# Active Sensor Assessment of Corn Nitrogen Status and Yield Potential

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## INTRODUCTION

Use of active crop canopy sensor reflectance measurements of corn (Zea mays L.) nitrogen (N) status for directing spatially-variable N applications has been advocated to improve N use efficiency (NUE). We have assembled a prototype high-clearance applicator (Fig. 1) configured with model ACS-210 Crop Circle active sensors (manufactured by Holland Scientific of Lincoln, NE), drop nozzles with electronic valves, and variable rate controller that is intended to deliver in-season variable rates of liquid N fertilizer based on crop needs. The Crop Circle active sensor we are evaluating measures canopy reflectance in two bands (visible and NIR; centered at 590 and 880 nm). Our research goals were to determine the most appropriate: 1) growth stage and 2) sensor-determined vegetation index with greatest sensitivity in assessing canopy N status and yield potential.

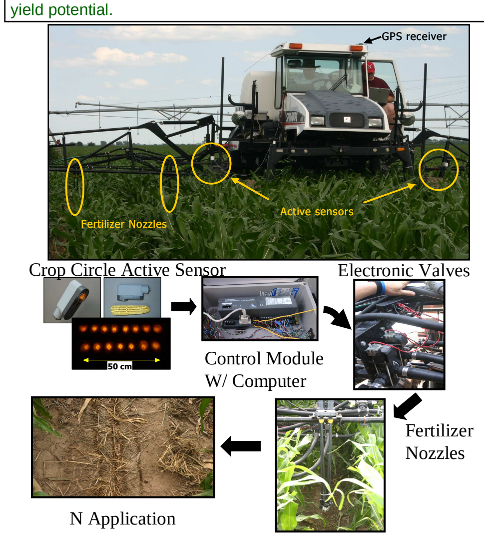


Fig. 1. Prototype in-season N applicator and system components.

## METHODS

Fig. 2. Aerial photograph of 1 of the 3 field studies conducted near Shelton, Nebraska in 2005 depicting small plots (consisting off 8 rows by 23.6 m) receiving 4 N rates (0, 45, 90, 270 kg ha-1) at planting and 5 N rates (0, 45, 90, 135, and 180 kg ha-1) at V11 & V15. Example of check plot (0 N) is denoted by yellow rectangle in image.

- Variable crop N conditions were generated by supplying fertilizer N at different amounts and times in three field studies in 2005 (Fig. 2).
- Crop Circle active sensor and chlorophyll meter readings were acquired at V11, V15, R1 and R3 growth stages (Fig. 1).
- Sensor readings in the 590 ($VIS_{590}$) and NIR bands were converted into two indices, the normalized difference vegetation index ($NDVI_{590}$) and chlorophyll index ($CI_{590}$) where:
  - $NDVI_{590} = (NIR - VIS_{590}) / (NIR + VIS_{590})$
  - $CI_{590} = (NIR / VIS_{590}) - 1$
- Chlorophyll meter and sensor readings were normalized to % of well fertilized check plot, also known as sufficiency index (SI).
- Grain yields determined at maturity.

## RESULTS

Table 1. Linear regression coefficient of determination ($R^2$) for linear relationships between variation in relative chlorophyll meter (CM) readings and relative values for two vegetation indices ($NDVI_{590}$, normalized difference vegetation index; $CI_{590}$, chlorophyll index) collected on four growth stages (two vegetative and two reproductive) for corn receiving varying amounts of N applied at different growth stages during the 2005 growing season at the MSEA 1, 2, and 3 sites located near Shelton, NE.

| GS and GDD+ | $NDVI_{590}$ | $CI_{590}$ |
|---|---|---|
| | MSEA 1 | |
| V11 (600) | 0.468** | 0.495** |
| V15 (700) | 0.784*** | 0.812*** |
| R1 (800) | 0.524** | 0.546** |
| R3 (1000) | 0.330** | 0.663*** |
| | MSEA 2 | |
| V11 (600) | 0.339*** | 0.339*** |
| V15 (700) | 0.364*** | 0.389*** |
| R1 (800) | NS | NS |
| R3 (1000) | NS | NS |
| | MSEA 3 | |
| V11 (600) | 0.725*** | 0.776*** |
| V15 (700) | 0.821*** | 0.847*** |
| R2 (900) | 0.201*** | 0.185*** |
| R3 (1000) | 0.042* | 0.040* |

*, **, *** significant at 0.05, 0.01, 0.001 levels, respectively.
NS, nonsignificant.
+, GS, growth stage according to Ritche; GDD, growing degree days according to McMaster and Wilhelm, 1997).

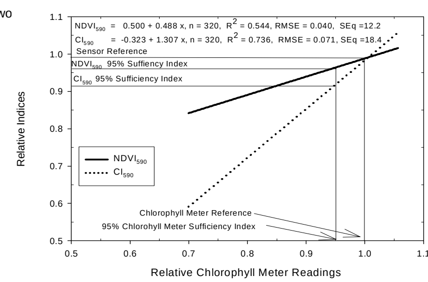


Fig. 3. Linear relationships between variation in relative chlorophyll meter readings and variation in relative values for two sensor-determined vegetation indices ($NDVI_{590}$, normalized difference vegetation index; $CI_{590}$, chlorophyll index) collected on the two vegetative growth stages (V11 and V15) for corn receiving varying amounts of N applied at different growth stages during the 2005 growing season at the MSEA 1 and 3 sites located near Shelton, NE. Regression parameters provided include sample number (n), slope, coefficient of determination ($R^2$), root means square error (RMSE) and sensitivity equivalent (SEq, SEq=RMSE/slope) for each relationship.

## RESULTS (continued)

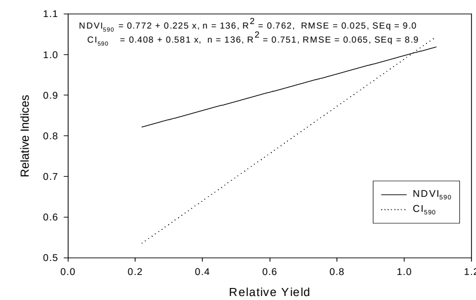


Fig. 4. Linear relationships between variation in relative grain yield and variation in relative values for two sensor-determined vegetation indices ($NDVI_{590}$, normalized difference vegetation index; $CI_{590}$, chlorophyll index) collected on the two vegetative growth stages (V11 and V15) for corn receiving varying amounts of N applied at planting during the 2005 growing season at the MSEA 1 and 3 sites located near Shelton, NE. Regression parameters provided include sample number (n), slope, coefficient of determination ($R^2$), root means square error (RMSE) and sensitivity equivalent (SEq, SEq=RMSE/slope) for each relationship.

- As shown in Table 1, nitrogen-induced variation in sensor-determined vegetation indices was more highly correlated with CM readings for vegetative (maximum $R^2$ of 0.85 for V11 or V15) vs. reproductive growth (maximum $R^2$ of 0.55 for R1 or R3).
- Stronger association between sensor and CM readings during vegetative growth was attributed to the inability of the sensor to detect variation in canopy greenness due to interference from tassels during reproductive growth.
- Slope value for CM vs. $CI_{590}$ relationship was over two times greater than the slope for the $NDVI_{590}$ relationship (Fig. 3).
- The sensitivity equivalent (SEq) value was also greater for the $CI_{590}$ vs. the $NDVI_{590}$ relationship (Fig. 3).
- Collectively, these results indicate $CI_{590}$ is more sensitive than $NDVI_{590}$ in detecting variation in canopy greenness (Fig. 3).
- The SEq values indicated there was no sensitivity differences between indices in distinguishing yield variation (Fig. 4).
- Our results indicate active sensor readings collected during vegetative growth and expressed as $CI_{590}$ are better suited than $NDVI_{590}$ for directing spatially variable in-season N applications and improving NUE.