COTTON NDVI RESPONSE TO APPLIED N AT DIFFERENT SOIL EC LEVELS

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ABSTRACT

Many fields in the Southeastern Coastal Plain are highly variable in soil physical properties and are irregular in shape. These two conditions may make it difficult to determine the 'best' area in the field to place an N-rich strip(s) for NDVI-based spatial N fertilizer application. This field study was conducted to determine if soil electrical conductivity (EC) could be used to delineate N-rich areas for spatial N application. Cotton was grown on a field that contained five different soil map units with soil surface EC ranging from 0.4 to 10 mS m^{-1}. Treatments in the study were three N rates (0, 34, and 112 kg N ha^{-1}). Mid-season NDVI increased with soil EC up to approximately 5 mS m^{-1}. Greatest differences among the N rates for NDVI were at soil EC levels between 2 and 5 mS m^{-1}. Cotton yields differed among the N rates, but there was no interaction between N rate and soil EC for yield. Predicted N fertilizer recommendations for the 0 and 34 kg N ha^{-1} plots using the Oklahoma State algorithm were low. These preliminary results suggests that there is potential for using soil EC for delineating N-rich areas on highly variable fields in the Southeastern Coastal Plain.

Keywords: cotton, spatial variability, soil electrical conductivity, nitrogen

INTRODUCTION

Improving nitrogen fertilization of crops is important to reduce N from escaping grower fields into surrounding environments and to increase grower efficiency. To achieve this, there is considerable research being conducted on the use of active sensors to measure normalized difference vegetative index (NDVI) and use NDVI for calculating in-season N fertilizer application rates (Raun, et al., 2006). One current method of using these sensors for variable rate N application employ use of applying a high rate of N in a strip through the field (an N-rich strip) to provide NDVI estimates of non-N-stressed plants. The N-rich strip accounts for spatial variability in plant growth that is not due to differences in soil N.

Some fields in the Southeastern Coastal Plain are highly variable for crop productivity, especially under rainfed production. The nature of the variability can make it difficult to determine the ‘best’ place in the field to establish an N-rich strip. Although the variability in productivity can be due to differences in soil pH and nutrients other than N, a considerable amount of the variability among soils is due to differences in ability to provide water to plants (Sadler et al., 2000).

Soil electrical conductivity (EC) is currently being used for delineating zones for site-specific management of nematocides and nutrients other than N on production fields. Khalilian et al (2008) proposed including soil EC in determining optimum sidedress N rates when using mid-season NDVI to determine application rates. Our objective was to evaluate the potential for combining soil EC with mid-season NDVI for making variable rate sidedress-N fertilizer recommendations.

MATERIALS AND METHODS

The experiment was conducted in 2009 near Florence, SC on a field that was cropped to soybean (Glycine max) in 2008. There were five different soil types within the 2.5 ha field that provided a range of soil EC. Soil types within the field were Nobocco loamy sand, Ocilla sand, Rains sandy loam, Coxville sandy loam, Norfolk loamy sand, and Blanton sand. Soil EC across these soils was mapped in March of 2009 using a Veris Technologies 3100 system. The surface EC (top 30 cm of soil) of the area ranged from 0.4 to 10 mS $m^{-1}$and the deep EC (30-90 cm) ranged from 1 to 75 mS m^{-1}. Only surface EC data were used in this analysis.

Treatments in the experiment were N rates (0, 34, and 112 kg N ha^{-1}). Experimental design was randomized complete block and there were four replicates. Plot size was four 1-m wide rows that were 335 m in length. Cotton was planted in early May using a four row planter at a seeding rate of approximately 10 seeds per m of row. Immediately after planting, the cotton receiving 34 and 112 kg N ha^{-1} had the N applied by dribbling urea-ammonium nitrate solution on the soil surface approximately 15 cm to the side of each row. Weeds and insect pests were scouted and controlled as necessary throughout the season using appropriate herbicides and insecticides.

At 50 days after planting, NDVI data were collected on the entire length of an interior row of each plot. Global position coordinates were collected with each NDVI measurement. Data were collected with a Crop Circle model ACS 210 crop canopy sensor (Holland Scientific, Lincoln, NE) that was mounted on a tractor and positioned between 76 and 100 cm above the top of the plant canopy. At the end of the season, seedcotton yield was determined with a yield monitor on a four-row cotton picker.

The density of the soil EC data was less than the density of the NDVI and yield monitor data. The response data points (NDVI or yield) were combined with the soil EC data by a spatial join to the nearest EC values data point. This was done in ARCMap using the Join function with the Spatial option. Soil EC data were then categorized by combining all data within 1 mS m^{-1} EC increments. Data with soil EC greater than 6 mS m^{-1} were discarded before analysis because of there were relatively few data points compared to the lower soil EC levels.

Predicted sidedress nitrogen fertilizer rates were calculated for each NDVI measurement in the 0 and 34 kg N ha^{-1} treatments using the Oklahoma State University algorithm for dryland cotton modified by Clemson University (A. Khalilian, personal communication). The 112 kg N ha^{-1} plots were used as the N-rich strip for calculating N application rates. All predicted N rates for the 0 and 34 kg N ha^{-1} rate treatments were then averaged for each soil EC level in each plot. Yield data were similarly averaged for each EC level in each plot and then analyzed using the GLIMMIX procedure of SAS. A split-plot model was used with N rates as the main plots and soil EC level as the subplots. Yield means were separated using the pdiff procedure in GLIMMIX and were considered significantly different if P values were $\leq$ 0.05.

RESULTS

There was substantial variability for cotton growth across the field in 2009. Average mid-season NDVI ranged from about 0.4 to 0.7 across all N rates (Figure 1). The NDVI response to N fertilizer was soil EC specific. Mid-season NDVI increased as soil EC increased to 5 mS m^{-1} for all three N fertilizer levels. The greatest response to at-plant fertilizer N for NDVI was at soil EC levels between 2 and 5 mS m^{-1}.

Like mid season NDVI, average seedcotton yield was influenced by both N fertilizer rate and soil EC (Table 1); however, the interaction between the two was not significant. Whereas midseason NDVI was highest when soil EC was approximately 5 mS m^{-1}, average yield did not increase above a soil EC of 3 mS m^{-1} (Table 1). Averaged over soil EC levels, the 112 kg N ha^{-1} rate had 26% higher yield than 0 kg N ha^{-1} rate and 12% higher yield than the 34 kg N ha^{-1} rate. This relatively low response to fertilizer N is not surprising. The recommended N rate for cotton on these coastal plain soils is 78 kg ha^{-1}. Since the cotton was grown following soybeans, 30 – 40 kg ha^{-1} of residual N would be expected.

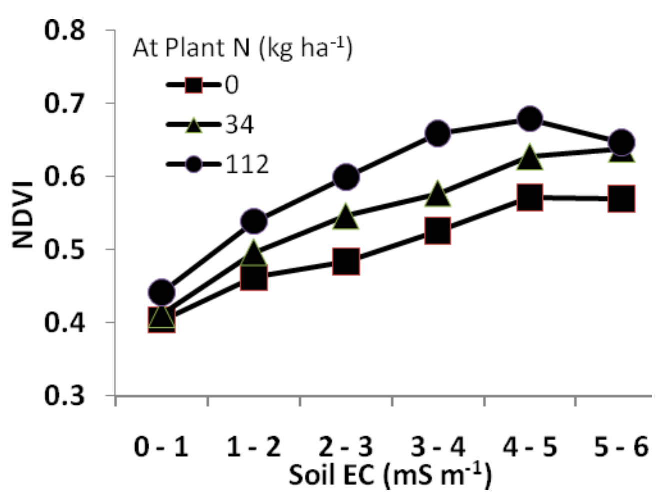

Figure 2. Mean NDVI of the three N fertilizer rates for the different soil EC levels on 2 July 2009.

Table 1. Effect of nitrogen rate and soil EC on seedcotton yield.

	Nitrogen Rate (kg ha^{-1})			
Soil EC	0	34	112	Mean
mS m^{-1}	----------------------	kg ha^{-1}	----------------------	
0-1	893	1077	1242	1071d†
1-2	1420	1756	2136	1771c
2-3	1961	2186	2577	2241b
3-4	1995	2385	2508	2296ab
4-5	2229	2379	2567	2392a
5-6	2142	2252	2404	2266ab
Mean	1773a	2006b	2239c	

†Nitrogen rate or soil EC means followed by the same letter are not significantly different ($P \leq 0.05$).

Recommended fertilizer rates for the 0 and 34 kg N ha^{-1} plots based on the NDVI measurements are given in Table 2. There were differences in fertilizer N recommendations among the soil EC levels for both N rates, but all recommended rates were quite low.

SUMMARY

These preliminary findings suggests that there is potential for using soil EC for delineating N-rich areas on highly variable fields in the Southeastern Coastal Plain where placement of N-rich strips would be difficult. Use of soil EC may significantly reduce the land area needed for N-rich areas – since whole strips through the field may not be needed - while allowing for a N-rich comparison for all areas of the field. Further definition of appropriate categorization of soil EC ranges for making NDVI-based N fertilizer recommendations appears warranted.

Table 2. Mid-season nitrogen rate recommendations for the NDVI data collected on 2 July 2009. The 112 kg N ha^{-1} rate was used as the N-rich values.

	At-Plant Nitrogen Rate (kg ha^{-1})	
Soil EC	0	34
mS m^{-1}	-----kg ha^{-1} -----	
0-1	13	12
1-2	17	13
2-3	25	13
3-4	28	19
4-5	24	12
5-6	17	6

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