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Airborne Videography to Identify Spatial Plant Growth Variability for Grain Sorghum

CHENGHAI YANG yang@pop.tamu.edu
USDA-ARS Subtropical Agricultural Research Center, 2413 East Highway 83, Weslaco, TX 78596

GERALD L. ANDERSON
USDA-ARS, Sidney, MN

Abstract. Much research has focused on the use of intensive grid soil sampling and yield monitors to identify within-field spatial variability in precision farming. This paper reports on the use of airborne videography to identify spatial plant growth patterns for grain sorghum. Color-infrared (CIR) digital video images were acquired from two grain sorghum fields in south Texas several times during the 1995 and 1996 growing seasons. The video images were registered, and classified into several zones of homogeneous spectral response using an unsupervised classification procedure. Ground truthing was performed upon a limited number of sites within each zone to determine plant density, plant height, leaf area index, biomass, and grain yield. Results from both years showed that the digital video imagery identified within-field plant growth variability and that classification maps effectively differentiated grain production levels and growth conditions within the two fields. A temporal comparison of the images and classification maps indicated that plant growth patterns differed somewhat between the two successive growing seasons, though areas exhibiting consistently high or low yield were identified within each field.

Keywords: grain sorghum, precision farming, remote sensing, spatial variability, and videography

Introduction

Remote sensing observations have been used to monitor plant growth conditions and obtain crop yield information for many years. More recently, aerial video imaging technology has emerged as a versatile data-gathering tool because of its high spatial resolution and the near real-time availability of data for monitoring and analysis (Everitt et al., 1991, 1995; Mausel et al., 1992). Remotely-sensed video imagery is becoming a valuable data source for precision farming. Precision farming aims to improve crop production efficiency and reduce environmental pollution by adjusting production inputs (i.e., seeds, fertilizer and pesticide) to the specific conditions within each area of a field. Therefore, it is necessary to partition individual fields into relatively homogeneous zones that can be treated differently. To date, the two approaches commonly used for establishing management zones within a field are intensive grid soil sampling (Bullock et al., 1994; Wollenhaupt and Wolkowski, 1994) and mechanical yield monitoring (Yang, 1994). Crop yield monitors are well developed and commercially available in the United States and Europe. Soil property sensors are being developed, but are not yet widely accepted.

Therefore, soil sampling on a grid followed by laboratory analyses remains the most used method for obtaining within-field soil information. When crop yield and soil data are collected, they are interpolated across the entire field to generate gradational yield and soil nutrient maps. Such maps are then used to establish within-field management zones. Yield mapping and grid soil sampling produce a wealth of information, but data analysis, especially soil sample analysis, tends to be very expensive and time-consuming. Moreover, yield maps can only be developed after harvest.

Aerial videography provides alternative or supplemental within-field spatial variability information. Digital videography can provide within-season data for immediate visual interpretation and digital processing. Video imaging systems used in vegetation monitoring typically sense in the visible and infrared portions of the electromagnetic spectrum. Spectral responses in the green, red, and near-infrared (NIR) portions of the spectrum have been used to estimate biomass, leaf area index (LAI), and crop yield (Wiegand et al. 1994; Yang and Anderson, 1996). Moreover, digital video images can be statistically clustered into regions of homogeneous spectral response (Yang and Anderson, 1996). These regions can then be used as management zones for the field. By separating the field into fairly homogenous regions of plant growth, the number of plant tissue and soil samples required to characterize the spatial variability of the field can be reduced (Anderson and Yang, 1996).

The objectives of this study were: (1) to identify within-field production zones for grain sorghum from aerial videography; (2) to compare differences in plant growth characteristics among different zones; (3) to determine the correlations between plant growth variables and video spectral variables; and (4) to detect consistency and change in plant growth patterns over the two growing seasons.

Methods

Image acquisition and classification

A multispectral digital video imaging system described by Everitt et al. (1995) was used for image acquisition. The system consists of three charge coupled device (CCD) analog video cameras equipped with a NIR (845–857 nm) filter, a red (625–635 nm) filter, and a green (555–565 nm) filter, respectively. The NIR, red, and green image signals from the cameras are fed into the RGB inputs of an image digitizing board (640 $\times$ 480 pixel resolution) installed in a computer, thus giving a CIR composite digital image. During image acquisition, the CIR composite image was viewed on the computer's built-in monitor and the three individual band images were viewed on three black-and-white monitors to ensure the cameras were functioning correctly and the area of interest was correctly obtained.

A 6-ha and an 11-ha irrigated grain sorghum fields (referred to as fields 1 and 2, respectively) were selected from a study area which included fields owned and operated by Rio Farms, Inc. at Monte Alto, Texas (26°23′ N, 97°58′ W). Grain sorghum and cotton are usually cropped alternately in these fields, although grain