DIFFERENTIATION OF COTTON FROM OTHER CROPS AT DIFFERENT GROWTH STAGES USING SPECTRAL PROPERTIES AND DISCRIMINANT ANALYSIS

Y. Lan, C. P. -C. Suh, J. K. Westbrook, W. C. Hoffmann

USDA-ARS
College Station, Texas

H. Zhang, R. Lacey

Department of Biological and Agricultural Engineering
Texas A&M University
College Station, Texas

ABSTRACT

Spectral reflectance properties of cotton (Gossypium hirsutum L.), corn (Zea mays L.), soybean [Glycine max (L.)], and sorghum [Sorghum bicolor (L.)] crops during their different growth stages of development were examined and spectral data was used to distinguish cotton from other crops. Spectral information was collected from all crops at different growth stages from May to July 2009. Reflectance spectra and the first derivative of the spectra were analyzed to characterize the spectral properties of crop varieties and compare the crops grown in different soil types. The red-edge points of cotton, soybean and sorghum shifted with the growth stages of development. Principal component analyses were successful in reducing the dimensionality of hyperspectral data. The discriminant analysis method was found to be able to differentiate cotton from other crop types at four critical growth stages.

Keyword: spectral reflectance, crop discrimination, red-edge point

INTRODUCTION

Detecting volunteer cotton in other crops or uncultivated habitats is also problematic because these plants are usually hidden by the surrounding vegetation. Thus, there is a need to develop or identify technologies that can be used to efficiently detect regrowth and volunteer plants in both cultivated and uncultivated habitats. One potential method may involve remote sensing with multispectral and hyperspectral sensors.

MATERIALS AND METHODS

The study site was located at the Texas A&M AgriLife Research Farm (30°31'19"N, 96°23'52"W) in Burleson County, Texas. Two field blocks with two different soil types (Belk clay (BaA) and Ships clay (ShA)) were set up with cotton, corn, soybean and sorghum in each block and grown using conventional production practices. Plant canopy spectral reflectance was collected with an ASD FieldSpec® Handheld spectroradiometer (VNIR (325-1075 nm), Analytical Spectral Devices, Inc., Boulder, CO) at four different growth stages, early vegetative, vegetative, reproductive, and late growth stages (Table 1).

Table 1. Hyperspectral measurement dates, days after planted (DAP) and respectivestages of plant development designation in parentheses, 2009 growing season.

Crop	May 7 [DAP]	May 27 [DAP]	June 11 [DAP]	July 16 [DAP]
Cotton	Early vegetative (EV) [21]	Early squaring [41]	Squaring (SQ) [56]	Bolls & Blooming (Boll/BM) [91]
Corn	Early vegetative (EV/V) [44]	Vegetative / Ear developing (V/E) [64]	Dough stage (DS) [79]	Hard dent (HD) [114]
Soybean	Early vegetative (EV/V) [44]	Pod developing (PD) [64]	Pod 3/16 inch at one of four upper nodes (POD) [79]	Seeding/full seed (SD) [91]
Sorghum	Early vegetative (EV) [22]	Vegetative (V) [42]	Boot (head surrounded by flag leaf) (BT) [57]	Black layer/mature (BL) [92]

RESULTS

The maximum contrast of the reflectance value of cotton to those of other crops was around the 680 nm wavelength. The highest reflectance in the NIR region was observed at the reproductive stage. Using the first derivative of the spectral data, the red-edge position of cotton crop was at the shorter wavelength than those of corn, soybean and sorghum at the vegetative stage and cotton, soybean and sorghum at the reproductive stage. The red-edge points of cotton, soybean and sorghum shifted about 4 nm, 1 nm, and 2 nm, respectively, from the vegetative stage to the reproductive stage.

Principal component analyses were successful in reducing the dimensionality of hyperspectral data and identifying significant features from original data. Most significant wavelengths selected were among 548-556 nm, 679-682 nm, 756-764 nm, and 928-940 nm regions of the spectrum. DISCRIM procedure in SAS was able to identify the crop varieties during the calibration step with different numbers of principal components (PCs). For May 27 and July 6 datasets, the accuracy of classification was 100 % with three or four PCs in both calibration and cross-validation steps. For June 11 dataset, six PCs were used to get 100 % accuracy of classification in both calibration and cross-validation steps. The discriminant analysis was able to differentiate cotton from corn, soybean and sorghum with 100 % accuracy of classification for all four days data.