WEATHERIZATION STUDY OF BOTANICAL COTTON TRASH WITH FLUORESCENCE IMAGING

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Abstract

In addition to lint fibers, seed cotton contains various types of trash components originating from botanical and non-botanical sources removed from the field during harvesting. Subsequent to harvesting, seed cotton is transported to the ginning facilities where it is subject to decontamination. Samples of ginned cotton are extracted from bales and they undergo quality assessment by human classers and the grading instruments, resulting in grades, which determine their marketability and monetary value. Grading by human classers is subjective, while more accurate quality grades are assigned by instruments like the HVI. The instruments provide a number of quality parameters but cannot differentiate and classify different categories of cotton trash. To investigate the possibility of using fluorescent imaging to acquire images of cotton trash, images of cotton trash were processed through a sequence of image processing steps and their respective channels used to provide essential information regarding cotton trash. The study presents the effects of aging on cotton trash samples extracted from cotton plants, and the ability of the imaging system to perform depth imaging of trash particles.

Introduction

During harvesting, lint fibers are mixed with cotton trash from the plants. The resultant seed cotton is transported to cotton gins, where it is cleaned of most trash particles. Smaller remaining particles still remain mixed with lint, and affect the quality grades assigned during assessment by either human classers and or the grading instruments. In contrast to human classers, more objective grading is done by the High Volume Instrument (HVI), which has the ability to detect trash in sampled cotton, but cannot provide information regarding the trash types (Wakelyn et al., 2007). To examine if fluorescent imaging can provide complementary information to white light imaging performed by the HVI, an imaging system with color camera and blue LED and UV LED excitation sources was constructed.

The study presented was focused on examining the capabilities of the fluorescent imaging system in two main objectives. The first objective was to monitor botanical trash degradation over a period of 10 weeks, and quantify the changes in the red and green channels. The second objective was to examine whether reflectance and transmission imaging can be used to image cotton trash placed under lint samples of various thickness levels.

Materials and Methods

To observe the effects of aging, cotton plants grown in a greenhouse were utilized to provide samples of bark, bract, and hull. All samples came from four cultivars harvested in 2013, and from each cultivar, 7 samples were used, resulting in 28 individual samples of cotton trash for each category. Imaging of samples continued over a period of 10 weeks, and it consisted of placing them on a black background while the excitation sources illuminated cotton trash samples. Two blue LEDs were used as excitation sources due to their ability to provide optimal excitation light. Raw camera images were subject to and image processing sequence (Figure 1) consisting of using TIF images to extract the red and the green channel from which a binarized mask was created. The mask was multiplied with either the red or green channel to delineate the region of interest from which the average intensity could be extracted. Average intensity for both color channels was subjected to the ANOVA statistical analysis (SAS 9.2, Cary, NC) to see if statistically significant changes can be seen over the timeline of 10 weeks. Same mean separation letters indicate no significant change in respective means of each week.

To determine whether depth imaging can be applied to cotton trash found buried beneath a layer of lint, sample with lint thickness of 8, 15, and 24 mm were considered. Three trash types (paper, stem, plastic bale packing) were placed under the samples, while the blue and UV LED excitation sources provide the illumination light. In addition to reflectance imaging, transmission imaging was attempted, with the same types of trash sandwiched between two layers of lint with 4 mm thickness.

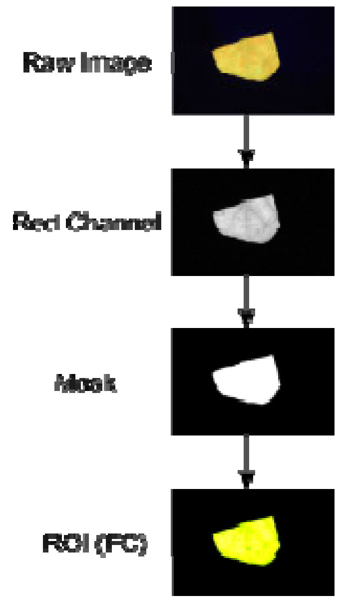

Figure 1: Image processing steps

Results

The average intensity for bark imaged over a period of 10 weeks (Figure 2) shows subtle changes in the red channel for the first 7 weeks, and from week 8 to week 10 a statistically significant increase. In contrast, changes in the green channel were less pronounced, with the overall trend line remaining constant over the period of imaging. Statistically significant changes were observed for bract (Figure 3) starting on week 8 and continuing through week 10. The same pattern of increased intensity is seen in both the red and green channel. In the case of hull, the trend line for the red and green channel is the same, with smaller changes over the entire imaging timeline, but no marked increase in either the red or green channel starting on week 8.

The depth imaging study results showed cotton trash was not visible under lint samples with thickness of 8, 15, and 24 mm, in the case of reflectance imaging. When the transmission imaging was used, trash sandwiched between two trash layers of 4 mm thickness was not visible.

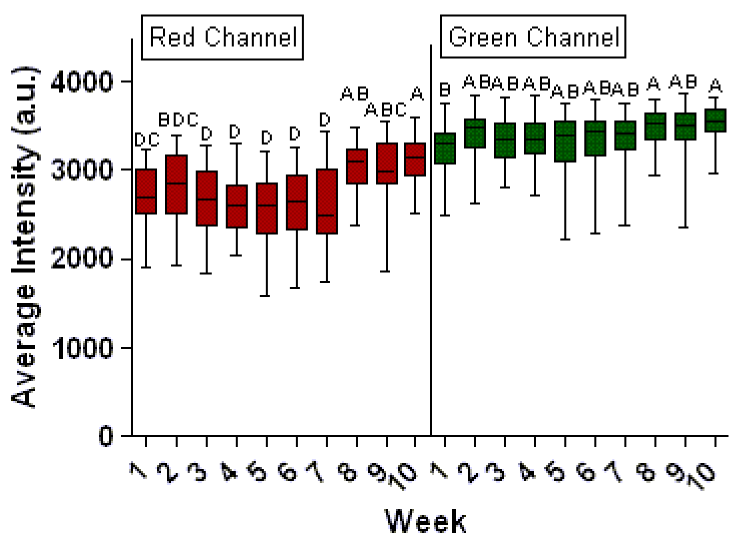

Figure 2: Average red and green channel intensity for bark shown over a period of 10 weeks.

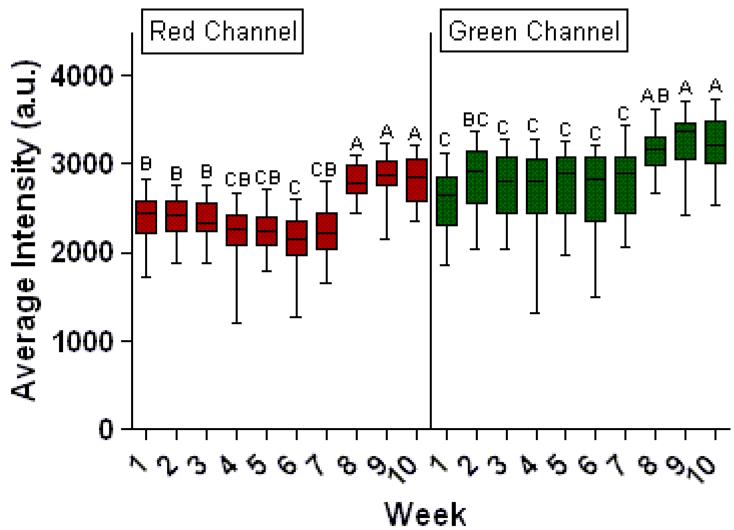

Figure 3: Average red and green channel intensity for bract shown over a period of 10 weeks.

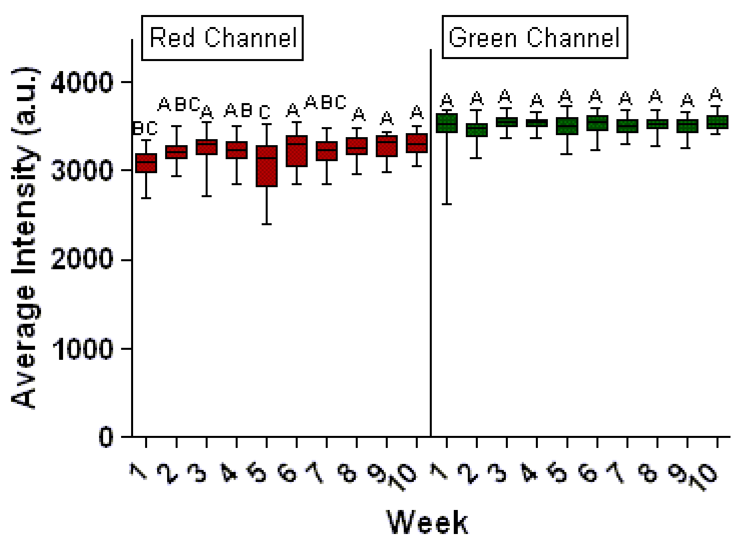

Figure 4: Average red and green channel intensity for hull shown over a period of 10 weeks.

Summary

Botanical trash degrades over time, and as a result their respective fluorescent signals change. To observe the pattern of changes, three trash categories (bark, bract, and hull) were analyzed with respect to their red and green channels. Significant changes were observed for the red channel of bark, and red and green channel of bract. The green channel of bark and both channels of hull remained less variant over the same period. The changes mentioned are due to the presence of different types of fluorophores found in cells, typically consisting of chlorophyll, flavonoids, cinnamic acid, and anthocyanins. As cell structures degrade, chlorophyll found in chloroplasts tends to decrease in concentration, however other fluorophores like anthocyanins became more visible, and are potentially responsible for increased emission.

The classing instruments like the HVI perform surface imaging using white light illumination, and can identify trash near the lint surface, but not the trash buried inside. The fluorescent imaging system was examined to see if it is capable of trash imaging at different depth levels by using reflectance and transmission imaging, however the results indicated only surface imaging was possible.

Acknowledgments

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References

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