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SOUTHERN REGIONAL RESEARCH CENTER REVEALS COLORFUL NEW METHODS

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Abstract

Naturally colored cotton refers to cultivars that produce lint in any color other than white. Breeders have improved the agronomic and physical properties of some colored cottons recently. However, the prevalence of short, weak fibers has presented some real and perceived processing concerns. The purpose of this paper is to report on the experiences of government scientists during their work with colored cotton. It briefly summarizes some of our major research accomplishments. Some of this information has not been published in detail due to commercial conflicts, contractual constraints, and/or proprietary issues. Our program has revealed a large range of properties among colored cottons. Experiences suggest that processing colored cotton on conventional machines is generally not a problem but minor accommodations for speed or settings can reduce fiber breakage or loss and improve product uniformity. Blending colored cotton with other natural or synthetic fibers is an easy way to facilitate processing on conventional machines but may also dilute color intensity. This paper reports on a method developed at SRRC that uses fusible fibers to dramatically increase the strength of colored cotton materials. Finally, a previously undisclosed method of converting short weak fibers into superior core yarns is revealed. The invention provides for the separate supply of core and wrap fibers during the production of bicomponent core yarns. The novel approach is totally different from the core yarn methods previously developed at this location, and produces more uniform core yarns.

Introduction

Naturally colored cotton, by definition, refers to cotton that produces fiber in any color other than white. Whereas most cotton currently cultivated yields white fiber that must be chemically dyed, the lint of colored cotton is pigmented by nature, mostly in shades of green and brown. Many varieties have been known to exist for thousands of years and several have been grown recently in limited quantities domestically and internationally (Anonymous 1987; Kohel 1984; Vreeland 1999; Waghmare 1998). These include *G. arboretum, G. herbaceum, G. barbadense and G. hirsutum* species, among others. Our work has focused primarily on *G. hirsutum* or Upland varieties. This paper reports on highlights of our research with some of these naturally colored fibers. We acknowledge making some generalizations based on our experiences, but readers are advised that results may vary among the many wild and cultivated varieties, and between diploid and tetraploid species of pigmented cotton.

Objectives

The purpose of this paper is to report selected experiences and observations of government scientists from the Southern Regional Research Center (SRRC) during several years of work with colored cotton. We aim to briefly summarize notable research accomplishments, some of which were precluded from publication in detail due to commercial conflicts, contractual constraints, and/or proprietary issues. The methods and results are thereby described in general terms. The text references published manuscripts for details beyond the scope of this paper. We also wish to report on a previously undisclosed method that was invented to convert short and weak fibers into superior textile yarns.

Materials and Methods

The colored cotton used during this program derived from domestic and international sources of naturally pigmented green, red, brown, and tan fibers. The materials were supplied or purchased in quantities ranging from breeder samples to bale quantities. Among these were several lots obtained directly or indirectly from former domestic producers BC Cotton and Fox Fibre. Some colored cotton was grown for us at the LSU Agricultural Center in northwestern Louisiana from germplasm obtained from seed banks or other sources. Additional fiber was received from government, academic, and commercial entities in the United States, Australia, France, Guatemala, India, Israel, and Peru. The colored cotton was tested as accurately as possible on instruments designed for white cotton. Not all lots of colored lint were available in sufficient quantities to be converted into yarn. Pure colored fiber was processed as available using conventional methods (ring and rotor yarns, knit, woven, and nonwoven fabrics), modified methods (intimate or strategic blends, fusible fibers and/or scrim reinforcement) and several novel methods (core yarn techniques). Other fibers utilized included a variety of natural and/or synthetic fibers such as nylon, polyester, rayon, lyocell, Nomex, Kevlar, Dyneema, fiberglass, milkweed, flax, and kenaf, among others. The fusible materials used included amorphous and bicomponent fibers containing polyesters and/or polyolefin. The subject materials were processed and spun on laboratory or pilot scales using sample or commercial-sized machinery with appropriate methods. Testing was generally in accordance with AATCC or ASTM standards (AATCC, 2000; ASTM 1999) with some reduction in replication when necessary. Statistics were used to analyze data where quantities and procedures permitted.

Results and Discussion

Fibers

Selected data for a set of pigmented Old and New World cottons are presented in Table 1 and Figures 1-4 (Kimmel, et al. 2001; Kimmel and Day, 2001). Uster AFIS and HVI model 900A measurements of fiber length and strength exhibit slight downward trends when plotted against calculated CIELAB color differences (AATCC, 2000; ASTM 1999) [Figures 1 and 2]. By contrast, the short fiber content is seen to increase substantially with an increase in color difference [Figure 3]. This suggests that it may be more difficult to process the more colorful fibers. The micronaire measurements of the green fibers were low as a group and occasionally exceeded the measurable range of testing (ASTM 1999). There was little correlation between the very diverse micronaire readings and the calculated color differences for the other cottons [Figure 4].

Yarns and Fabrics

A compensatory effect was witnessed for finer fibers in comparably sized yarns due to having more of them in the cross section. In other words, low micronaire fibers that may be fine and weak individually can collectively produce relatively strong yarns (Lee, 1996). Flatter (less round) cross sections and high levels of wax were observed in some green fibers (Kimmel, et al., 2002). Maximum yarn strength can be achieved at relatively low levels of twist for some green cotton, which is consistent with theory but perhaps counterintuitive in practice. Thus, the efficiency and economy of producing green yarns could possibly be improved by reducing yarn twist. Flame testing indicated that the brown cottons tend to burn more slowly than the white cottons and that the green cottons tend to burn more vigorously (VanZandt, et al., 1997; Kimmel et al., 2002). The relative amounts of char residues for the cottons were also shown to coincide with their rates of burn propagation. These results were corroborated by thermogravimetric (TGA) analysis under controlled heating conditions (Kimmel et al., 2002).

Blends

Increasing quantities of other fibers in blends with colored cotton can modify their properties at the risk of a concomitant loss of color. For example, blends of colored cotton with white cotton may improve yarn strength or uniformity and blends with synthetic fibers may improve yarn strength and resilience. Thus, appropriate blend ratios must be selected with trade-offs between the color, quality, cost, and efficacy of specific applications. The color change with the addition of lyocell to green cotton, for example, was barely discernable until the former fibers were present in excess of 40 percent. Higher quantities produced an attractive sheen that corresponded with increased levels of reflectance. The combination of lyocell and colored cotton was promoted as having market potential based on the collaborative efforts of a group of researchers led by Kimmel (Kimmel, et al. 1999, 2002).

Fusibles

A process was developed as part of an SBIR grant whereby small quantities of fusible fiber were blended with colored cotton for subsequent heat treatment (Kimmel and Ferguson, 1998). The inclusions of specific low-melt polymers were proven to enhance the strength, durability, and abrasion resistance of a variety of yarns and fabrics containing the fibers. Early production methods passed discrete quantities of yarn or fabric through an oven for heating. Later methods involved passing a continuous strand of yarn through an oven at a constant speed. The low melt fibers that worked best for the brown and green cottons were different. Ideal heating conditions were a function of the materials and methods. However, the approach increased yarn tenacity as much as 50 percent. The method was envisioned to integrate spinning and heating processes sequentially for commercial implementation. Low melt fibers were also shown to be capable of improving the strength and serviceability of nonwoven fabrics made from colored cotton (Kimmel, et al., 2000, Kimmel, et al., 2001).

Core Yarns

The object of core yarns is to achieve good aesthetic and functional properties from a bicomponent yarn. ARS scientists developed two methods known as staple-core and filament-core spinning some time ago, which were refined for application to colored cotton via a CRADA under Kimmel's leadership (Kimmel, et al., 2002). The resulting core yarns were significantly stronger and considerably more resilient than conventional yarns containing homogeneous blends of the same fibers. Now, the present authors have invented a better method of making core yarns that is revealed for the very first time. It involves differential fiber flow via the separate supply of core and wrap materials for spinning. The yarn core can be made of natural or synthetic materials in the form of a monofilament, multifilament, or staple yarn. The wrap fiber would generally be cotton. The patent pending claims the production of more uniform core yarns with less fiber loss. The approach is ideal for cottons containing a predominance of short, fine fibers.

Comments and Conclusions

There is great diversity in colored cotton and prejudices and generalizations about the fibers should be avoided. The reported measurement ranges should not be construed to be inclusive of all pigmented fibers. Although many of them tend to be relatively short and weak when viewed against the standards of white cotton, there are some with reasonable length, strength, and uniformity. Yet cottons of similar hue may exhibit very different properties (Kimmel, et al. 2002). The measured micronaire tends to be low for green cotton but varies widely among the others. Further study of colored cottons may provide insight into issues distinguishing fiber fineness and maturity in relation to micronaire readings. The distinguishable differences in the insulation values and flammability of the cottons warrant further study. Identification of the pigments or other chemical compositions in colored cottons and/or their waxes may help explain their unique color responses reported elsewhere.

Conventional, adapted, or novel methods can be employed to process naturally colored cotton. In our experience, most colored cotton can be processed with care on common machinery. Minor accommodations with respect to speeds or settings can be helpful. The blending of colored cotton with other fibers can facilitate its processing with some modification of properties. The inclusion of low levels of fusible fibers can vastly improve the strength and serviceability of colored cotton materials with appropriate treatment. Finally, we assert that comparable improvements in the processing, properties, and performance of colored cotton can be accomplished more readily with the new core yarn techniques revealed by this paper. The methods of manufacturing conceptually similar yarns can have a great affect on their properties. The method is suitable for certain colored and white cottons.

This author appreciates the unique attributes and beauty of colored cottons and would like to see them regain a larger share of the domestic market. Demand for the fibers continues to escalate worldwide and production has recently increased in Peru, China, Australia, and India. By contrast, the growth of pigmented cotton reached a peak in the in the 1990s in the United States. Since then, the unfortunate state of the declining domestic textile industry and plight of cotton farmers have made the future for pigmented cotton in the U. S. looking less colorful. Although our own group has committed to turning the focus of our research to white cotton at this time, we remain interested in supporting others interested in colored cotton. On a final note, we previously proposed the combination of colored cotton and lyocell for textile applications. Lyocell fibers are fairly strong and are produced from renewable resources with recyclable organic solvents. Its use can thus be construed to be consistent with the natural and ecological aspects of colored cottons. The mixture produces soft and attractive textiles that do not require dyeing.

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Table 1. Range of Fiber Properties.

COLOR	AFIS Length (inches)	HVI Strength (g/tex)	AFIS Short Fiber Content (%)	HVI Micronaire	Fibronaire Micronaire
Green	0.74-1.24	14.8-29.4	4.4-18.9	2.1-5.4	<2.40-3.25
Red	0.57-0.87	14.0-20.1	14.0-46.4	2.5-6.9	2.60-6.80
Brown	0.64-1.00	14.3-28.4	6.0-28.4	2.7-6.6	2.70-4.95
Tan	0.62-1.13	20.3-27.3	5.8-30.9	2.7-6.3	2.75-6.35
White	0.98-1.25	24.3-35.4	3.0-11.1	2.8-6.7	4.30-6.70

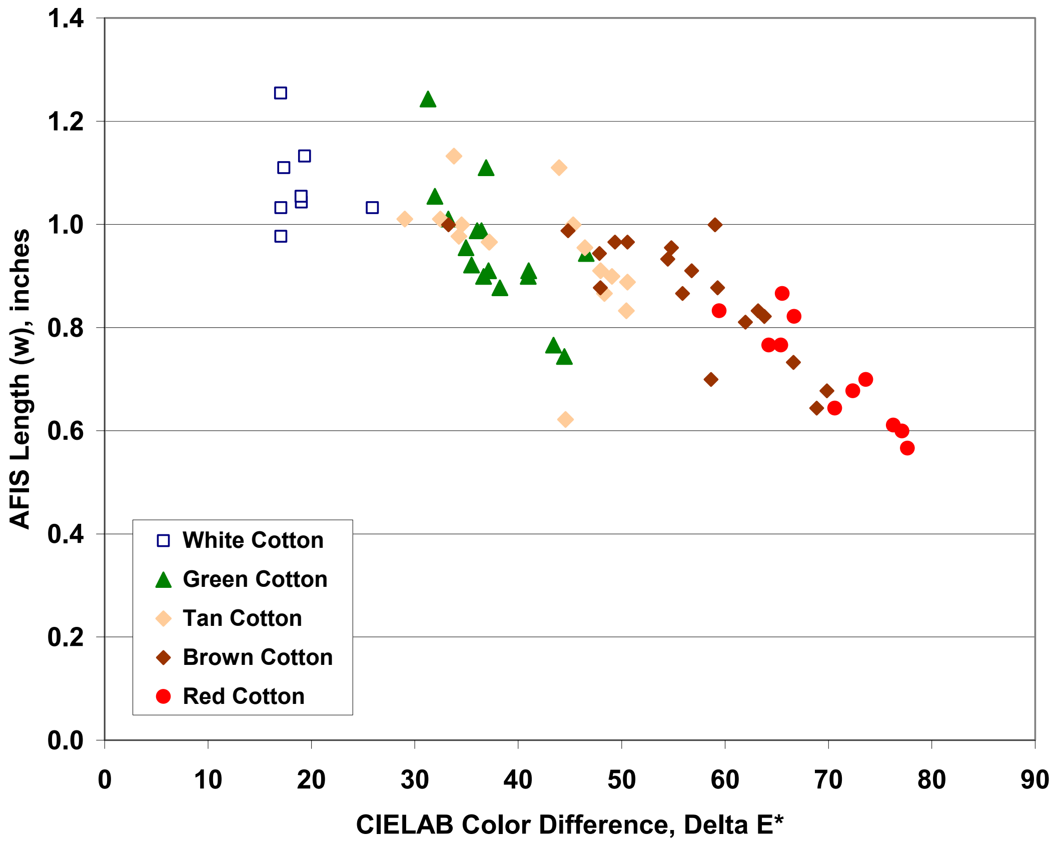

Figure 1. Fiber Length.

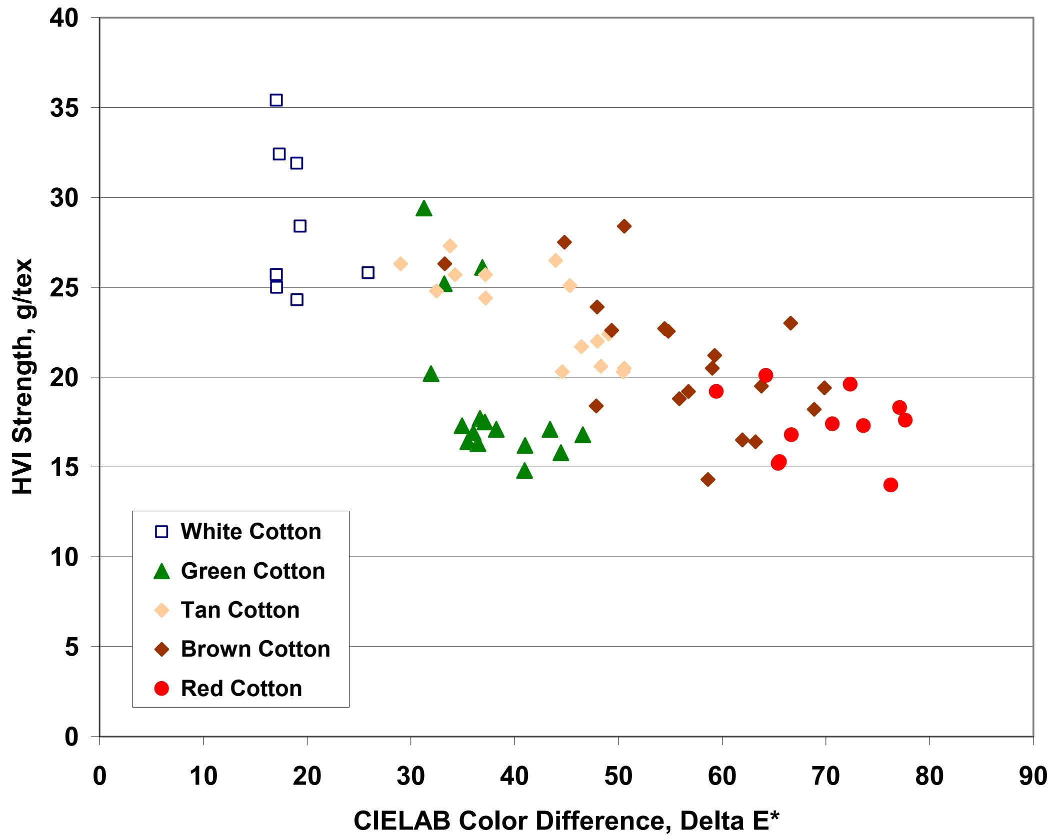

Figure 2. Fiber Strength.

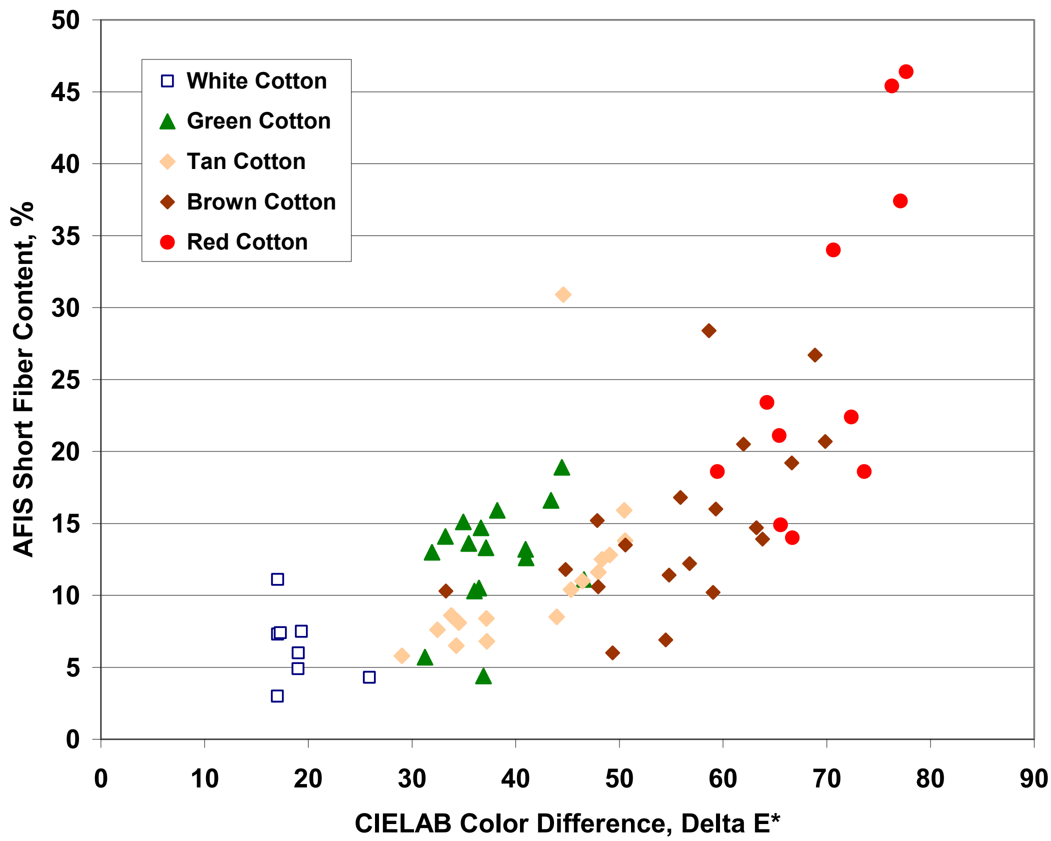

Figure 3. Short Fiber Content.

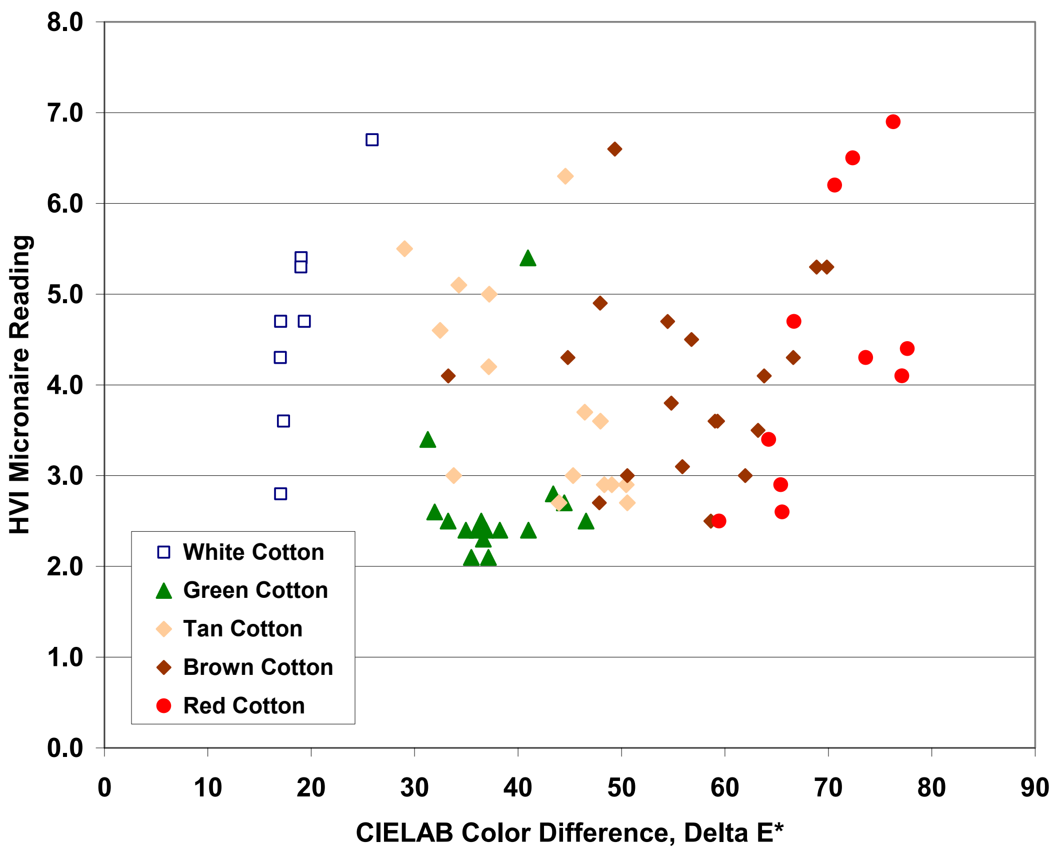

Figure 4. Micronaire.