***	ns	***	***	***	+,**	ns,*	ns	ns
10	Washington	Cape Fear	3.7	7.3	***	***	***	***	***	***	***	***	ns	ns	ns	ns
Pooled data across sites (relative yield & ndvi values)									**	***	***	***	ns	ns	*	ns

† Soil classifications: Cape Fear & Portsmouth – Typic Umbraquults, Comus – Fluvaquentic Dystrochrepts, Perquimans – Typic Ochraquults.
‡ All plots received banded starter fertilizer including 2-6 kg N ha-^{1}.
§ Based on individual plots receiving no additional N following sensor reading.
†† Sensor values at V5 and V7 were correlated with treatment mean yield increase after sidedress applied at V7, and values at V10 and V12 were correlated with treatment mean yield increase after sidedress applied at V12. Separate correlations were run for each sidedress rate (symbols indicate significance probabilities at 84 & 168 kg N ha^{-1}, respectively).
Symbols indicate significant differences at p levels of +0.1, *0.05, ** 0.01, *** 0.001; with ns p>0.1.

N Response Examples

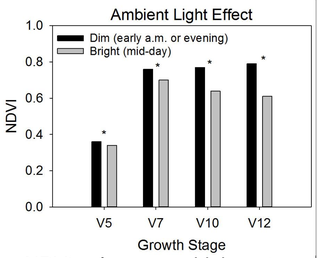


For each figure, vertical lines represent LSD $_{0.05}$ for treatment means comparisons. There was no significant response to N at site #5.

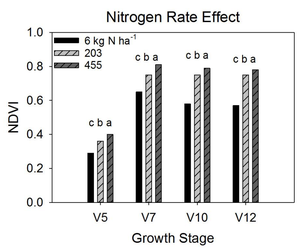
Sensor Efficacy Evaluation (adjacent to site #10)

Table 2. ANOVA results with responses at each growth stage to ambient light level, N rate treatment, sensor height, and interaction effects. Symbols indicate significant differences at p levels of *0.05, ** 0.01, *** 0.001; with ns indicating p>0.05 and letters indicating differences in means at p<0.05.

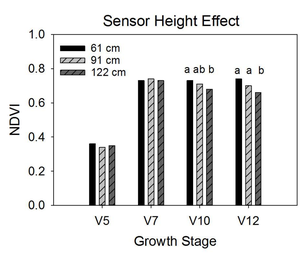
Effect	V5	V7	V10	V12
Light (Lt)	*	***	***	***
N	***	***	***	***
Height (Ht)	ns	ns	**	***
Lt x N	ns	ns	ns	ns
Lt x Ht	ns	ns	ns	*
N x Ht	ns	ns	ns	ns
Lt x N x Ht	ns	ns	ns	ns



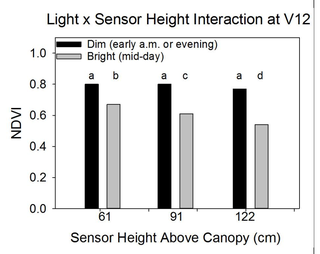
NDVI values were higher at dimmer light conditions for all growth stages tested.



NDVI values were higher at higher N rates for all growth stages tested.



At V10 and V12, NDVI values decreased as distance from the canopy increased.



NDVI did not vary with sensor height at dimmer light conditions, but with brighter light the NDVI values decreased as distance from the canopy increased.

Summary

-9 of 10 field sites exhibited grain yield responses to N fertilizer.
-Sensor NDVI more frequently identified low N rate treatments, and were more frequently correlated with grain yield levels, at V7-V12 than at V5.
-Pooled across sites, relative yield with no additional N fertilizer was positively correlated with relative NDVI at V5, 7, 10, & 12.
-Pooled across sites, the magnitude of the response to additional N was only significantly correlated with relative NDVI measured at V10 prior to a V12 sidedress.
-At an N-responsive site (#10), the Greenseeker sensor consistently differentiated among N rate treatments.
-Sensor values vary with ambient light intensity and height above the crop canopy.
-N sidedress prescriptions based on sensors such as the Greenseeker should consider effects of operational parameters (growth stages, sensor height, ambient light); as well as uncertainty in environmental conditions that are likely to influence response to additional N.

Acknowledgements

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