PREDICTING FOREIGN MATTER IN COTTON AT THE GIN

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Abstract

Improved processing of cotton requires measurement of the trash in the cotton before and after cleaning at the gin. Cameras are currently used in some gins to measure trash levels. This study ascertained the relationships between standard laboratory tests (Shirley Analyser for lint and Fractionation for seed cotton) and marketing assessments of trash (High Volume Instrument) and mesurements by a new, strobe-type camera. About 1,000 samples each of seed cotton and lint representing the full range of trash levels expected in both spindle-harvested and stripper-harvested cottons were evaluated. Laboratory trash levels ranged from 2 to 36% for seed cotton and from 1 to 14% for lint. Significant regression equations accounted for 76% of the variations in the Shirley Analyser data for lint and 92% for seed cotton fractionation. Similar correlations were found for HVI trash and manual leaf grade.

Introduction

Measurement of cotton quality is rapidly becoming more objective through the use of instruments as the U.S. cotton industry seeks to improve cotton quality by providing common reference methods to quantify important cotton parameters. Instruments are now available to rapidly measure several of the physical properties of cotton. Scanning color/trash cameras are available commercially to measure the color and trash (foreign matter) of ginned lint. The Agricultural Marketing Service (AMS) of the U.S. Department of Agriculture uses the color and trash readings from these cameras in their High Volume Instrument (HVI) classification system to assist visual inspection methods by humans used to classify the 15 to 20 million bales of cotton produced in the U.S. They also manually assess the trash in ginned lint and refer to it as "leaf" grade.

The HVI color/trash camera scans the surface of a sample while it is compressed with a pneumatic force against a window. The sample is illuminated with incandescent lamps placed 45 degrees from perpendicular. Black-and-white cameras are located directly above and below the window and analyze pixels over the total window area on each side of the sample. The electrical signals are analyzed for the appearance of a trash particle which is defined as anything that causes the reflectance signal from any pixel to drop 30% below the average light level reflected from the sample. Two readings--area and count--are obtained from the instrument which relate to trash content. Area is a measure of the portion of the sample surface covered with trash particles and count is related to the number of occurrences of the particles. Reflectance (Rd or greyness) and yellowness (Plus b) are measured as the two components of color.

Taylor (1983, 1984, and 1985) tested one model of the trash cameras extensively and found that trash readings correlated well (R-square = 0.83 to 0.94) with the trash content of lint samples based on the Shirley Analyzer method (ASTM Method D 2812). The Shirley Analyzer method employs rigorous mechanical cleaning and gravimetric weighing, and alters the lint so that no further grading can be done. Ginned lint samples typically contain between 2 and 8% trash based on the Shirley Analyser. Visible trash on the surface of the ginned lint is usually in the 0.1% to 1% range based on the HVI camera and the manual leaf grade lies between 2 and 7.

Anthony (1984) also found that the standard Motion Control Inc. HVI color/trash camera readings correlated well (R-square = 0.81) with Shirley Analyzer measurements of the trash content of ginned lint. Anthony (1987) reported in a separate study that a HVI color/trash camera could be modified and used to estimate the trash content of seed cotton so that the optimal cleaning process sequence in a ginning system could be selected. The HVI color/trash camera, together with a suitable moisture meter can provide the necessary input data to a dynamic computer model developed by Anthony et al. (1982) for optimal control of the ginning process. Patents for the process control system are licensed to Zellweger Uster for commercial implementation.

Based on the Fractionation procedure by Shepherd (1972), spindle-harvested seed cotton typically contains from 3 to 10% trash before cleaning and stripper-harvested cotton contains as much as 40% trash before cleaning. After cleaning with traditional gin machinery, trash levels are about the same in ginned lint for both harvesting methods because additional machines are used for the stripper-harvested cotton.

A color/trash camera that is substantially different from the HVI camera and the ones used by Anthony and Taylor is used in gin process control systems marketed by Zellweger Uster. The new strobe-type camera overcomes problems with over-heating and intensity degradation usually experienced by the standard incandescent bulbs because it "flashes" only when a sample is available for testing. This camera is being used successfully to measure the trash in both seed cotton and lint in 17 commercial gins. The camera has been improved since its initial introduction in 1997.

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Laboratory methods for measuring the trash (foreign matter) in seed cotton with a Fractionator are described by Shepherd (1972). The trash in lint is measured in the laboratory with a Shirley Analyzer. The correlation between the gravimetric laboratory reference methods and the strobe-type camera has not been published.

Purpose

The purpose of this research was to investigate the relationship between the laboratory-based trash content of seed cotton and lint samples, and measurements made by a strobe-type camera used in gin process control systems.

Procedure

Evaluation of the relationship between laboratory measurement of the trash in seed cotton and the trash in lint, and measurements made by a camera was accomplished by measuring over 2000 samples with laboratory and camera methods. These samples weighed about 200 grams each and were collected from several ginning studies in 1998 that had both spindle- and stripper-harvested cottons. Samples were collected before and after processing the test material through various gin sequences. From 3 to 10 samples were taken from each replication. Each sample was evaluated with a Zellweger Uster table-top sampling station normally used as an online sensing station in a gin for trash, color, and moisture determination. The camera was calibrated before and after each series of samples and on a daily basis in accordance with manufacturer's guidance. Four readings were made on each sample with the strobe-type camera. Readings were taken on the top and bottom of the sample and the sample was rotated vertically and two more readings taken. The seed cotton samples were then evaluated with the fractionation procedure as described by Shepherd (1972). The lint samples were classified by the USDA-AMS Classing Office at Dumas, Arkansas, for color (reflectance and plus b), trash in percent of surface area, manual color and manual leaf. Lint samples were then evaluated with the Shirley Analyzer procedure at the Stoneville Ginning Lab.

Data were analyzed with regression procedures to determine the correlation between reference and camera readings. Means for each sample were used in the analyses.

Results

Seed Cotton

Total trash in the tested samples ranged from 2% to 36% which is near the range normally found in spindle-harvested and stripper-harvested cotton. Regression analyses of seed cotton trash as determined by fractionation with the average of the four readings taken by the instrument on the 1,050 samples yielded an R-square value of 0.92 when area and count were used in the same equation. Area (R-square = 0.91) and count (R-square = 0.90) values and their combinations were the best correlations. The trash was also highly correlated with reflectance (R-square = 0.90).

The regression equation for trash in the seed cotton as a function of trash, area, and count is responsible for about 92% of the variation in the data. Figure 1 demonstrates the relationship between the actual and estimated seed cotton trash content. The foreign material in the seed cotton can be predicted with the camera. Thus, the amount of foreign material to be removed can be used to select appropriate levels of cleaning for the seed cotton. For example, a trash area reading of 4% corresponds to about 10% foreign matter and would likely require multiple seed cotton cleaners for adequate removal. Conversely, a trash reading of 1% which corresponds to about 4% foreign matter would likely require only one precleaning machine for adequate foreign matter removal.

Lint Cotton

Visible trash in the lint samples used in the study ranged from 1% to 14% and encompassed the range normally expected in samples of ginned lint. Regression analyses are presented in Table 2 for laboratory, AMS and strobe camera measurements. The Shirley Analyzer visible waste related to the camera area or camera count measurements with a significant R-square of 0.76 and 0.73, respectively. Figure 2 portrays the relationship between visible Shirley Analyser trash and area as measured by the camera. The amount of foreign matter per pound of lint can be estimated from the Shirley Analyser visible waste, and thus from the camera readings. Prediction of the amount of visible waste provides information to help select the number and types of lint cleaners required. For example, a trash area reading of 0.5 suggests that about 2% visible trash is in the cotton and would likely require only minimal cleaning to achieve an acceptable market grade.

Summary and Conclusions

This study ascertained the relationships between standard laboratory (Shirley Analyser for lint and Fractionation for seed cotton) and marketing assessments of trash (HVI) and measurements by a new, strobe-type camera. Cottons from both spindle-harvested and stripper-harvested cottons were evaluated. Laboratory trash levels ranged from 2 to 36% for seed cotton and from 1 to 14% for lint. Significant regression equations accounted for 76% of the variations in the Shirley Analyser data for lint and 92% for seed cotton fractionation. Similar correlations were found for HVI trash and manual leaf grade.

Disclaimer

*Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

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Table 1. Regression equations for predicting foreign matter in seed cotton from measurements with a strobe-type camera (range = 4 to 28% foreign matter).

Dependent variable	Independent variable	Intercept		Coefficient		R-square[1]
		t	P>t	t	P>t	
Trash	Area	2.217	0.0001	2.912	0.0001	0.91
Trash	Count	-2.576	0.0001	0.095	0.0001	0.9
Trash	Area*area	7.015	0.0001	0.297	0.0001	0.84
Trash	Count*count	4.734	0.0001	0.000252	0.0001	0.88
Trash	Area*count	5.855	0.0001	0.009	0.0001	0.89
Trash	Area	--	--	1.67	0.0001	0.92
	Count	--	--	0.041	0.0001	--
Trash	Rd	78.294	0.0001	-1.023	0.0001	0.9
Trash	Area	37.48	0.0001	1.587	0.0004	0.92
	Rd	--	--	-0.076	0.0001	--
Trash	Count	39.685	0.0001	0.046	0.0001	0.92
	Rd	--	--	-0.488	0.0001	--

[1]F = 0.0001 for all equations.

Table 2. Comparison of strobe-type camera measurements taken on samples at Stoneville as well as the HVI system at the AMS at Dumas, AR, and the Shirley Analyzer at Stoneville.

Dependent Variable	Independent	Intercept t	P>t	Coefficient	P>t	R-square[1]
Pctarea	Areacam	-0.239	0.0003	1.395	0.0001	0.74
Pctarea	Countcam	-0.403	0.0001	0.0116	0.0001	0.70
Leaf	Areacam	2.935	0.0001	27.392	0.0001	0.70
Leaf	Countcam	2.581	0.0001	0.023	0.0001	0.69
Pctarea	Areasq	0.349	0.0001	0.622	0.0001	0.68
Pctarea	Countsq	0.27	0.0001	0.406×10^{6}	0.0001	0.56
Rd	Rdcam	10.2	0.0001	0.87	0.0001	0.66
Plus b	Plus b cam	3.731	0.0001	0.537	0.0001	0.35
Leaf	Savisi	3.306	0.0001	0.321	0.0001	0.66
Leaf	Satotal	2,772	0.0001	0.308	0.0001	0.66
Pctarea	Savisi	-0.141	0.0013	0.18	0.0001	0.85
Leaf	Pctarea	3.684	0.0001	1.637	0.0001	0.66
Savisi	Areacam	-0.153	0.6286	7.25	0.0001	0.76
Savisi	Countcam	1.017	0.0099	0.06	0.0001	0.73
Savisi	Pctarea	1.503	0.0001	4.711	0.0001	0.85
Savisi	Countcam	None	--	0.051	0.0001	0.70

[1]F = 0.0001 for all equations.

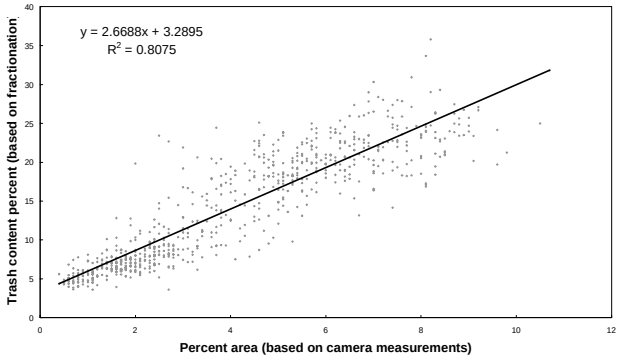

Figure 1. Comparison of foreign matter in seed cotton based on Fractionator and trash area reading from strobe-type camera.

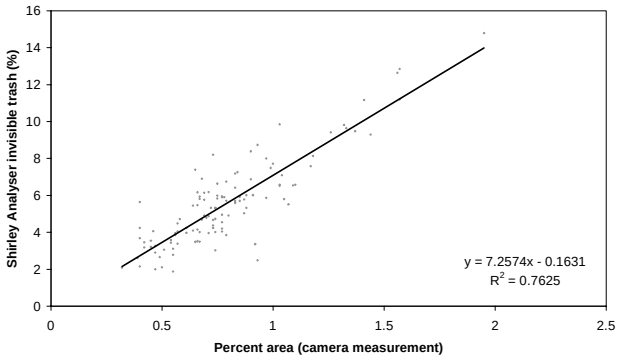

Figure 2. Comparison of foreign matter in lint cotton based on Shirley Analyser and trash area reading from strobe-type camera.