**Using Remote Sensing to Map In-Field Variability of Peanut Maturity**

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**Objective:** Determine the feasibility of using remote sensing to map in-field variability of peanut maturity and quality

The study was conducted in two peanut fields – a rainfed field in Coffee County and an irrigated field in Calhoun County. Both fields were planted to GA-06. Historical satellite images of the fields were analyzed to select a block of the field with the most soil variability. The block was divided into twenty-four 2.5 ac grid cells (Figure 1). Ten peanut plants were collected from an area approximately 30 ft in radius at the center of the grid cells weekly for the 6 weeks prior to harvest (Figure 2). Two hundred peanut pods were removed from each group of plants and pressure-washed to expose the mesocarp. The pods were placed on the Peanut Profile Board (PPB) and the number of nuts in each color class recorded. The peanut maturity index (PMI) was also calculated for each sample.

During each sampling day, a Parrot Sequoia camera attached to a 3DR Solo quadcopter UAV (Figure 2) was used to capture multispectral images in 4 different bands; Green (530-570 nm), Red (640-680 nm), NIR (770-810 nm) and Red Edge (730-740 nm). All UAV flights were performed within 2 hours of solar noon from an altitude of 90 m with 70% overlap. At 300 ft, the spatial resolution of the camera was 3.75 in. Pix4D software was used to create mosaics of reflectance maps in each one the four bands and the ArcGIS software was used to extract an average reflectance value for the pixels in each of the 24 grid cells. A full 7-day workweek by two PhD-level graduate students was required to collect, process, and analyze the samples from each field.

Seven vegetation indices (VIs) that have been used by other studies to predict crop maturity and three modified VIs were selected for evaluation. The average reflectance values for each grid cell were then used to calculate the response of the ten VIs for each sampling date (Figure 1). Pearson's correlation ($p<0.001$) and regression analysis were used to compare the response of the VIs to PMI.

All VIs had a negative linear relationship with PMI where the value of the VI decreased as PMI increased. The best results were for three VIs that included the Red Edge (RE) band. These were the Nonlinear Index ($NLI_{RE}$) the Modified NLI ($MNLI_{RE}$) and the Simple Ratio ($SR_{RE}$). The highest $R^2$ for the linear fit was observed for $NLI_{RE}$. NLI using the Red band rather than the RE band was the VI that showed the best results in the exploratory studies we conducted in 2012-13. In those studies, NLI showed good response in predicting maturity, with the slope of NLI consistently decreasing and approaching zero at maturity. Although, a consistent change in slope was not observed with any VI in the current study, we did observe a sharp inflection point and sudden decrease in the response of the VIs when we fit a 5$^{th}$ order polynomial to the data (Figure 3). In the Coffee County field, this occurred 12 days before the PPB-indicated days until

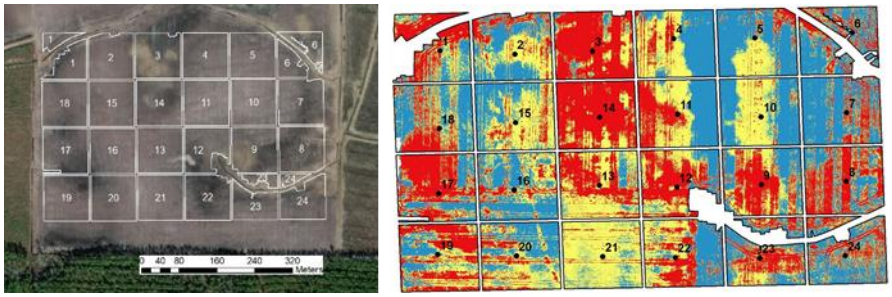

Figure 1. Full color satellite image of the 62.5 ac block in the rainfed field which was divided into 24 2.5 ac sampling plots (left). $NLI_{RE}$ map of the field from 15 September 2018 (right).

Figure 2. Collecting peanut plant samples (left) and the 3DR Solo quadcopter UAV with the Parrot Sequoia camera used to collect multispectral images (right).

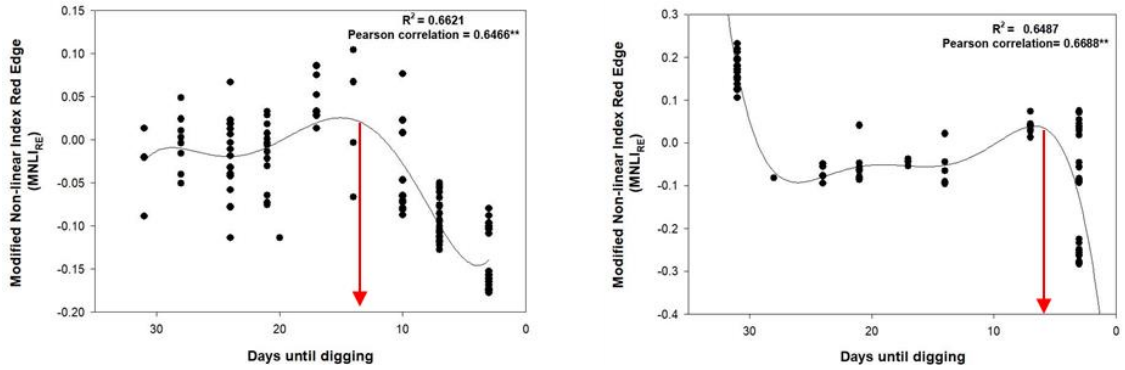


Figure 3. Fifth order polynomial fit to the VI data showing an inflection point at 12 days before the PPB-indicated days until digging for the Coffee County field (left) and 5 days for the Calhoun County field (right).

digging. In the Calhoun County field, the drop occurred 5 days before the PPB-indicated days until digging. The best statistical results were for $NLI_{RE}$ and $MNLI_{RE}$. The $MNLI_{RE}$ curves and inflection points for both fields are shown in Figure 3. Considering the relative inaccuracy of the PPB-indicated days until digging and that each field was not sampled on exactly the same interval, our results appear to be good indicators of peanut maturity. The results are very encouraging and indicate that remote sensing may provide an alternative to the Hull-Scrape Method.