# EVALUATING MULTIPLE INDICES FROM A CANOPY REFLECTANCE SENSOR TO ESTIMATE CORN N REQUIREMENTS

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## INTRODUCTION

✓ Concurrent research (Session 51-7, Poster #259) has shown that Relative Green Normalized Difference Vegetation Index (RGNDVI; Table 1) measured using an active sensor such as Crop Circle (Holland Scientific Inc., Lincoln, NE) can be used to estimate in-season N requirements for corn.

✓ While the index GNDVI (Table 1) can be calculated directly using the Crop Circle sensor, simultaneous reflectance measurements in the near-infrared (NIR) and Green bands can be used to calculate different vegetation indices (Table 1), which can be potentially used to estimate in-season N requirements for corn.

✓ Fluctuations in the N:corn price ratio, emphasize the relevance of explicitly considering the N:corn price ratio in developing N recommendations for corn.

## OBJECTIVES

✓ Evaluate different vegetative indices derived from an active reflectance sensor in estimating in-season economic optimum N rate (EONR) for corn.

✓ Consider the influence of N:Corn price ratio on the EONR developed using these indices.

## METHODS

✓ Field experiments were conducted at 8 sites in central Pennsylvania during two growing seasons with varying crop rotations and manure history.

✓ A two-way factorial experimental design was implemented as a split plot in randomized complete blocks with four blocks:

- ✓ Main plot: N applied at planting ($N_{PL}$): Zero, 56 kg ha$^{-1}$ N as $NH_4NO_3$ and 37 – 122 kg ha$^{-1}$ available N as dairy manure.
- ✓ Subplots: N rates applied at V6 ($N_{V6}$: 0, 22, 45, 90, 135, and 180 kg N ha$^{-1}$ in 2005 and 2006, plus 280 kg ha$^{-1}$ in 2006).

✓ Quadratic-plateau (QP) model was used for determining EONR at V6.

✓ The following N:Corn price ratios were evaluated: 4:1, 6:1, 8:1, 10:1, 12:1, and 14:1 ($ kg$^{-1}$ N : $ kg$^{-1}$ Corn).

### Sensor System

✓ Crop Circle ACS-210 Plant Canopy Reflectance Sensor (Holland Scientific, Inc., Lincoln, NE)

✓ Uses a modulated polychromatic Light Emitting Diode (LED) array that emits light in the NIR (880 nm) and Green (590 nm) region of the spectrum.

✓ Canopy spectral measurements were taken just prior to $N_{V6}$ applications.

Table 1. Different spectral vegetation indices used in this study.

| Abbreviation | Spectral bands and indices | Formula |
|---|---|---|
| G | Green | G |
| NIR | Near-Infrared | NIR |
| GDVI | Green Difference Vegetation Index | NIR – G |
| GRVI | Green Ratio Vegetation Index | NIR/G |
| GNDVI | Green Normalized Difference Vegetation Index | (NIR – G)/(NIR + G) |
| GSAVI | Green Soil Adjusted Vegetation Index | [(NIR – G)/(NIR + G + 0.5)] × 1.5 |
| GOSAVI | Green Optimized Soil Adjusted Vegetation Index | (NIR - G)/(NIR + G + 0.16) |

✓ Relative indices were calculated using a reference plot, one that received the highest N rate at a site-year. For Example:

Relative GNDVI (RGNDVI) = $GNDVI_{plot}$ / $GNDVI_{reference\ plot}$

## RESULTS

### Corn Grain Yield Response to Nitrogen Treatments

✓ Mean sub-plot corn grain yields across the experimental sites ranged from 2.9 to 14.3 Mg ha$^{-1}$.

✓ There was no response to $N_{V6}$ applications at three site-years where corn followed soybean or alfalfa and had high residual soil $NO_3$-N level (PSNT: 23.8, 34.2 and 47.3 mg kg$^{-1}$) at V6 (Critical level for PSNT in PA is 21 mg kg$^{-1}$ $NO_3$-N).

✓ The range of EONR at a 6:1 N:Corn price ratio for the 24 site-year-$N_{PL}$ combinations was 0 to 220 kg ha$^{-1}$ with a mean of 69 kg ha$^{-1}$.

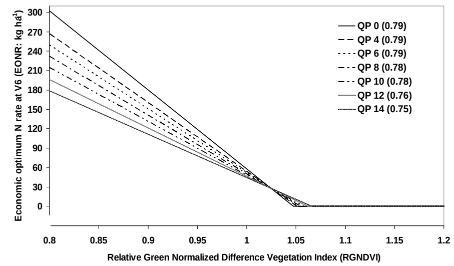


Fig 1. Relationships between economic optimum N rate ($N_{V6}$) and Relative Green Normalized Difference Vegetation Index (RGNDVI) and the best-fit linear-floor models at different N:Corn price ratio. QP4 refers to economic optimum N rate calculated using a N:Corn price ratio of 4:1. The numbers in parentheses indicate the $R^2$ for the corresponding linear-floor model.

### Determination of EONR Using Crop Reflectance

✓ The raw reflectance values for the NIR and Green were not significantly correlated with EONR.

✓ Among the different absolute indices, only GSAVI was significant and accounted for 45% of the variability in a linear relationship with EONR.

✓ Among the relative indices investigated, RGRVI ($R^2$ = 0.71) and RGNDVI ($R^2$ = 0.71) accounted for the greatest amount of variability in a linear regression with EONR.

✓ Overall, a linear-floor model using RGNDVI was as good or better an estimator ($R^2$ = 0.79) for EONR than any of the indices considered.

✓ At a N:Corn price ratio of 6:1:

EONR (kg ha$^{-1}$) = 1040.4 + (-988.4 × RGNDVI)
when RGNDVI < 1.0527
$R^2$ = 0.79

✓ For a selected value of RGNDVI (e.g., RGNDVI = 0.8750) the N rate to achieve maximum yield is highest (210 kg N ha$^{-1}$ for QP0) and the EONR decreases with an increase in the price ratio (EONR of 187, 176, 164, 152, 141, 129 kg N ha$^{-1}$ at a price ratio of 4:1, 6:1, 8:1, 10:1, 12:1, and 14:1, respectively).

### Influence of N:Corn Price Ratio on the Relationship between EONR and Crop Reflectance

✓ The resultant parameters from two regression models (the slope and intercept of each of the linear-floor models (Fig 1) and the corresponding N:Corn price ratio) were used to develop a model to determine EONR at any N:Corn price ratio:

$EONR_{PR}$ = [1281.7 + (-40.21 × PR)] + [(-1223.9 + (39.26 × PR)) × RGNDVI]
where PR is the price ratio calculated as:
PR = Price of fertilizer N ($ kg$^{-1}$ N) / Price of Corn ($ kg$^{-1}$ corn)

✓ The change in EONR between N:Corn price ratios is greater when the slope of the yield response function is smaller (Fig 2).

✓ This indicates that the effect of N:Corn price ratio on EONR is not additive and can vary based on the nature of corn response for a given year and/or field.

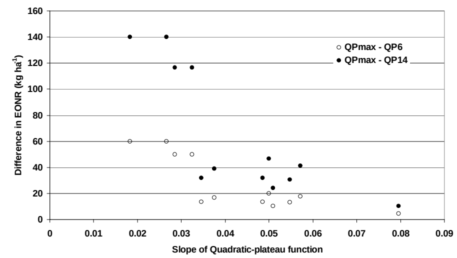


Fig 2. Relationship between the change in EONR between N:Corn price ratios and slope of the quadratic portion of QP.

## CONCLUSIONS

✓ Spectral reflectance of corn expressed using GNDVI relative to a high-N strip was strongly related to EONR ($R^2$ = 0.79), performing as well or better than any other indices considered in this study.

✓ The prediction model was effective for a wide range of initial soil N fertility and can be used to estimate in-season EONR at any given N:Corn price ratio.