PRELIMINARY FIELD TRASH STUDIES USING NEAR-INFRARED SPECTROSCOPY

Chanel Fortier
James Rodgers
Cotton Structure & Quality Research Unit (CSQ), SRRC-ARS-USDA
New Orleans, LA
Jonn Foulk
Cotton Quality Research Station (CQRS), ARS-USDA
Clemson, South Carolina
Derek Whitelock
USDA-ARS- Southwestern Cotton Ginning Research Laboratory (SCGRL), ARS-USDA
Mesilla Park, New Mexico

Abstract

Cotton is a cash crop that is important in the world market. Development of instrumental techniques which measure cotton quality parameters that are accurate, precise and fast would be beneficial. Cotton trash comingled with lint adversely affects the quality and profit margin associated with producing, harvesting, and processing of cotton lint. Conventional instrumental testing techniques including the Shirley Analyzer and the High Volume Instrument (HVI^{TM}), presently do not specifically determine the types of trash present with the lint. A program was employed to determine the specific identity of different field trash types using Near-Infrared (NIR) spectroscopy. Recent results reveal that identification of trash types is feasible by NIR spectroscopy with a high degree of accuracy.

Introduction

Presently, the HVI technique is commonly used to classify different attributes of cotton including micronaire, length, length uniformity, color, and specific to this study, trash content. The HVI involves using a visible imaging technique to determine total trash content which is present in a sample, but individual types of trash are not identified.

Previously, Himmelsbach and co-workers successfully used Mid-Infrared (MIR) spectroscopy to study small-size cotton trash types (Himmelsbach et al., 2006). By employing an Attenuated Total Reflectance accessory in their method, several cotton trash types were identified following the creation of an MIR spectral library. NIR offers many advantageous features including little to no sample preparation, accuracy, precision, non-destruction of samples, and ease of use. Based on these characteristics, NIR has been previously used to study textiles, including cotton (Taylor, 1980; Montalvo and von Hoven, 2004; Rodgers and Ghosh, 2008; Rodgers and Beck, 2009; Rodgers et al., 2010a; Rodgers et al., 2010b). In a recent preliminary study, NIR was employed to accurately classify and identify specifically various botanical cotton trash types (Fortier, et al, 2010). It was the goal of this study to improve the robustness of the original NIR spectral library with the addition of various field trash types.

Materials and Methods

One class of "clean" cotton was used as the cotton reference, and 35 powder and pepper botanical trash samples (hull, leaf, seed coat, and stem) of 9 botanical cotton trash types from three states [Mississippi (MS), New Mexico (NM), and South Carolina (SC)] acquired from USDA ARS CQRS were used as is in the NIR spectral library and the prediction set. Also, field trash varieties acquired from USDA ARS SCGRL were included in the NIR spectral library and the prediction set and was used as is. A bench top Bruker MPA NIR instrument was used to analyze the cotton and trash types. The NIR spectral library was created using Bruker OPUS IDENT software. The types for the botanical powder- and pepper-sized samples were labeled in the calibration and prediction set by assigning the first two letters from the state the samples were acquired in and the last letter as the sample type. The calibration set was different from the prediction set in that the corresponding powder and pepper samples in the calibration set were represented as the opposite powder and pepper samples in the prediction set. Three replicates were made of each cotton trash variety sample and the average spectra for the calibration and prediction sets were used. The beginning spectral library was composed of the botanical trash sample types belonging to the hull, leaf, seed coat, and stem groups. The spectral library was then expanded to include some types of field trash including (grocery bag, blue module cover, module cover strap, and twine) as shown in Table 1.

Table 1. NIR field trash types included in study for prediction set.

Prediction Set	Number of Samples
Grocery bag	2
Blue Module Cover	2
Clear Plastic bag	2
Module Cover Strap	2
Total Field Trash	8

Results and Discussion

During the harvesting and processing of cotton, different types of botanical and field trash types can become comingled with cotton lint. Compounding this problem is the formation of small-size (powder-size and pepper-size) cotton trash. The development of a technique which can detect and specifically identify cotton trash types would be desired. Thus, NIR spectroscopy was used in this study to classify and specifically identify different trash types based on their spectral signature which is directly influenced by their chemical properties.

Originally, a reference library consisting of cotton and botanical trash (hull, leaf, seed coat, and stem) NIR spectra was created to identify cotton and the different botanical trash types as previously described (Fortier et.al, 2010). Field trash types (grocery bag, blue cover, module cover strap, and clear plastic bag) were added to make the library more robust. Representative NIR spectra of cotton and field trash types are shown in Figure 1.

Initially, the field trash was added to the reference library consisting of botanical trash and cotton without incorporating sub-libraries. However, this setup led to the inability of the NIR method to discriminate between the spectral types. Thus, a "top down" method was employed that consisted of designing multiple sub-libraries which were able to separate cotton from the individual botanical and field trash types.

After much iteration involving different spectral ranges and preprocessing methods, a reference library was applied using a method where first the field trash types (grocery bag, blue module cover, clear plastic bag, and module cover strap) were separated out. Then a sub-library consisting of cotton and botanical trash (hull, leaf, seed coat, and stem) was created to separate these components. Another sub-library consisting of the hull and seed coat varieties was created to separate these trash types which had very similar first derivative NIR spectra. Overall, a percent accuracy of 99% was achieved for the identification of cotton, botanical and field trash types as shown in Table 2.

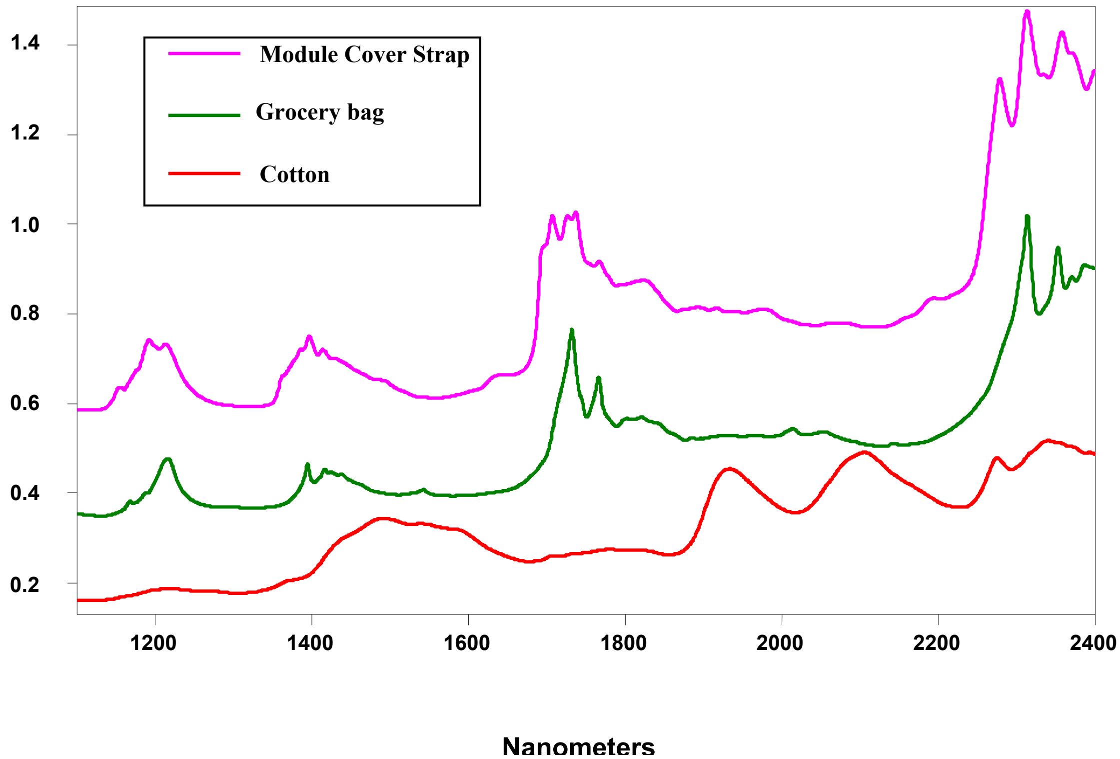

Figure 1. Representative NIR absorbance spectra of cotton and field trash types spectra over entire spectral range (1100-2400 nm). No preprocessing and standard method was applied.

Table 2. NIR Identification results for cotton and botanical and field trash types

Prediction Set	**Individual Samples**		
	No. of Samples	**No. Correct**	**% Correct**
Cotton	3	3	100%
Botanical Cotton Trash	102	101	99%
Field Trash	8	8	100%
Total Trash	113	112	99.1%

Summary

In the current study, NIR spectroscopy was successfully used to identify botanical trash and field trash types that can be found present with cotton. After much iteration of different spectral ranges and preprocessing applications, the NIR technique was successfully used to achieve an overall 99% accuracy in the identification of some botanical and field trash types. Compared to the previously used MIR technique, the use of NIR afforded distinct advantages including sample size and flexibility. This use of NIR spectroscopy has demonstrated that a robust spectral library can be created and expanded to include different field trash types with high identification accuracy.

Disclaimer

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