Remote Sensing Technologies Used as Management Tools in Cotton Production

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RESEARCH PROBLEM

Development of site-specific maps describing soil variability within individual fields using precision agriculture technologies provides an opportunity to improve fertilizer and chemical use in production agriculture. This study was conducted to determine the effectiveness of multispectral aerial imagery and Veris electrical conductivity data as tools to identify field variability.

BACKGROUND INFORMATION

The field observed in this study is located in Mississippi County approximately 4.5 miles south of Blytheville. This field is an example of the dramatic soil changes caused by the violent earthquakes of 1811-1812 along the New Madrid Fault. These earthquakes affected much of the mid-Mississippi River Valley, changing the terrain for hundreds of miles (Johnston and Schweig, 1996). Remote sensing techniques were implemented in order to gain a better understanding of the impact of this earthquake series on soil variation.

The remote sensing technologies utilized in this study were an attempt to indirectly determine variations in soil physical properties. By categorizing the canopy density from the remote sensing data into three yield classifications (low, medium, and high), an expected cotton production map can be developed (Vellidis et al., 1997). In-field variation of soil texture is a determining factor in the amount of fertilizer that is required at site-specific areas. A measure of the electrical conductance (EC) of soil is being studied to determine the correlation between these measurements and the textural differences of the soil. The Veris cart is one method of directly measuring soil EC (Moore and Wolcott, 2001).

PROCEDURES

Using a Duncan Tech camera (Duncan Technologies Inc., Auburn, CA), a multispectral aerial image of the field was acquired on 28 July 2002. The resolution of the imagery was approximately one meter. The imagery was processed using ArcView 3.2 with the Image Analysis extension (Environmental Systems Research Institute Inc., Redlands, CA). The imagery was used to divide the relative cotton density into three productivity classes (low, medium, and high).

Using a Kawasaki 2025 Mule (Kawasaki Motors Corp., USA, Santa Ana, CA), a Veris 2000 XA (Veris Technologies, Salina, KS) was used to collect soil EC data on 21 November 2002. The Veris collects conductivity readings at a probe depth of approximately 2 to 3 inches once every second. The swath distance for the each round made through the field was approximately thirty feet, and the average driving rate was 8 mph. The Veris data were then transferred into the ArcView 3.2 mapping system where the latitude and longitude coordinates where overlaid onto a color infrared digital orthoquarterquad (DOQQ). A new and more detailed map was created using the Veris data points. This map was based on an inverse distance algorithm that produced estimates every 0.5 m. The interpolated Veris data were then compared to the field variations that could be seen in the multispectral aerial image and the soil series information.

Surface soil samples taken to a depth of 6 inches were collected and then sent to the University of Arkansas Soil Test Laboratory for analysis of soil nutrient levels. The samples were collected on an irregular pattern at a density of approximately one sample per acre.

RESULTS AND DISCUSSION

The enhanced multispectral image clearly indicated the areas of the field where the pivot irrigation system could not reach (Fig. 1). The irrigated portion of the field shows through as a lighter colored 65.1 acre semicircle area in the image. The darker corners of the image, totaling 8.9 acres, were not covered by the field irrigation system.

Sand blows are a common occurrence in this area. These features (darker shaded areas) were readily identified in the aerial imagery (Fig. 2). The sand-blow intrusion patterns revealed by the imagery were spatially related with the soil series information for this field. The soil-survey information maps out these sand-blow intrusions as the Crevasse soil series. This same relationship between the sand-blow intrusions and the Crevasse soil series was identified by the Veris soil EC information as having lower soil levels (Fig. 3). The spatial relationship between the Veris soil EC map and the multispectral image was well correlated (Fig. 3 and Fig. 2). Soil nutrient data were not found to correlate with field soil-survey texture variations (data not shown).

Field observations clearly indicated the sand blow intrusions severely limited cotton growth due to moisture stress. In order to quantify these low plant-density areas, the image was classified into three groups (low, medium, and high) (Fig. 4). The high category is the area in the field with the highest expected yield. The medium category did show indications of stress and would be expected to suffer some yield loss. The low category (12% of the field), which is the class that contains the sand-blow intrusions, would not be expected to produce an economic return based on input costs.

PRACTICAL APPLICATIONS

Cotton production zones were classified into high, medium and low stress levels based on remote imagery and Veris soil EC. Approximately 13% (9.6 acres) of the field would not benefit from production inputs due to moisture stress because of the sand blow-intrusions. These data suggest that it would be more viable from an economic viewpoint to limit inputs such as fertilizer, growth regulator, insecticide, and defoliant in areas of the field classified with low productivity. A variable-rate controller could be used to apply inputs based on site-specific production zones instead of treating the field as a uniform area.

LITERATURE CITED

Johnston, A.C. and E.S. Schweig. 1996. The enigma of the New Madrid earthquakes of 1811-1812. Anna. Rev. Earth Planet Sci. 24:339-384.

Moore, S.H. and M.C. Wolcott. 2001. Mapping and interpreting electrical conductivity in production fields. Louisiana Agriculture. Vol. 44 No. 3.

Vellidis, G., D. Thomas, T. Wells, and C. Kvien. 1997. Cotton yield maps created from aerial photographs. ASAE Paper No. 991139.

Fig. 1. Enhanced multispectral aerial image (04/28/02) illustrating the cotton canopy area covered by the irrigation system.

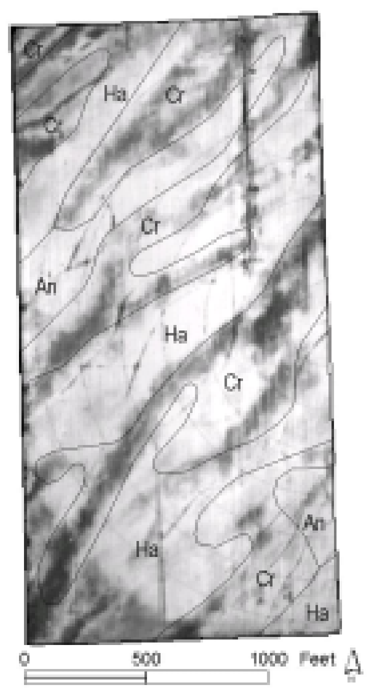

Fig. 2. Visual correlation of the spatial relationship between the soil series map units and the sand-blow intrusion areas as revealed by the enhanced multispectral image (Cr -Crevasse, Ha - Hayti, An - Amago).

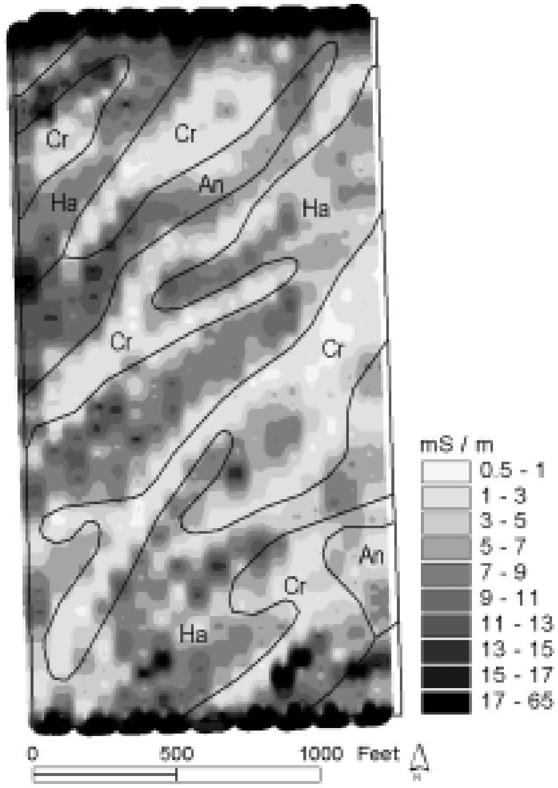

Fig. 3. Soil electrical conductivity map developed from Veris measurements used to indirectly access textural variations within the field.

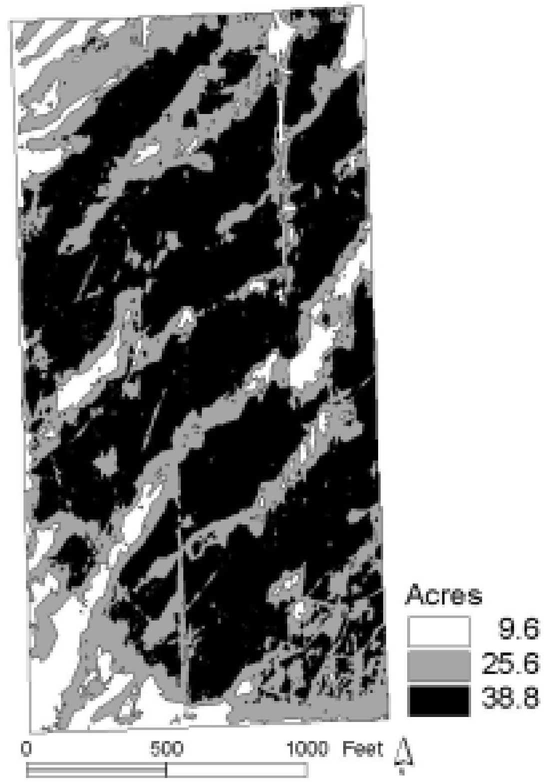

Fig. 4. Zone-specific variability of the enhanced multispectral image classified into three productivity zones (low-white, medium-grey, and high-black) indicating cotton yield potential.