COMPARISON AMONG DIFFERENT TYPES OF SPATIALLY DISTRIBUTED FIELD INFORMATION OF POSSIBLE USE IN PRECISION FARMING

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Abstract

Spatially distributed data were obtained for a field planted to cotton (*Gossypium hirsutum* L.) in 1998. Six types of data (yield map, mid-season infrared imagery, soil water-holding capacity map, soil texture map, soil electrical conductivity map, and soil color imagery) are compared. Potential information content of each is examined, and their utility in precision farming applications is discussed.

Introduction

Precision farming is a concept in which agricultural management practices are selectively applied in response to the known variability of growing conditions across a field. Inherent to the success of this approach is the capability to obtain information on the spatial distribution of field characteristics (such as soil moisture, soil nutrient content, weeds, and insect pests) that can affect crop growth. Characteristics of some data acquisition systems, such as remote sensing (Hart et al., 1997; Robert, 1997), favor their use in precision farming applications. Since systems that provide spatially distributed data vary in their cost and ease of application, study of the possible relationships among different types of spatially distributed information may help determine which are of more practical use in operational precision farming activities. The objective of this presentation is to compare six types of spatially distributed field information and discuss their possible application to precision farming applications.

Materials and Methods

Spatially distributed data were obtained for a 7-acre (2.8-ha) field at the Shafter Research and Extension Center, Shafter, CA, during 1998. The field was planted on April 20 with the Acala cotton variety 'MAXXA' in 30-in (0.76-m) rows. The field was divided lengthwise into four plots; two of these plots were furrow irrigated, while the other two plots were irrigated using subsurface drip irrigation. All four plots received adequate water throughout the growing season to avoid water stress. The crop was picked over the period November 6-20 using a single-row picker equipped with a yield monitor (Zycom Corp., Bedford, MA).

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The soil of the field is in the Wasco series of sandy loams (coarse-loamy, mixed, nonacid, thermic Typic Torriothents). Core samples for determining soil texture were taken from 42 locations forming an equally spaced grid across the field. Soil samples were taken to a depth of 4 ft (1.2 m) in 1-ft (0.3-m) increments. Sand, silt, and clay content of each sample was determined using standard sedimentation techniques (Taylor and Ashcroft, 1972, p.129). Soil moisture data were obtained weekly at 20 locations forming an equally spaced grid across the field. Soil moisture was measured to a depth of 4 ft (1.2 m) in 1-ft (0.3-m) increments using a neutron soil moisture probe (Troxler Corp., Research Triangle Park, NC).

Soil electrical conductivity was estimated by traversing the field lengthwise with a portable electrical conductivity sensor (Veris Technologies, Salina, KS). Conductivity data were assumed to represent conditions in the upper 3 ft (0.9 m) of the soil profile.

High-resolution imagery of the field was obtained from a multispectral sensor carried aboard a light aircraft. Imagery was obtained before planting and at various times during the growing season. Images were obtained in the blue, green, red, and near-infrared spectral wavebands (480, 550, 660, and 850 nm, respectively). Spatial resolution in the imagery was approximately 2 m.

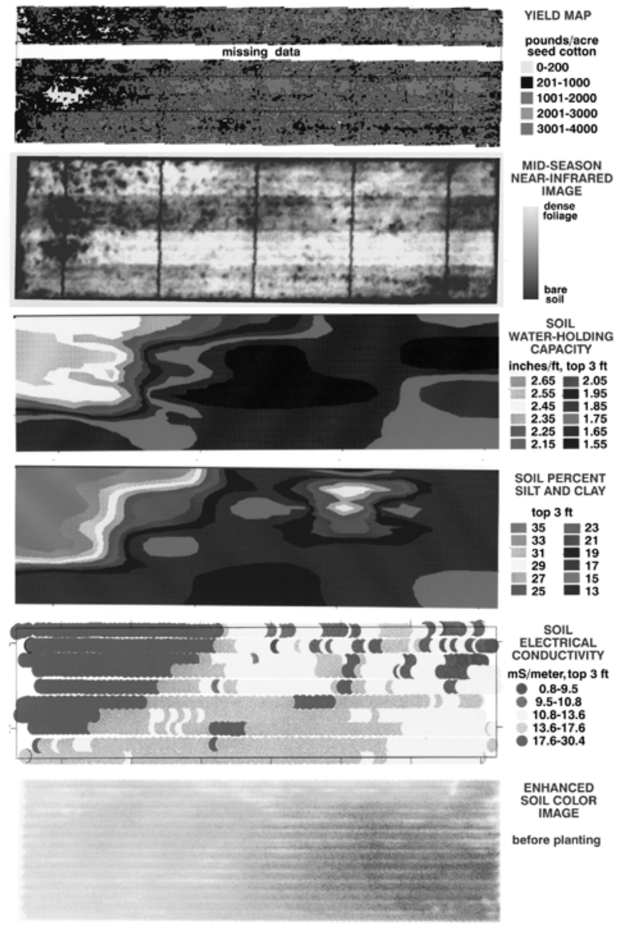
Results and Discussion

The accompanying figure displays a set of six different types of spatially distributed information for the study field: a yield map, a mid-season near-infrared image, a soil water-holding capacity map, a soil texture map, a soil electrical conductivity map, and a soil color image. Each map or image exhibits noticeable patterns that can be compared among the set.

The yield map indicates that the poorest yields occurred on the western side of the field. Scouting indicated that this yield reduction was directly attributable to damage to the leaf canopy caused by spider mites (*Tetranychus* spp.). Other smaller areas of yield reduction, like along the southern portion of the field, were also associated with spider mite damage. The defoliation associated with this damage is clearly visible in the mid-season (August 19) near-infrared image of the field, obtained when the cotton canopy was at its fullest stage of growth. As in standard aerial infrared photography, the brightness of any portion of the image depends on how dense the vegetation canopy is in it. The effects of the irrigation treatments (furrow versus drip) are also apparent in the image, with generally denser (brighter) plant canopy being found in the drip irrigated plots.

The soil water-holding capacity (estimated from the neutron probe moisture measurements) and soil texture (percent silt and clay) maps appear to be highly correlated. As one might expect, the denser soil in the field is accociated with a greater soil water capacity. The overall pattern is also reproduced in the soil electrical conductivity map. The soil in this field is inherently low in salt, so the patterns in the conductivity map may be explained by variations in soil density and/or moisture content. In the yield map, the areas of reduced yield on the western side of the field appear to be associated with the areas of highest water-holding capacity, percent silt and clay, and electrical conductivity. Soil moisture conditions associated with this part of the field may have favored spider mite attack, perhaps through more luxurient canopy growth earlier in the season. However, this apparent correlation may also be an artifact, since spider mites appeared to have initially entered the field from an existing almond orchard adjacent to the west side of the field.

The soil color image, developed from a true-color (red, green, and blue band composite) image obtained prior to planting, hints at the patterns of soil physical characteristics noted in the water-holding capacity, percent silt and clay, and electrical conductivity maps. Though it does not provide quantitative information, the soil color image might find use in intelligently directing the sampling of soil properties like texture and water holding-capacity, thus reducing the overall number of samples taken.



Six types of spatially distributed information for the cotton field at Shafter, CA.

Conclusions

High-resolution spatially distributed information such as remote sensing imagery can be highly correlated with small-scale features of crop growth, such as yield. The success of using imagery to direct precision farming activities would then depend on the earliness that a crop stress (such as nutrient or water stress, weeds, or insect attack) could be detected through remote sensing. These stresses tend to be episodic, and may be related to larger-scale variations in soil properties (such as texture, ion exchange capacity, or salinity) that can be revealed through grid sampling. Collection of fine-scale grid sampling data can be tedious and expensive. Simple data products such as soil color maps may be used to direct soil sampling to reduce the overall number of samples required. Recently developed ground-based remote sensing techniques, such as electrical conductance, might replace standard grid sampling of soil properties, although proper interpretation of results in terms of soil physical properties would be required.

Disclaimer

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