MEASURING LEAF, BARK AND GRASS PARTICLES IN COTTON WITH NIR IMAGING

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Abstract

Digitized images from black and white video cameras are being used to measure the area and numbers of particles in cotton. The method now provides trash grades for nearly all U. S. cotton. Small samples from each bale are compressed against a glass window and illuminated for imaging. Trash area readings are based on the relative darkness of each particle when compared to the cotton lint. Herein, we report the results of visible and near-infrared spectral reflectance from several different types of trash found in cotton. The feasibility of identifying different types of trash particles such as grass and bark is discussed.

Keywords: trash area, cotton lint, color, contrast, threshold.

Introduction

Since 1990 the USDA has used instrument-based methods to report cotton grade factors. Instruments now provide separate estimates of color and trash components of grade. Trashmeters employ black and white video cameras to identify regions darker than a calibrated threshold level[1,2,3]. Computers are used to digitize images and report the number of particles and total trash area. However, visual classification is still used to identify cottons containing grass and bark particles.

Trashmeter area is a measure of percent surface area occupied by trash when scanned by the video camera. We will use a simple model to develop an understanding of particle contrast and how it influences the video system output. Contrast was defined by the percent change in video output between a particle and its surrounding (i. e., the percent change in output voltage at a particle). A threshold voltage (T_0) was selected during trashmeter calibration to produce the prescribed particle area measurement (Figure 1). Calibration threshold values are usually set near 70% of the background output. This threshold level was initially selected because it produced a video image which "looked" like the cotton sample being viewed. Calibration tiles and cotton samples under glass are now used to precisely control the area calibration between trashmeters. Light colored particles and those immersed in among cotton fibers, will contribute a reduced area measurement or be ignored entirely (Figure 2). The reader should note that, when using black and white imaging, it is impossible to distinguish between light colored particles and those partially submerged in cotton fibers.

We have reported on the effects of particle contrast and color on trash area measurements[4,5]. In this report we examine the feasibility of identifying specific types of trash particles using optical filters to isolate new spectral bands. We were especially interested in investigating imaging opportunities in the near- infrared region. To do this, we measured particle reflectance in that region and calculated spectral contrast.

Experimental Procedure

Cotton trash samples of interest were collected and dried in the instrument research laboratory at Clemson. Two mechanically cleaned cotton fiber samples (i.e., white cotton and yellow cotton) were included to provide background values for reflectance and contrast calculations. All test samples were measured for visible color (Table I) using our laboratory spectrophotometer (i.e., Model TCM from Pacific Scientific Inc.).

Spectral absorbance values (i. e., Log 1/R) for each trash and fiber sample were measured for visible and near-infrared regions using our near-infrared spectrophotometer (i. e., Model 6500 from Perstorp Analytical Inc.). This instrument provided absorbance values for two spectral photodetector regions (i. e., Silicon; 400 to 1100nm and Lead-Sulfide; 1100 to 2500nm).

Results

Visible/Silicon Region: Absorbance data in this region generally decreased with increasing wavelength (Figure 3). Only the green grass sample indicated level of chlorophyll absorption (i. e., near 650nm). Spectral absorption data for all samples reached a maximum near 420nm which was caused by a drop-off in the spectrometer response.

Reflectance values for each sample were calculated from absorbance data (Figure 4). After the reflectance data for each trash particle was normalized with the reflectance for white cotton (Figure 5) and for yellow cotton (Figure 6), it was very easy to see which spectral region was best for imaging. Existing trashmeters use sharp cut spectral filters to exclude light with longer wavelengths than 600 to 725 nm. Note that for both spectral examples given (i. e., white and yellow cotton), the contrast of bark particles was between green and brown grass. This situation will make it extremely difficult to discriminate the bark from grass with simple black and white imaging.

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Near-Infrared/Lead-Sulfide Region: Spectral data for all cotton trash particles in this wavelength region (Figure 7) exhibited the customary absorbance bands (i.e., water at 1905nm, cellulose at 2100nm and a multiple combination band for water and sugars near 1500 nm). When these data were converted to reflectance values (Figure 8), the inverse spectral trends were noted. Normalization of the reflectance from each particle with cotton (Figures 9 and 10), showed a very low level of particle contrast throughout the near-infrared spectral region. This finding showed that it will be extremely difficult to find a near-infrared spectral where cotton trash particles exhibit a high level of contrast. Additionally, the NIR data showed that the contrast values for bark was also between two samples of grass. This condition will make the discrimination of bark from grass using NIR data impossible.

Bark Particle Size Effect: Two samples of cotton plant bark were tested in this study. Bark particles were segregated into small and large categories. Because of difference in light scattering, from particle surface differences in the near-infrared spectra were observed (Figure 11).

Summary

Among the cotton trash particles examined in this study, all gave the best particle contrast in the short wavelength visible region. Additionally, all spectral data for bark was between two different colored grass particles. Therefore, it will be impossible to separately identify bark and grass particles with a simple video image thresholding technique. Trash particle contrast was very low throughout the near infrared region which will also make imaging in that spectral region very difficult.

Table 1. Color of test samples

Sample	Reflectance Rd (%)	Yellowness +b	Redness +a
Bark	20.3	16.4	9.4
Brown Grass	12.5	11.8	4.9
Green Grass	13.7	12.9	-1.6
White Cotton	76.3	13.0	1.5
Yellow Cotton	58.8	15.4	4.2

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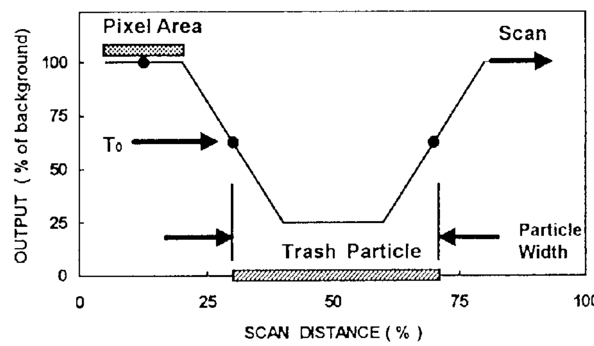

FIGURE 1 PARTICLE AREA ANALYSIS

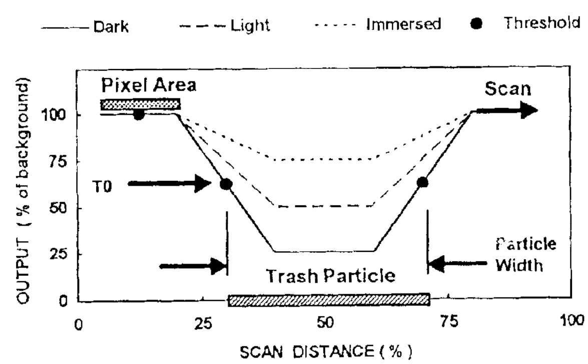

FIGURE 2 ANALYSIS FOR 3 LEVELS OF PARTICLE CONTRAST

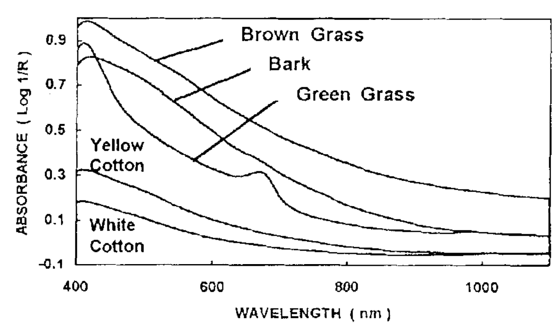

FIGURE 3 VISIBLE ABSORBANCE DATA

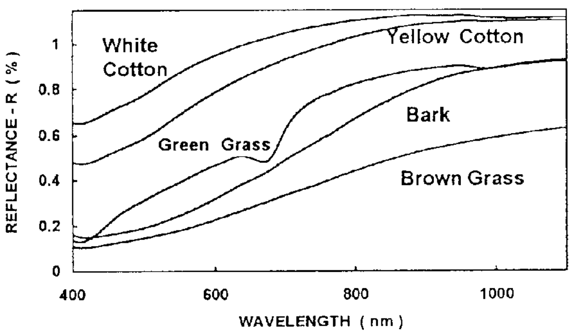

FIGURE 4 VISIBLE REFLECTANCE SPECTRA

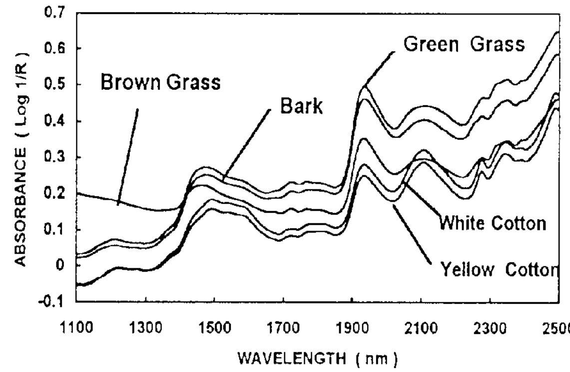

FIGURE 7 NEAR - INFRARED ABSORBANCE DATA

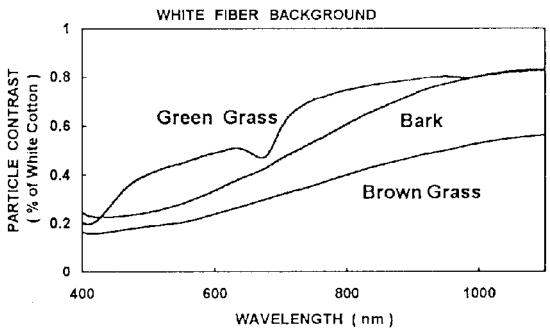

FIGURE 5 CONTRAST WITH WHITE COTTON

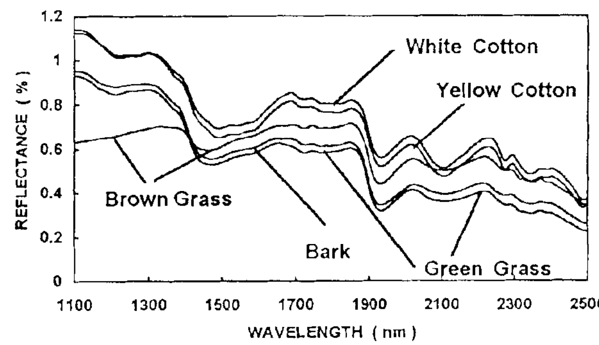

FIGURE 8 NEAR - INFRARED REFLECTANCE

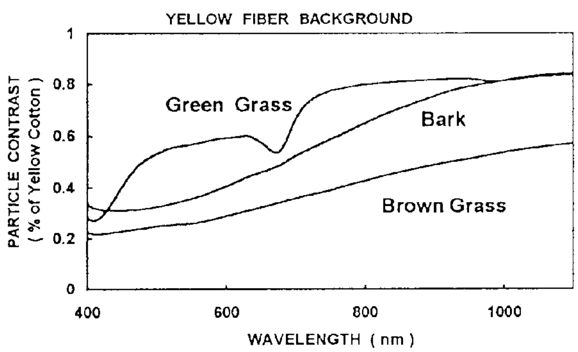

FIGURE 6 CONTRAST WITH YELLOW COTTON

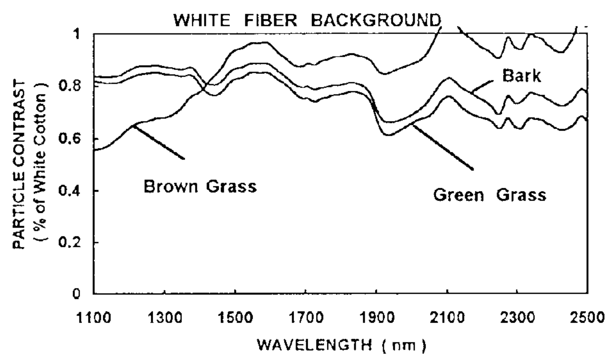

FIGURE 9 N I R CONTRAST WITH WHITE COTTON

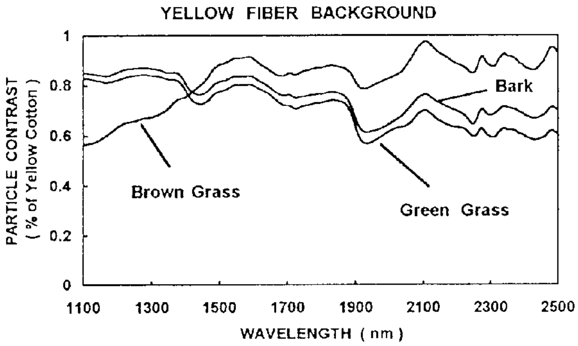

FIGURE 10 N I R CONTRAST WITH YELLOW COTTON

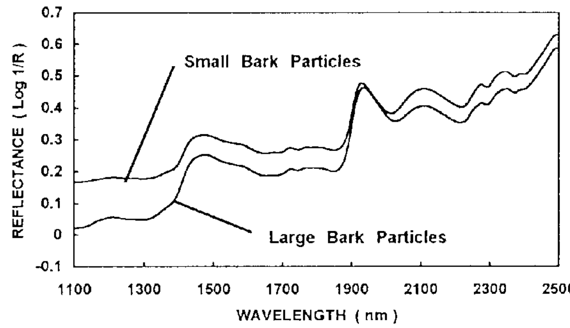

FIGURE 11 NEAR- INFRARED SPECTRA OF BARK