

Digital Imagery Technologies Aid in Crop Management

Recently farmers have been witnessing a surge in different digital aerial imagery technologies. High resolution satellite imagery, low cost UAV systems, speedy imagery delivery and real time analytical solutions are designed for better field scouting, estimating plant stand, identifying weed disease, insect and pressure, detecting nutrient deficiencies and predicting yields.

Because many atmospheric and external factors can impact the digital signal or reflectance of the plant canopy, the imagery should be of a specific quality by calibration to reliably visualize and compare these dense data over time.

During the 2018 growing season, the Iowa Soybean Association (ISA) Analytics team partnered with the researchers from Southern Illinois University Edwardsville and commercial imagery providers, such as IntelinAir, Aeroptic, TerraAvion, DaveronUAS and SatShot, to execute the following goals:

1. Evaluate spatial accuracy, band registration, pixel size and mosaicking quality.
2. Assess the shape (linearity) of calibration imagery equations using information from on-the-ground imagery calibration tarps.
3. Produce and evaluate different vegetation indices from calibrated imagery.
4. Quantify temporal patterns of soybean vegetation indices under different management practices.
5. Identify best vegetation indices, best timing of imagery collection and the optimal number of flights during the growing season.
6. Effectively communicate results to farmers and industry to make digital imagery products more cost effective, reliable and a “digital fit” for different outcomes.

In this report, the Analytics team shows how three vegetative indices were used to benchmark biomass growth and development, differentiate soybean and corn yielding zones and indicate potential problems with the imagery. This is only possible if the imagery has a common scale or is calibrated.

Soybean and corn fields in central Iowa were flown over 10 times during the growing season. The imagery was calibrated using on-the-ground calibration tarps with known reflectance value percentages. Yields were split into four categories from low to high to study how well different indices can predict yields. Although the imagery resolution was about 8 cm, analyses were done using 75 x 75-foot grids.

Normalized Difference Vegetation Index (NDVI): NIR-Red (NIR+RED) is historically the most common index used. The values for plant vegetation range from 0 to 1, with higher values indicating larger biomass. The majority of modern plant health indices and products are based on NDVI or its variation.

Soybean: NDVI increased and then reached a field maximum by the end of June (Figure 1A). This is an example of NDVI saturation, when it is no longer sensitive to changes in biomass growth. In general, the higher yield categories had higher NDVI values, but only the lowest soybean yield category could clearly separate well by the index between June 12 and August 3. Temporal patterns in NDVI for the 75 x 75-foot grids show large spatial variability within field in canopy reflectance, most of the colors intermingled, indicating difficulty to separate the four yield categories (Figure 1D).

Corn: NDVI reached a field maximum, or became saturated, by mid-June almost a month earlier than soybean (Figure 2A). NDVI clearly separated all four yield categories after August 14 (Figure 2A).

Chlorophyll Index Green-CIG, NIR/Green-1: Unlike NDVI, this index does not use red reflectance, but includes green reflectance in calculations, which is more sensitive for plant chlorophyll content.

Soybean: CIG shows less saturation than NDVI. Similar to NDVI, it separated low yield categories well (Figure 1B).

Corn: CIG values increased by mid-July and then gradually decreased (Figure 2B). CIG values separated all four yield categories after July 10 (Figure 2E).

Difference Vegetation Index-DVI, NIR-Red: DVI is a simple difference between NIR and Red, which enables the separation of vegetation from soil reflectance. DVI is more prone to the effects of shadowing and other atmospheric factors.

Soybean: For aggregate data from June 12, DVI values clearly separate the low yield categories from the rest (Figure 1C). However, it has an unusual bump for the high yielding category on June 25. Visual analyses confirmed that the image on June 25 had hot spots and dark spots with extreme high and low values.

Corn: DVI shows clear separation of the four yield categories by the end of the season (Figure 2C and 2F). Similar to soybean, corn also has an unusual DVI bump on June 25, but only for the low yielding category.

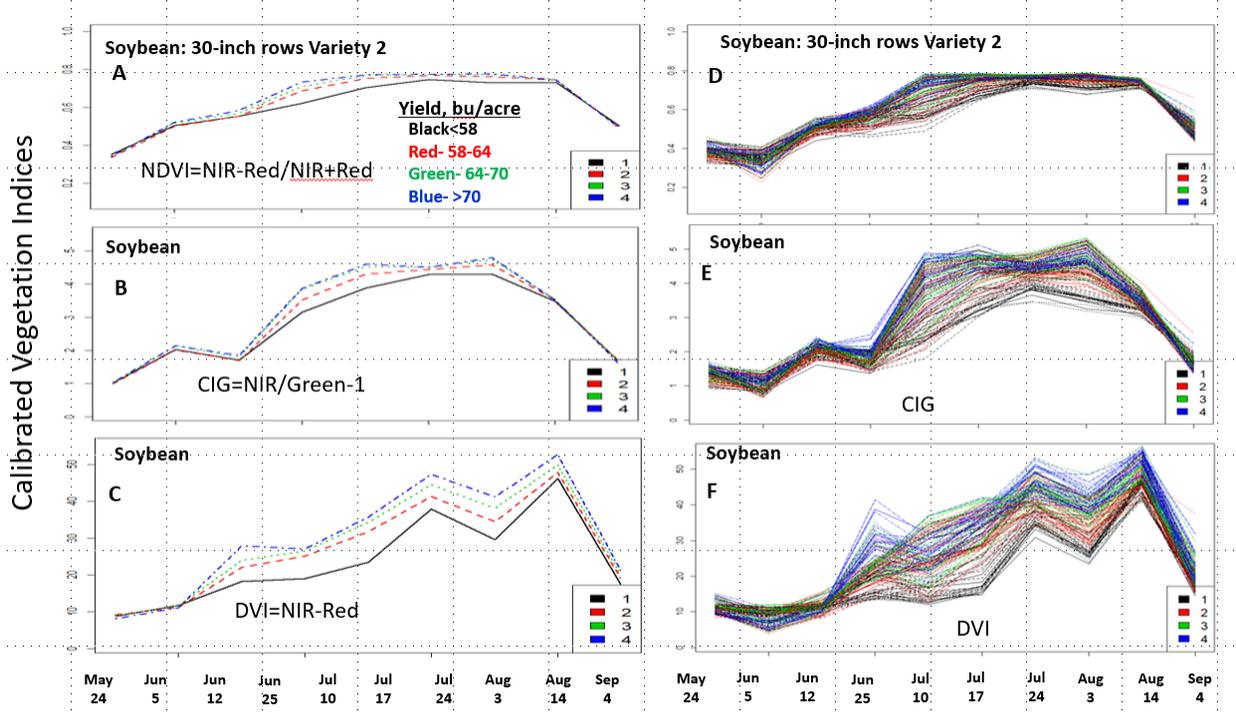


Figure 1. Three temporal vegetation indices — Normalized Difference Vegetation Index (NDVI), Chlorophyll Green Index (CIG) and Difference Vegetation Index (DVI) — of soybean canopy to separate four yield zones for a 15-inch row soybean field in Central Iowa using calibrated imagery.

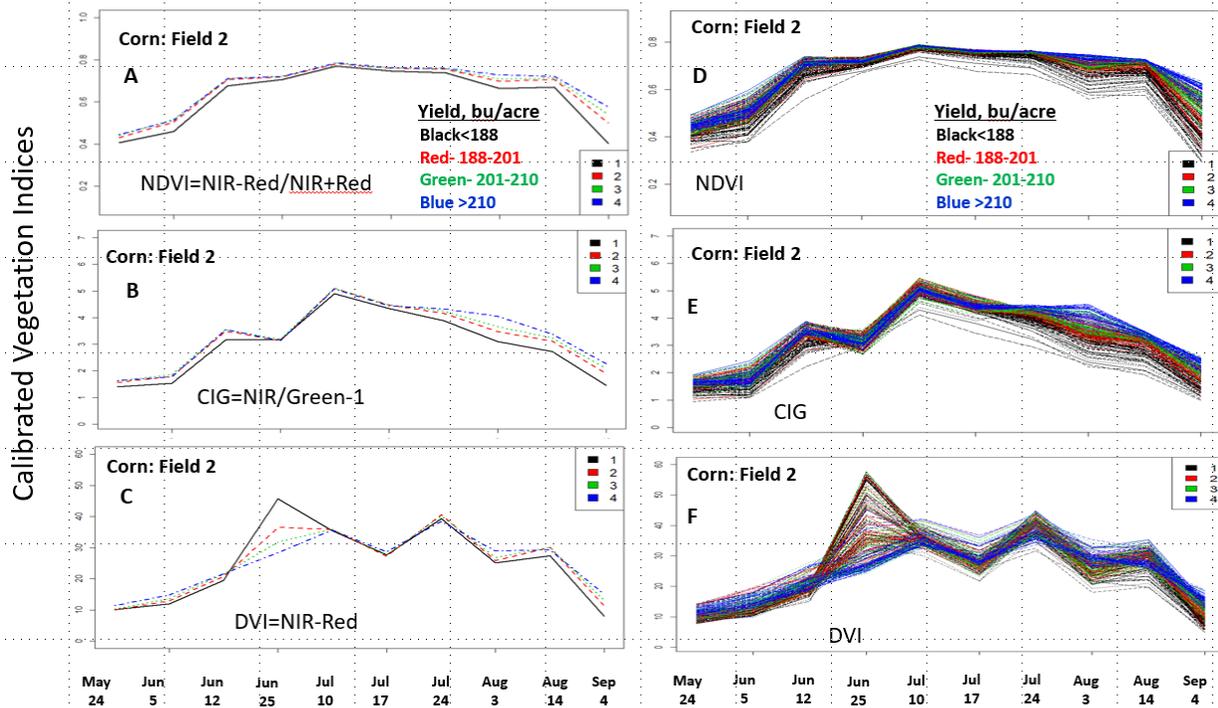


Figure 2. Three temporal vegetation indices — Normalized Difference Vegetation Index (NDVI), Chlorophyll Green Index (CIG) and Difference Vegetation Index (DVI) — of corn canopy to separate four yield zones for a corn field in Central Iowa using calibrated imagery.

Observations from the rainfall station installed at the site indicated that the field received 0.78 inches of rainfall on June 24 and then 1.45 inches on June 25. This might have caused changes in soil and canopy reflectance values, and therefore, in addition to post-processing imagery, contributed to the unusual hot spots in the imagery.

Because many imagery problems are not easy to detect visually, observations with the DVI index demonstrate the need to use several calibrated vegetation indices simultaneously to avoid potential problems with the imagery. While the DVI index is prone to the effect of shadowing, it was useful to diagnose the hot spot problems which might not be easily detected visually by farmers.

The next steps in the project are to identify optimal numbers of flights and the best dates for imagery collection.

The Analytics team also started drafting a scientific manuscript that will discuss the essential value of using the calibration and the best methodologies of testing calibration quality of different commercial imagery sources.