Evaluation of Optical Canopy Sensors for In-Season N Rate Management in Corn

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INTRODUCTION

Optical canopy sensors are an emerging technology that can serve as a useful in-season N fertilizer management tool for corn (*Zea mays* L.) production. The sensors provide an estimate of plant biomass and N status at the time of sensing. These growth parameters can be used to make in-season N rate adjustments and variable rate N applications. Currently, a robust and accurate algorithm to determine the appropriate N rate based on canopy sensing is need in order to improve the effectiveness of active sensors in production fields. The objective of this study is to determine the ability of optical canopy sensors to differentiate N stress in corn for adjustment of N fertilization rates.

MATERIALS AND METHODS

The study was conducted in 2006 on Iowa State University Research and Demonstration farms. Small plot fertilizer N trials were conducted on 14 sites in a corn-soybean [*Glycine max* (L.) Merrill] rotation and 7 sites in a corn-corn rotation. Each N trial site was evaluated for N stress using the Crop Circle ACS-210, GreenSeeker (green) model 505, and SPAD 502 sensors at the V10-V13 corn growth stages. Grain yield was harvested after physiological maturity, and adjusted to 15.5 g kg^{-1} moisture content. The economic optimum N rate (EONR) was calculated for each site from a fitted regression model of the maximal yield response to N at the 10:1 corn-to-N fertilizer price ratio. Applied N rate difference to EONR (dEONR) was calculated by subtracting the applied N rate from the calculated EONR.

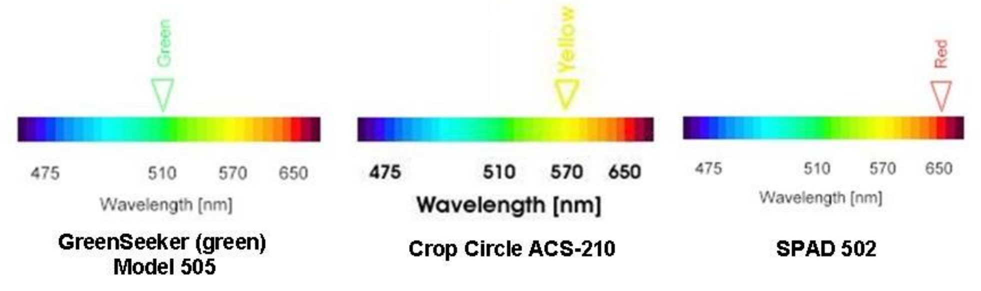
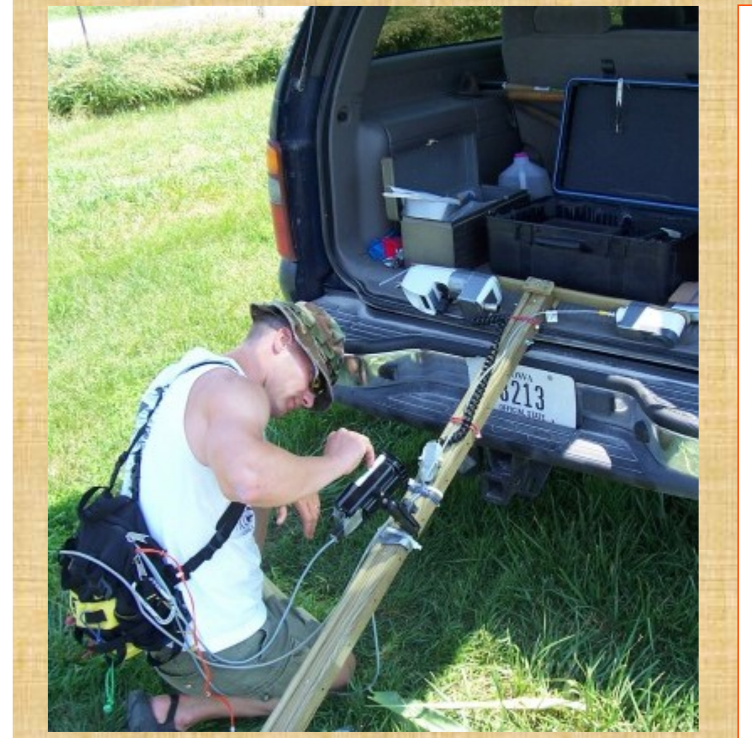


Fig. 1. The 3 optical sensors used in the study emit visible light at different wavelengths, and infrared light >774 nm.



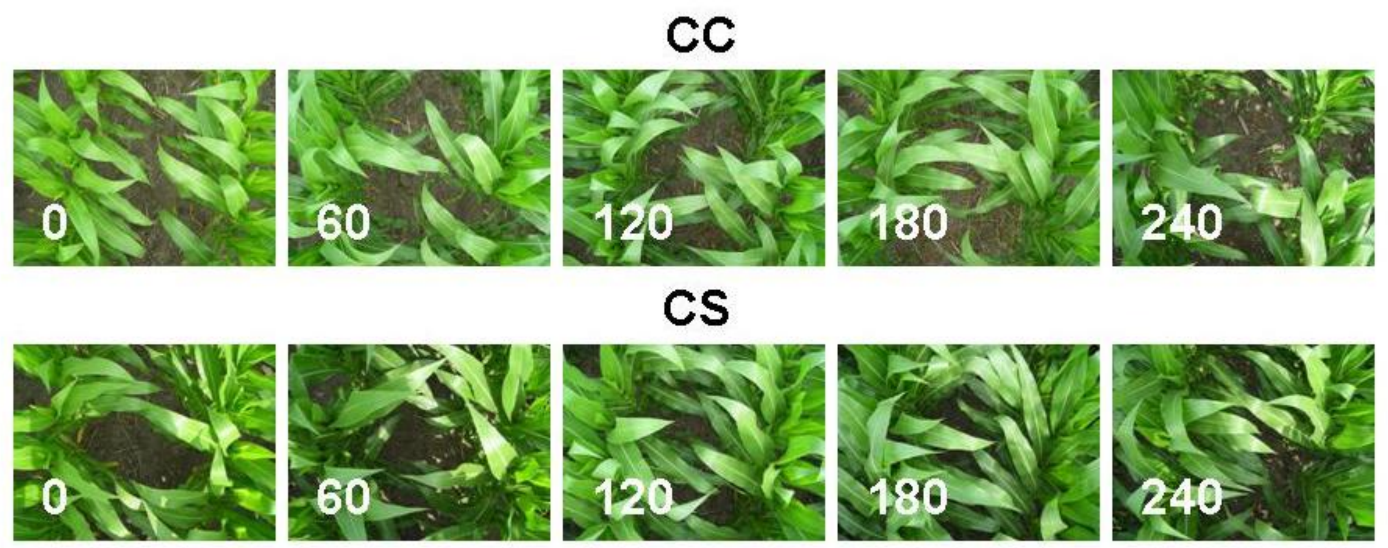


Fig. 2. A view from the Crop Circle and GreenSeeker canopy sensor's perspective. Includes 5 N fertilizer rates (0-240 kg N ha^{-1}) in CC and CS crop rotations. The distance to canopy is 90 cm at the V10 corn growth stage.

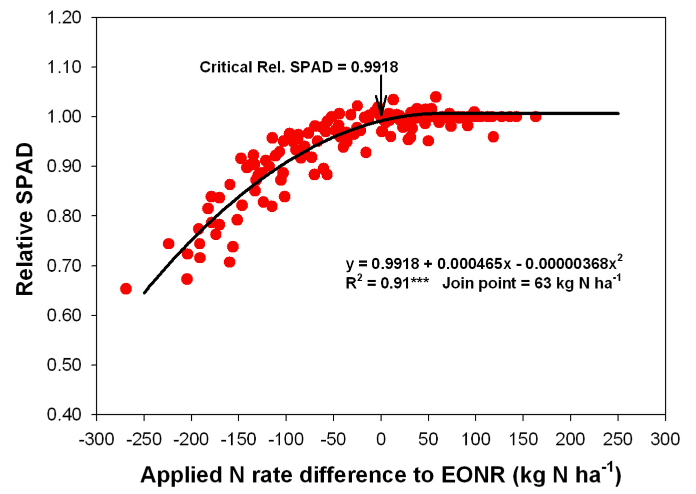


Fig. 3. Algorithm to predict economic optimum N rate using the SPAD-502 meter.

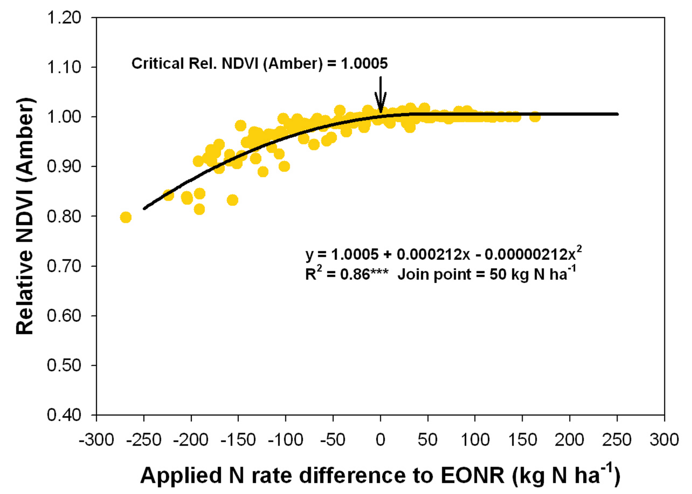


Fig. 4. Algorithm to predict economic optimum N rate using the Crop Circle ACS-210 canopy sensor.

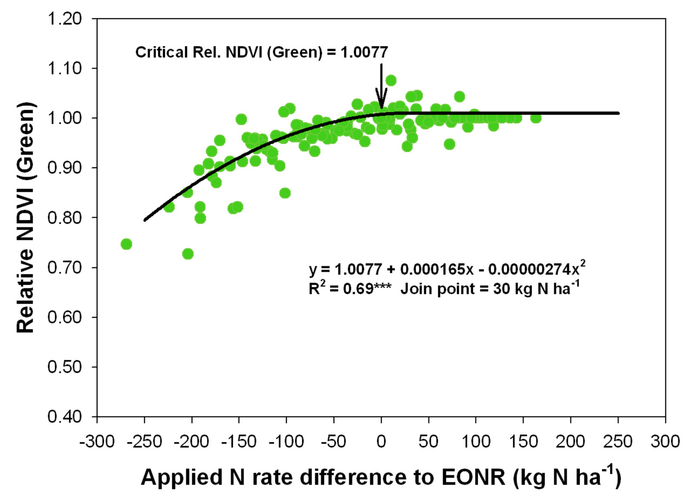


Fig. 5. Algorithm to predict economic optimum N rate using the NTech GreenSeeker (Green) Model 505 canopy sensor.

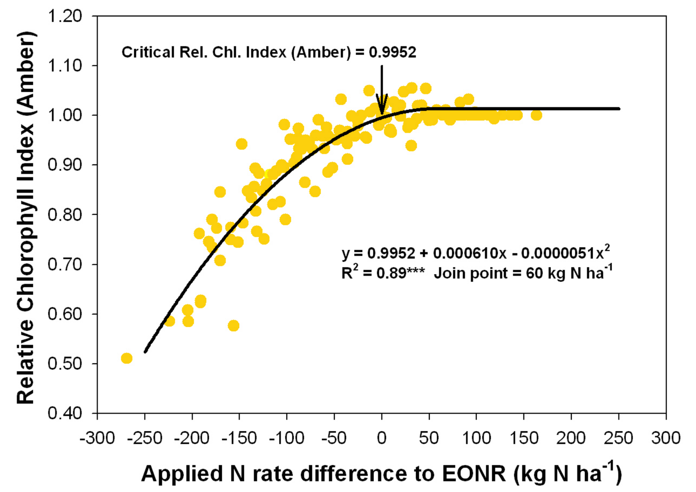


Fig. 6. Algorithm to predict economic optimum N rate using a chlorophyll index calculated from the Crop Circle ACS-210 canopy sensor.

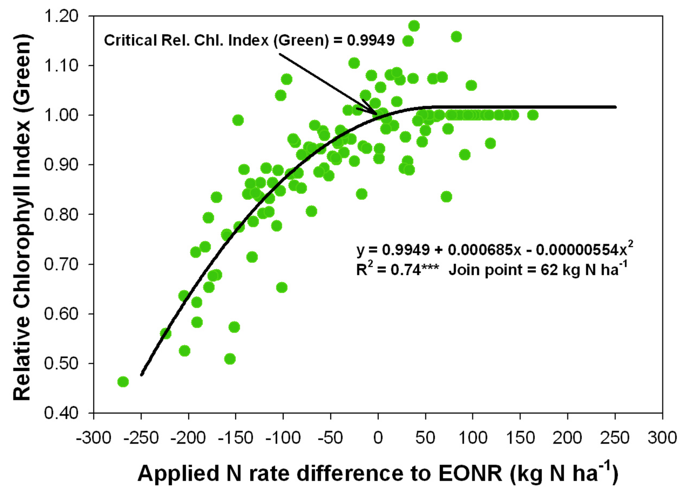


Fig. 7. Algorithm to predict economic optimum N rate using a chlorophyll index calculated from the NTech GreenSeeker (Green) model 505 canopy sensor.

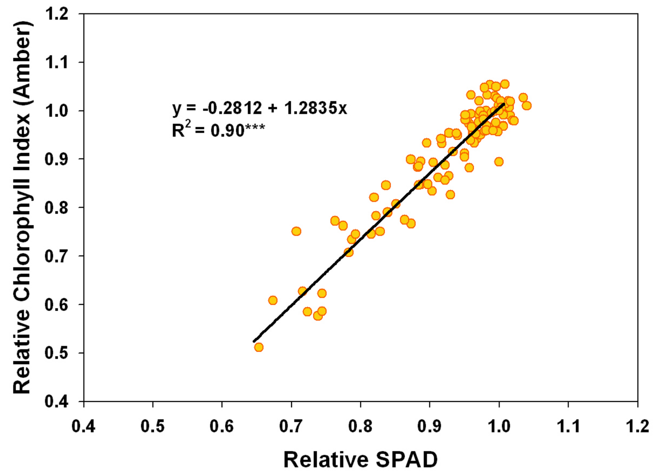


Fig. 8. Comparison between the SPAD 502 meter and chlorophyll index (Amber) calculated from the Crop Circle ACS-210

RESULTS AND DISCUSION

The five algorithms studied were all significantly correlated to dEONR (Figs. 3-7), and resulted in similar critical values. However, there are distinct advantages and disadvantages associated with each algorithm. Rel. SPAD produced the highest correlation to dEONR (R^2=0.91), and shows better differentiation between N rate when compared with rel. NDVI (amber, green). Rel. NDVI (amber) showed less variability than rel. NDVI (green), but is less distinctive to changes in N rate prior to the 0 kg N ha^{-1} dEONR critical value. Both rel. chl. indexes (amber, green) showed good distinction prior to the critical dEONR value of 0 kg N ha^{-1}, but rel. chl. index (amber) produced a higher correlation coefficient (R^2=89 vs. R^2=74).

The algorithm with the highest correlation to dEONR and the most differentiation between dEONR was rel. chl. index (amber). Algorithms produced by the SPAD meter and Crop Circle were well correlated R^2=0.92 (Fig. 8), but the canopy sensor offers greater speed, efficiency, and more application options when determining plant N stress variables in-season.

CONCLUSION

Optical canopy sensors can differentiate N stress in corn at the V10 growth stage. Algorithms that are highly correlated to optimum N rates should be useful when making in-season N rate applications. Additional research on canopy sensor algorithms is needed to confirm their accuracy in production corn fields over multiple growing seasons.

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