Model Systems Progress Report

Model System: Herbicide injury (imazethapyr, lactofen)
State: Michigan State University
Investigator(s): K.D. Thelen, C. Lee

Introduction: Optical remote sensing provides a powerful tool for monitoring changes in the crop canopy over the growing season. Radiometric measurements in the solar spectral domain contain important information pertinent to the health of vegetation. Remote sensing has been used to estimate yield, monitor plant health and plant stress, and characterize properties of vegetation such as plant biomass and leaf area index In the discipline of Weed Science, most applications of optical remote sensing have focused on detecting the presence of weeds within a crop canopy. The ability to use remote sensing to detect herbicide injury would also be of value to growers in interpreting images taken for general crop scouting and in monitoring the accuracy and potential overlap with new spray application technology such as parallel tracking.

Several options are available for obtaining optical remote sensing data. These include ground based systems, aerial imagery, and satellite imagery. Remotely sensed measurements of canopy multi-spectral reflectance can provide a quick, inexpensive, and non-destructive method of a real time assessment of biophysical variable estimation of the whole field. Current methods of crop assessment can be tedious, laborious, costly and time consuming.

Objective: The objective of this study was to determine if ground-based and aerial imagery optical remote sensing could be used to assess herbicide injury in soybean.

Procedures: Experiments were conducted at the Michigan State University Experiment Farm in Ingham County and at a farmer cooperator farm in Kalamazoo County over the three-year period between 2000 and 2002. The soil at the Ingham county site was a Capac loam (fine-loamy, mixed, mesic Aeric Haplaqualfs) and the predominate soil at the Kalamazoo site was a Brady sandy loam (coarse-loamy, mixed, mesic Aquollic Hapludalfs). The soil pH was 6.7 and 6.9 at the Ingham and Kalamazoo sites respectively. In each of the six site-years the previous crop was corn. At the Ingham county site the soybean variety grown was Pioneer 19B91, in 2000, Mycogen 5251, in 2001 and Pioneer 92B38 in 2002. The soybeans were planted in 15 inch rows at a target planting population of 190000 plants/acre. Planting dates were 5 June 2000, 3 May 2001, and 8 May 2002. Plot size at Ingham County was 10 x 40 ft in 2000 and 2001 and 20 x 40 ft in 2002. At the Kalamazoo County site the soybean variety grown was Asgrow 2001 in 2000, Becks's 243, in 2001 and Beck's 323 in 2002. The soybeans were planted in 7.5 inch rows at a target planting population of 205000 plants/acre. Planting dates were 7 June 2000, 4 May 2001, and 24 April 2002. Plot size at Kalamazoo County was 10 x 100 ft.

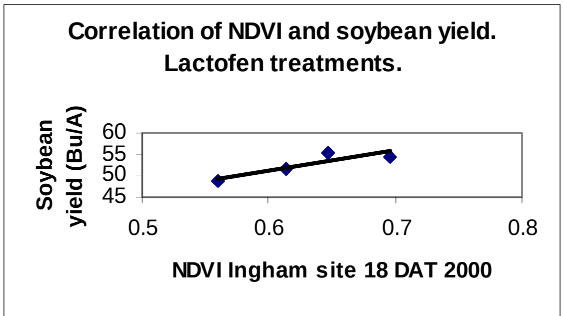
The experimental design was a randomized complete block with four replications at the Ingham county location and 5 replications at the Kalamazoo county location. The treatment design was a two-factor factorial, with the first factor being herbicide (lactofen and imazethapyr) and the second factor being herbicide rate (0, x, 2x, and 4x). Lactofen was applied at rates of 6, 12, and 24 oz/acre corresponding to an x, 2x and 4x rate respectively. Imazethapyr was applied at rates of 1.4, 2.8, 5.6 oz/acre for the x, 2x, and 4x rate of imazethapyr treatments respectively. The spray dates for the Kalamazoo site were 11 July 2000, 25 June 2001, and 28 June 2002. At Ingham County the spray dates were 29 June 2000, 25 June 2001, and 28 June 2002. All of the soybean varieties were glyphosate tolerant and received an application of glyphosate approximately 10 days prior to the lactofen and imazethapyr treatments to eliminate spectral interference from weeds.

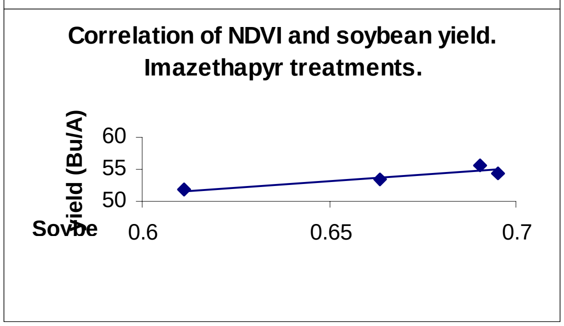
Ground-based optical remote sensing and aerial imagery were obtained from treated plots between 7 and 21 days after herbicide treatment. A multi-spectral ground based radiometer (CropScan, MSR87) was used to measure crop canopy reflectance. The CropScan radiometer contained eight narrow-band filters centered at 460, 510, 560, 610, 660, 710, 760, and 810 nm. The radiometer had a 28 degree field of view. The sensor was mounted on a 2.6 m pole above the soybean canopy for nadir viewing. Four measurements were randomly taken per plot and averaged to provide the reflectance value for each plot.

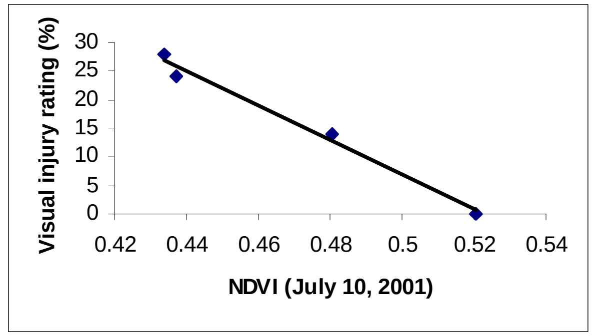
In addition to the reported NDVI reading for each plot, a ΔNDVI was also calculated by determining the difference in NDVI between the 0x rate (nontreated) and each treated plot within an experimental block.

Multi-spectral images were obtained using a 3-band (green, 520-600 nm, red 630-690 nm, and near-infrared (NIR) 735-865 nm) real time digital airborne camera system (RDACS) model II CCD array camera sensor (Eastman-Kodak, Rochester, NY). The camera system was mounted on a Cessna T-210 aircraft (Wichita, KS). Images were taken at approximately 9000 ft altitude and provided a nominal spatial ground resolution of approximately 1.0 m. Imagery was acquired near mid-day under cloudless conditions. GPS coordinates were obtained for each experimental field with a DGPS receiver (Model Invicta 210S, Starlink, Austin, TX). Digital imagery was geo-rectified and processed using the Imagine (ERDAS, Atlanta, GA) image processing software. Borders around each plot were over-lain as an area of interest on each image. The areas of interest were than used to derive the mean digital number for the red and NIR bandwidths used in calculating the NDVI.

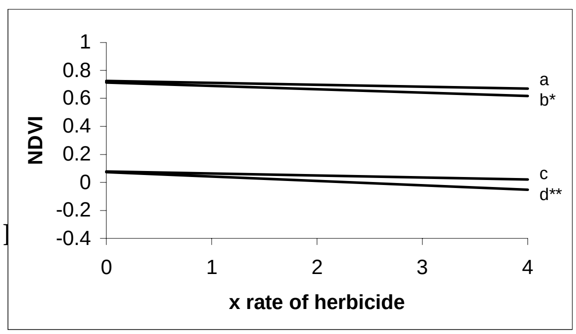
Results: Both aerial imagery and ground based optical remote sensing were effective in detecting lactofen and imazethapyr injury on soybean. Interpretation of spectral data was improved by comparing reflectance values from soybeans in treated areas to nonstressed soybeans (ΔNDVI). Optical remote sensing was not effective at estimating actual application rates of lactofen and imazethapyr across a broad range of field and weather conditions due to temporal and spatial variability in crop response to the herbicides. The precision of optical remote sensing in detecting herbicide injury was significantly improved when data acquisition were conducted at peak crop injury. When aerial imagery was conducted 7 days following herbicide application, a 2x application rate was distinguishable. However, when optical remote sensing was delayed beyond peak crop injury, resolution was diminished. Overcast conditions in the Northern cornbelt could be a practical limitation in acquiring timely data with aerial imagery.







Above: Correlation of NDVI and visual injury rating treatment means. Kzoo County, 2001, 15 DAT. R^2 = 0.98. **Left:** Correlation of NDVI with soybean yield for lactofen and imazethapyr, Ingham site, 2000. At other site years herbicide effect on soybean yield was NS.



Above: Regression lines for NDVI (left) and ΔNDVI (right) as affected by herbicide and detection method combined across years and locations. a = imazethapyr using the ground-based radiometer; b = lactofen using the ground-based radiometer; c = imazethapyr using aerial imagery; d = lactofen using aerial imagery.

*P < 0.05; ** P < 0.01; *** P < 0.001.