Satellite Mapping of Winter Biomass Distribution and Related Patterns in Soil Organic Carbon

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ABSTRACT

For years, winter cover crops have been used as a component of a reduced tillage and residue management system and hailed as conservation practice that improves soil quality through soil organic carbon accretion. Currently, rising fuel costs, high returns on winter wheat, and the demand for alternate energy crops make estimates of winter cover crop production a necessity. The objective of this study was to determine the accuracy of a satellite based method for predicting early spring winter biomass production.

To accomplish this task, 32 fields having a range in cultural practices were evaluated. Practices included: 1) conservation tillage in the form of strip tillage with winter rye (*Secale cereale* L., n = 38), winter wheat (*Triticum aestivum* L, n =30.) or weeds (n=10), and 2) conventional tillage (n=27) left fallow (Figure 1). The study area was located in the southern Coastal Plain of Georgia, proximate to the Little River Experimental Watershed near Tifton, GA. Soils classify primarily as fine-loamy, kaolinitic, thermic Plinthic Kandiudults, are grayish brown in color with loamy sand surface textures. To ensure a dynamic range in plant response potential, sample locations within each field were pre-selected using digital soil survey information and Landsat5 TM imagery collected during the 2007 growing season.

Satellite imagery for the current study was acquired via the Linear Imaging Self Scanner (LISS-3) 22 Feb. and 24 March 2008. Imagery has a spatial resolution of 23.5 m and acquires reflectance in four bands (0.52 – 1.70 µm). Two common vegetation indices, the normalized difference vegetation index (NDVI) and the greenness normalized difference vegetation index (GNDVI), as well as a middle infrared band (MIR) band ratio were calculated and used for statistical analysis (Table 1).

Ground truth data were collected proximate to each satellite acquisition as a measure of the winter cover crop at each of the pre-determined sample locations (n = 105). All samples consisted of a composite of five subsamples (with the exception of whole biomass, which was sampled discretely) within a 10 m radius of the sample point. Measurements included: above ground biomass (dry weight), leaf nitrogen content, plant height and gravimetric soil water content.

Preliminary analysis of ground truth variables indicate a strong correlation exists between plant attributes measured during sampling events one and two. Correlations ranged from r = 0.63 – 0.80 (alpha = 0.10) across all cover crop types. This relationship improved when cover crop types were analyzed discretely ranging from r = 0.51 – 0.92 for rye only. More importantly, remotely sensed data collected during the first sampling event was highly correlated with plant variables collected during the first and second sampling events, ranging from r =0.43 – 0.67

(alpha = 0.10). These relationships generally improved when the dataset was sorted by cover crop type as well.

A stepwise linear regression was used to evaluate the utility of using an early season image to predict winter cover crop biomass production, plant height and leaf N content using three remotely sensed vegetation indices. Winter biomass collected 24 March 2008 exhibited a strong linear correlation ($r^2 = 0.63$, alpha = 0.05) with vegetation indices calculated from the 22 Feb. 2008 image. When the data were sorted by cover crop this relationship improved for wheat only. Plant height and nitrogen content were best explained by vegetation indices when data were sorted by cover crop type, having coefficients of determination ranging from 0.25 – 0.83 and 0.30 – 0.32 for plant height and nitrogen content, respectively.

Data demonstrate the potential of satellite imagery to identify and forecast winter cover crop production in a southeastern Coastal Plain production system. Information from this study shows promise as a tool to develop estimates of potential feedstock for energy production from winter cover crops in a southeastern Coastal Plain watershed.

Table 1. Spectral specifications for the Linear Imaging Self Scanner 3 (LISS3).

Wavelength (µm)	Band	Spectrum Region
0.52 - 0.59	B2	Green
0.62 - 0.68	B3	Red
0.77 - 0.86	B4	Near Infrared
1.55 - 1.7	B5	Mid Infrared
	NDVI	(B5 -B3)/(B5+B3)
	GNDVI	(B5 -B2)/(B5+B2)
	MIR_{index}	B5/B3

Figure 1. Site location map showing field boundaries county lines and state map inset.