IMPACTS OF GLASS USE IN COTTON COLOR MEASUREMENTS

James Rodgers
USDA ARS, SRRC
New Orleans, LA
Sho Yeung Kang
University of Georgia
Athens, GA
Xiaoliang Leon Cui
USDA ARS, SRRC
New Orleans, LA
Vikki Martin
Michael D. Watson
Cotton Incorporated
Cary, NC

Abstract

Cotton color is an important classification property. In the U.S., cotton is classified for color using the Uster® High Volume Instrument (HVI). The color of cotton on the HVI is denoted by the parameters Rd and +b, which represent the cotton's diffuse reflectance and yellowness, respectively. Rd and +b are specific to cotton fiber and are not typical globally recognized color systems. An earlier program established and validated the feasibility of correlating Rd and +b to the globally recognized color system L*a*b* for both standard tiles and cottons. The major impact on agreement between the HVI and standard color spectrophotometers and between color spectrophotometers was the use of glass (required for cotton color analyses) between the sample and the spectrophotometer measurement port. A program was implemented to 1) investigate the impact of glass and glass type on the spectrophotometer color measurements and 2) to determine the feasibility of minimizing the glass impact. The glass impact on spectrophotometer color results was much greater than that of specular component type. The glass impact of the 6 mm thick HVI glass on color results was significantly greater than that of the 1 mm thick microscope slide. Protocols for minimizing glass impacts on spectrophotometer color measurements were determined, with the best overall results obtained with the use of specular component included (SCI) and glass with glass calibration.

Introduction

The Uster® High Volume Instrumentation (HVI) is used to machine class cotton produced in the U.S. The HVI uses two broad-band filters to obtain the color parameters Rd and +b (2-dimensional color system). Rd is the reflectance of the fiber sample, and +b is the "yellowness" of the sample. The HVI unit uses a camera-based system for color analyses, To class cotton fiber for color, two sets of color standards are supplied by the Agricultural Marketing Service (AMS)—a set of 5 ceramic tiles and a set of 12 uniform cotton "batts". The tiles and cottons range in color from white to off-white in color, and each AMS standard is measured on the AMS master colorimeter for Rd and +b.

Rd and +b are cotton specific color terms, and they do not readily relate to other well known and globally recognized color systems that are based on 3-dimensional tristimulus color. In addition, there is no "NIST-like" traceability or means to certify/verify the color results for the AMS standard tiles or standard cotton batts measured on the HVI. Thus, significant improvements in fiber color measurements could lead to a much improved overall color analysis system for cotton fibers, to include standards traceability or certification, and these improved systems and protocols could be used to complement and strengthened the present HVI cotton color system. Color spectrophotometers and colorimeters use the full visible spectral region (400-700nm, minimum) in place of the standard two wavelength color measurement of the HVI system, use globally recognized color spaces in place of the cotton-specific Rd and +b, and have National Institute of Standards and Technology (NIST)-traceable standards. One global color system often used for fibers and textiles is L*a*b* or CIELAB. L* is from 0 to 100 and denotes the lightness or darkness of a sample; a* denotes the redness or greenness of a sample; and b* denotes the blueness or yellowness of a sample (Billmeyer and Saltzman, 2000; Harold, 1992; Hunter, 1975; Judd and Wyszecki, 1975). Color difference between L*a*b* results are expressed by DE* (equation 1), which is the square root of the square of the differences in L* (DL*), in a*(Da*), and in b*(Db*) between a reference unit or system and the unit or system being compared. When DE* > 1.0, a color difference is considered to be significant. (Berger-Schunn, 1994)

$$DE^* = \sqrt{(DL^*)^2 + (Da^*)^2 + (Db^*)^2} \qquad (1)$$

Previous evaluations by several bench-top and portable color spectrophotometers established and validated strong L*↔Rd and b*↔+b correlations between the spectrophotometers and the HVI for both tiles and AMS cottons. (Thibodeaux, et. al., 2005; Rodgers, et. al., 2006; Rodgers, et. al., 2007) Color unit agreement was very good-to-excellent between the bench-top units and fair-to-good for the portable units for the color tiles and AMS tiles when a HVI glass was not placed in front of the tile sample at the measurement port. Glass use (required for cotton fiber color measurements) resulted in poor-to-fair color unit agreement for both the bench-top and portable color instruments, with unit agreement for cotton being worst than the agreement for tiles. The use of HVI glass was the primary impact on the color unit agreement and on the L*↔Rd relationships. The use of glass often resulted in moderate-to-large DE* differences in color results, and L* was the color parameter that was most impacted by the use of glass.

A program was implemented to 1) investigate the impact of glass and glass type on the spectrophotometer color measurements and 2) to determine the feasibility of minimizing the glass impact. The program was a joint project between the AMS, Cotton Incorporated, and the Cotton Structure & Quality (CSQ) research unit with the Southern Regional Research Center (SRRC) of the Agricultural Research Service (ARS).

Experimental

The samples used in this evaluation consisted of one set of color tiles (13 color tiles, wide color range), two sets of AMS standard ceramic tiles (5 tiles per set), and 2 boxes of AMS standard cotton batts (12 batts per box). The cotton and tile samples were measured on the Gretag MacBeth CE7000A color spectrophotometer at SRRC. The spectrophotometer settings were illuminant D65, 10^{O} observer, and large area of view. Each sample was measured 5 times by specular component excluded (SCE) and included (SCI).

Each tile sample was measured "with glass" (a glass "plate" was placed between the sample and the spectrophotometer port) and "without glass" (tile samples placed directly against the spectrophotometer port), and the cotton samples were measured "with glass" only. Two types of glass plate were used in these evaluations—a portion of a ~6 mm thick HVI glass and a 1 mm thick microscope slide. Four conditions of glass use were used to evaluate the impact of glass on the color results—no glass use, standard glass use, glass use with a glass correction factor (X-Rite), and glass use with a glass calibration (instrument calibrated with the glass).

Results and Discussion

Specular Component Evaluations

The impact of spectrophotometer specular component was evaluated. Each tile sample was measured with the conditions SCE and SCI, both with and without the use of HVI glass. The SCI and SCE color results were in overall good agreement, with the SCI color measurements normally yielding higher L* results and slightly lower a* and b* results compared to the SCE color results. The use of HVI glass impacted significantly both the SCI and SCE color results. (Figures 1 and 2) The major impact was for L*. The impact of HVI glass on SCE and SCI color differences (DE*) was much greater for AMS tiles than the changes that were observed between SCE and SCI results when no glass was used in the color measurement—demonstrating that once again the major impact on color results is the use of HVI glass. The HVI glass impact was much greater for SCE than for SCI measurements, and the use of SCI tended to reduce the glass impact by ~50%, based on DE*. Based on the above results and the results from the glass impact study, SCI has been designated for use on all future SRRC color measurements.

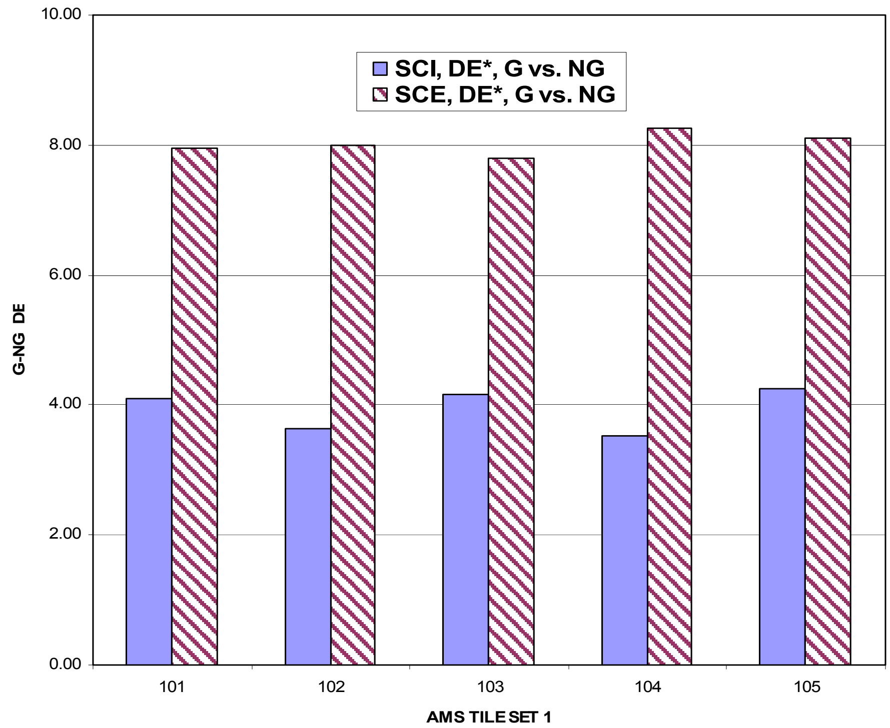

Figure 1. HVI glass impact on SCE and SCI, DE*, AMS standard tiles.

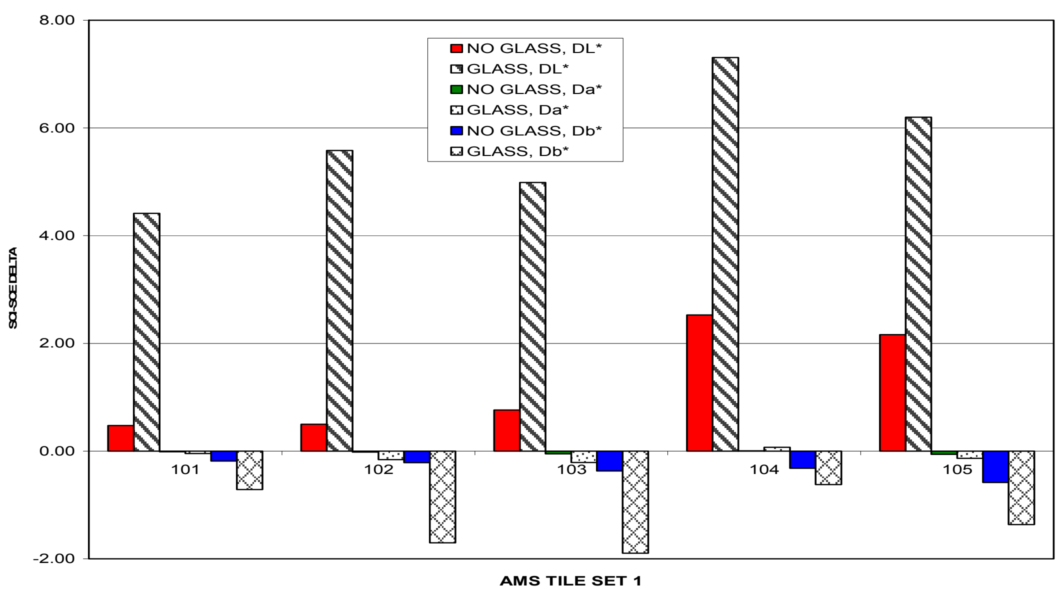

Figure 2. HVI glass impact on L*a*b* results, SCE and SCI, AMS standard tiles.

Glass Impacts Evaluations

The impact of glass type and glass use was evaluated. Two glass types were used—the standard 6 mm HVI glass and a standard 1 mm microscope slide. Each tile and cotton sample was measured with both glass types under the conditions of SCE and SCI. Four glass use measurements were used to evaluate the impact of glass on the color results—no glass use (tiles only), normal glass use, glass use with a glass correction factor, and glass use with a glass calibration. The instrument glass correction factor did not yield significant changes in color results, compared to those from normal glass use, when the thick HVI glass was used. As observed above, the major impact on color results with the use of glass was to lower L* for both SCE and SCI measurements, regardless of glass type used. The use of a microscope slide significantly minimizes the glass impact for SCI results. For microscope glass, the glass impact is minimized for tiles and cottons when either the glass correction factor or glass calibration is used with SCI. (Figure 3) For HVI glass, the glass impact is minimized for tiles and cottons only when the glass calibration is used with SCI and SCE. (Figure 4) Thus, the use of glass calibration leads to the maximum minimization of all glass impacts, regardless of glass type and thickness, on tile color measurements, with the best results obtained with SCI (DE* < 1.0 normally).

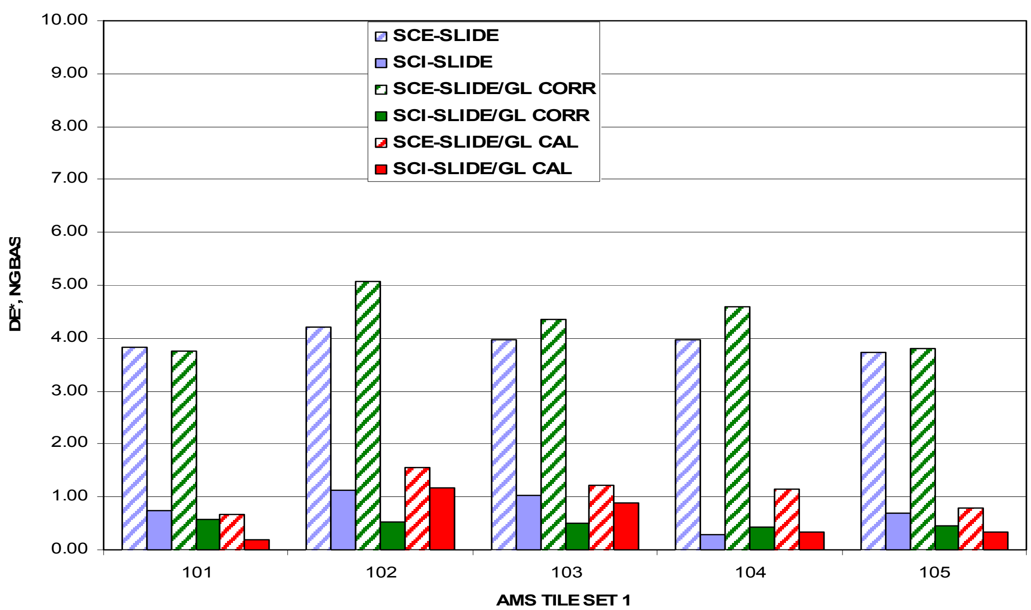

Figure 3. Impact of glass use and glass minimization methods, DE*, microscope slide.

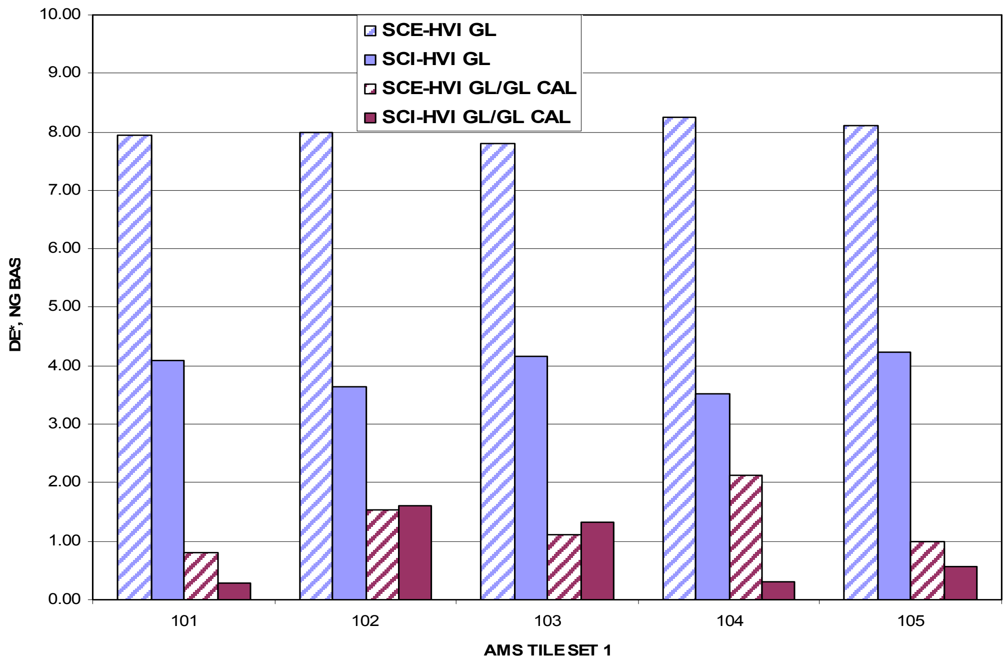

Figure 4. Impact of glass use and glass minimization methods, DE*, HVI glass.

The impact of HVI glass use on cotton fiber, and means to minimize the HVI glass impact, can be inferred from a comparison of AMS tiles and AMS cotton batt samples that have very similar L* color results. Four samples (2 tiles and 2 cottons each for SCE and SCI conditions) were compared under the glass conditions of no glass, normal HVI glass use, and HVI glass use with glass calibration. (Table I) For the AMS tiles, the increase in L* obtained with glass calibration lead to L* color results that were very similar to the L* color results obtained for no glass use, with DL* often less than 1.0. For the AMS cotton batts, the increases in L* obtained with glass calibration were very similar to the L* color results obtained for the corresponding AMS tiles. It can be inferred from these results that the very good agreement in L* between the AMS tiles and cotton batts for normal HVI glass use and glass calibration use would lead to very good agreement for L* with “no glass” use for the cotton batt measurements. Thus, the use of glass calibration and SCI leads to the significant minimization of glass impact on cotton fiber measurements, with DE* between no glass and glass calibration conditions normally expected to be less than 1.0.

Table I. Minimization of glass impact on L*, AMS tiles and cotton batts.

SAMPLE	NO GLASS	GL/HVI GL		HVI GL/CAL WITH GL		
	L*	L*	DL* (NG-GL)	L*	DL* (GL CAL-GL)	DL* (GL CAL-NG)
AMS TILES						
SCE						
202	**78.22**	**70.61**	**-7.61**	**77.04**	**6.43**	**-1.17**
105	**87.17**	**79.12**	**-8.06**	**86.28**	**7.17**	**-0.89**
SCI						
202	**78.85**	**76.43**	**-2.42**	**79.70**	**3.27**	**0.84**
103	**86.78**	**83.25**	**-3.54**	**86.96**	**3.71**	**0.18**
AMS COTTON BATTS						
SCE						
307	**NA**	**70.80**	**NA**	**77.85**	**7.05**	**NA**
301	**NA**	**79.93**	**NA**	**86.59**	**6.66**	**NA**
SCI						
312	**NA**	**76.66**	**NA**	**79.87**	**3.21**	**NA**
304	**NA**	**82.96**	**NA**	**86.22**	**3.26**	**NA**

Conclusions

A program was implemented to 1) investigate the impact of glass and glass type on the spectrophotometer color measurements and 2) to determine the feasibility of minimizing the glass impact. The glass impact on spectrophotometer color results was much greater than the impact of specular component type, with L* being the major color parameter impacted by glass use. The use of SCI decreased the glass impact on DE* color results by ~50% compared to the DE* color results obtained with SCE. The glass impact of the 6 mm HVI glass on color results was significantly greater than that of the 1 mm microscope slide. Protocols for minimizing glass impacts on spectrophotometer color measurements were determined for both AMS standard tiles and cotton fiber batts, with the best overall results obtained with the use of specular component included (SCI) and glass with glass calibration.

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