Canopy Sensing for Improving In-Season Corn Nitrogen Recommendations

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Introduction and Concept

Canopy Wavelength Interaction

The human eye can only see the visible portions of the electromagnetic spectrum (Fig 1). However, optical sensors can quantify visible to near infra-red wavelengths and are well suited to assess the nutritional status of a growing corn crop (Fig 2).

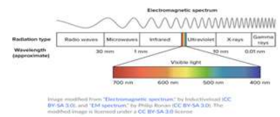


Figure 1. Canopy reflectance focuses on the visible and near infared (NIR) wavelengths of the electromagnetic spectrum.

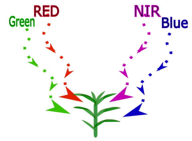


Figure 2. As sunlight strikes the surface of a leaf, chlorophyll absorbs blue and red while green and NIR are reflected.

Vegetation Index (VI)

- Method to convert electromagnetic radiation into an index [-1 to +1] that can indicate N status.

Example: NDVI

- The Normalized Difference Vegetation Index (NDVI) calculates the difference between red reflectance (red is absorbed by chlorophyll) and NIR reflectance (NIR is reflected) (Fig 3).

$$NDVI=(NIR-Red)/(NIR+Red)$$

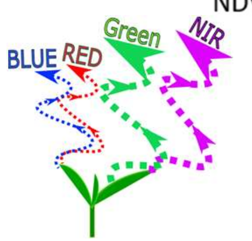


Figure 3. Healthy growing corn has low red and high NIR reflectance

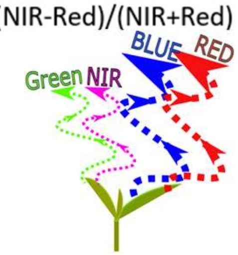
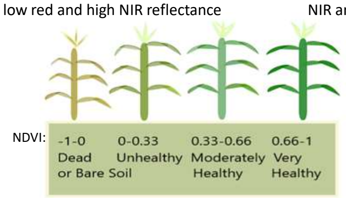


Figure 4. Deficient corn has low NIR and high red reflectance.



Adapted from Taipale (2020)

Figure 5. Healthy corn has a high positive NDVI value while unhealthy corn has a low to negative value.

Sensors can differentiate healthy and unhealthy corn (Fig 5). **Early in the growing season, low canopy coverage and high soil background suppress the NDVI value of a crop. However, farmers need to decide N application rates early in the growing season, around V4 stage of corn, before canopy closure.**

Objective

To evaluate the reliability of optical sensors to predict in-season the most economic N fertilizer rate for early growing corn.

Current In-Season N Calculation

Optical Sensors

Step 1. Determine VI for reference area (non-limiting, N-Rich) and test area.

Active Optical Sensor

- Has own light source that emits light pulses and measures the intensity of light reflected back (Fig 6). (Cao et al., 2015; Franzen et al., 2019)

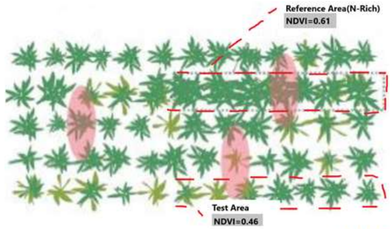
Figure 6. An example of active optical sensors.

Passive Optical Sensor

- Uses a light source by sensing the amount of radiation reflected (Fig 7) wavelengths (Franzen, 2019)

Figure 7. An example of a passive optical sensor

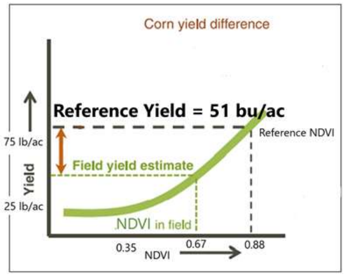
Step 2. Difference in VI of reference plants with high nitrogen (N rich) to other plants in the field (target area) using Figure 8.



Adapted from Trimble Inc., 2010

Figure 8. N-Rich sensor VI compared to sensor VI of the test area.

Step 3. Convert VI difference into yield difference (Fig 9).



Adapted from Franzen et. al 2019

Figure 9. Yield difference in relation to NDVI differences compared to N rich area.

Step 4. Calculate In-Season N requirement from yield difference

Calculations	Equation	Results
Yield Difference	Reference-Test	51 bu/ac
lbs Yield Diff.	56 lbs/bu X bu	2856 lbs/ac
lbs N in Yield Diff.	1.30%N X lbs/ac	37.1 lbs/ac
Fert N to Add	0.60 N Efficiency X lbs N/ac	62 lbs N fert./ac

Improved Early Season N Sensing

My Study

Nitrogen response trials to in-season fertilizer in Manitoba using optical sensors on commercial fields from 2018 to 2021.

Canopy Reflectance Measurements

Three Optical Sensors readings around the V4, V8 and VT stages

- Data from two active optical sensors: (GreenSeeker and CropCircle 470) collected by hand
- Passive sensor: (DJI Matrice 100 Quadcopter Drone) with a Red Edge 5-channel (Red, Green Blue Nir and Red Edge)

The passive sensor images taken within 2.5 hours of solar noon at a height of about 60m

Image Processing

- Pix4D Mapper to orthorectification(Fig 10) and stitch together flight images (Fig 11)

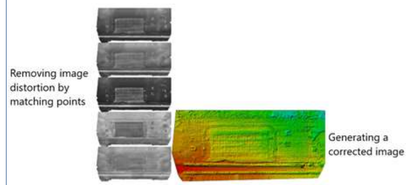


Figure 10. Orthorectification: Removing image distortion through 3D point reconstruction

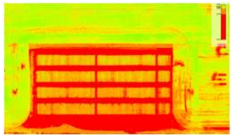


Figure 11. Example of a NDVI image at V8 of Carman 2020 site using Pix4D.

- ArcGis to remove soil from the image using red/green ratio for each pixel and focusing solely on pixels with green vegetation.

Acknowledgment

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