# WHITE SPECK, A DYE DEFECT IN MECHANICALLY AND HAND PICKED COTTONS

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## Abstract

The textile industry is often caught off guard by white specks showing up in dyed fabrics. The current grading system does not always pick up the level of maturity that causes white specks. Research using international cottons is aimed at finding high-speed measurement systems that can be used to predict the white speck potential of bale cotton. Cottons were gathered from the following countries: Australia, Brazil, China, Pakistan, Turkey, Uganda, the United State, Uzbekistan and Zimbabwe. Ultimately a White Speck Potential (WSP) measurement could be included in the HVI data that the mills currently use to buy cottons. By knowing the WSP, mills could eliminate white speck dye problems and still use those cottons for their other fiber properties and produce whites or pastels where the dyeability of the cotton is not a problem. The cottons with a high WSP can also be combed or rotor spun to minimize white specks. This will also be a useful tool for breeders so they can eliminate new varieties that are prone to high WSP early on in the breeding process.

## Introduction

Mechanical neps are found in ginned lint, card web, yarns and cloth. Their numbers are strongly influenced by mechanical processing (Bel-Berger, 1998). They have been attributed to fiber properties such as immaturity, staple length, and fineness and to moisture content and handling methods in production such as over- or under-beating the fibers in the carding or ginning operations (Jakes, 1984). Other contributing factors may be harvesting methods, early frost, plant disease, and premature use of harvesting chemicals (Supak, 1992). Clumps of very immature fiber are the source of another type of biological nep. These clumps of highly entangled fiber can be found in seed cotton prior to mechanical processing. Typically, these neps are found in the unginned lint near malformed seed (Watson et al, 1991). Coalesced fiber entanglements are created as a result of the contents of the lumen escaping or liquid from the boll adhering the dead or immature fibers together and result in "shiny" specks on the dyed fabric.

White speck neps cause significant financial losses to the textile industry. Past studies looked at processing factors, such number of lint cleaners used at the gin, mill card settings, and combing to show the effects on white specks in the finished fabrics. The US Extreme Variety Study (EVS) shows the importance of proper settings and maintenance of cards and the effect on white specks. The Leading Variety Study by AMS (LVS) also compares carding with combing. Four varieties from the 26 samples (LVS) were carded and combed and the fabrics were analyzed for white specks. Combing was found to reduce the white speck problem, while other processing seems to open and separate the immature fibers, spreading the white speck problem. Rotor spinning reduces the level of white specks significantly, on the same level as the combed. This paper examines the white speck phenomena as seen in mechanically and hand picked cottons based on High Volume Instrument ($HVI_{TM}$) and Advanced Fiber Information Systems - Professional (AFISPro) Data. Ultimately we would like to develop strong predictions of white specks from high-speed instruments that test bale fibers, and have the white speck potential included in the classification of cottons.

## Material and Methods

US cottons were processed at the Cotton Quality Research Station (CQRS) from bale quantities and 30 pound lots at Southern Regional Research Center (SRRC). After Hurricane Katrina damaged the SRRC Mill, the US studies were repeated at CQRS using 30 lb lots. The International cottons were spun at CQRS in 15 lb lots (They were scheduled to be processed in 30 lb lots but many of the cottons had little more than 15 lbs).

Cotton Samples: Five years of US-ATMI studies (stripper harvested cottons from Texas, and spindle picked in Georgia and Mississippi) were spun at CQRS (processed in bale and 30 lb quantities) and woven and dyed. Figure 1 shows examples of the extremes of two cottons from the first year ATMI samples. Wakefield Inspection Services, Ltd. supplied us with high quality, medium quality and low quality cottons from 8 foreign countries. We were supposed to have 30 lbs of each for processing, but some lots were almost half so it was decided to run all international cottons in fifteen pound lots. Fifteen pounds of each of the international cottons from Australia, Brazil, China, Pakistan, Turkey, Uganda, Uzbekistan and Zimbabwe were processed in CQRS's mill in an identical manner to the US cottons. Most of the international cottons were hand picked except for the Australian cottons which were spindle picked.

**Opening & Carding:** Process Bale or 30 lbs. or 15 lbs. of cotton into 60 gr. card sliver. Carding at 60 lbs./ hr..

**Drawing 1$^{st}$:** Make six cans for 2$^{nd}$ drawing 58 gr. sliver. 400 m/m

**Drawing 2$^{nd}$:** Make up to 32 cans for roving 55 gr. sliver. 400 m/m

**Roving:** Make as bobbins of 1.00 HR., with 1.30 TM, and 1200 RPM flyer speed for ring spinning

**Spinning Ring:** Spin Twenty seven tex (22/1) with a 3.96 TM, 14,750 spindle speed and a #1 traveler. Full bobbins.

**Winding:** Wind 2 – 1 lb cones for weaving

**Cloth Construction:** Twenty seven tex (22/1) experimental yarns from each lot were woven as filling into a 5-harness filling face sateen with a thread count of 80 x 93, with a twenty tex (30/1), common combed warp. The warp was combed to remove the white specks making the only white specks visible from the experimental filling yarns. The experimental yarns cover approximately 85% of the surface from the experimental yarns.

**Dyeing Procedure for Fabric Evaluation:** The scouring and dyeing procedures were standardized for use throughout this project. The fabric is finished with a 0.1% Prechem 70, 0.3% T.S.P.P. boil-off, a caustic scour of 1.1% Prechem SN, 1.1% Mayquest 80, 0.1% Prechem 70 and 0.7% sodium hydroxide (caustic soda), followed by the same boil-off procedure. The fabric was then bleached (0.1% Prechem 70, 0.5% Mayquest BLE and 3.0% peroxide (Albone 35)) followed by an acid scour (0.1% acetic acid) and dyed with 2% Cibacron Navy F-G Blue, 0.5% Calgon, 8% Sodium Chloride, 0.8% $Na_2$ $Co_3$ (soda ash) and 0.5% Triton Tx-100. This dye has a high propensity for highlighting white specks in finished fabrics.

The first year of the US-ATMI bale cottons were woven and dyed on the same common warp that the remaining fabrics were woven, but these were dyed as a separate lot and measured using AR2-03 image analysis system. These first year cottons and fabrics have been extensively studied and used to refine the accuracy of the AR2-03. The first year yarns were reserved and woven with all of the other cottons (US bale, 30 lb, card study and international) on the same warp and dyed as one continuous batch, so there were no differences due to dyeing.

**White Speck Measurements:**

Image analysis software was developed to measure white specks on the dyed fabrics. The fabric is scanned and Autorate Version 2.03 (AR-2-03) converts the image into pixels, then measures and analyzes the white specks resulting in the white speck count, size and percent white, as illustrated in Figure 2.

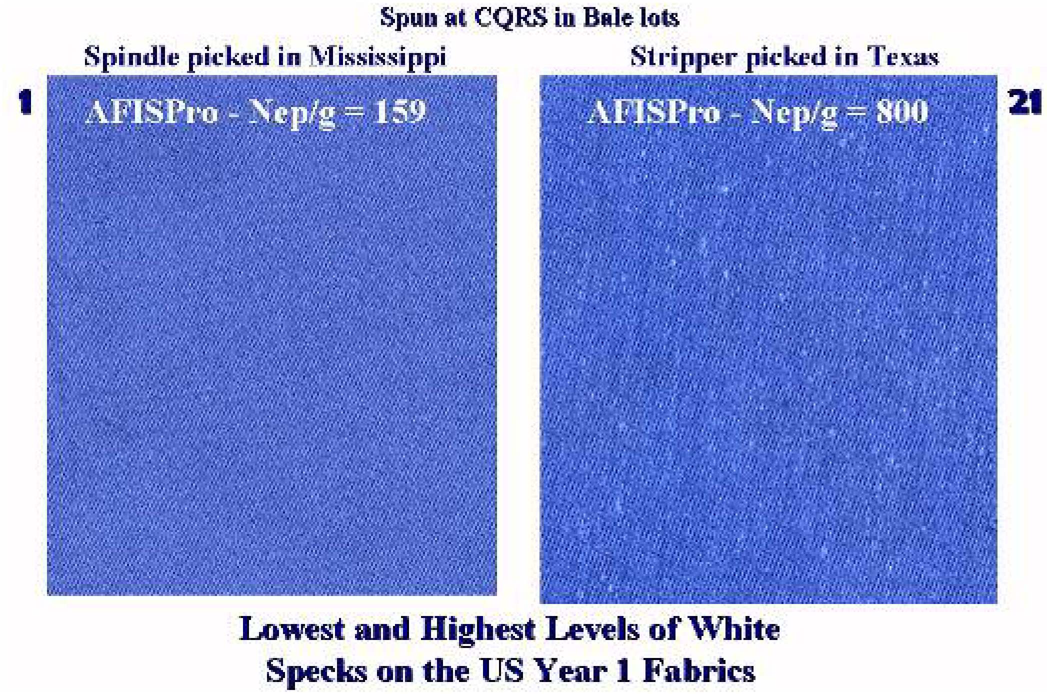


Figure 1: Pictures of ATMI fabrics with the lowest and highest levels of white specks

Cooperatively with Fabrate, LLC, WSA- White Speck Autorate (Figure 3), a fully automated system for scanning dyed fabric for white specks (defects on fabric) was produced and installed at Southern Regional Research Center (SRRC). The system can handle rolls of fabric and quickly and automatically detect, count and measure white speck neps on dyed cotton fabrics. The system is expected to replace human evaluation and to provide reliable and repeatable measurements. The data presented here is the initial data. The materials handling system and lighting system are being modified to improve the accuracy and ease of use of the system.

## Results

AFISPro Neps were tracked from the bale fiber (30 lbs in this case) through the opening line, carding, drawing and roving at SRRC's Mill (Figure 4). The opening line breaks apart large neps and the nep level increases, but when the fiber is carded, the neps are reduced to the lowest level in processing, and as the fibers are aligned and drawn down in drawing and roving a slight increase in nep levels is seen. This is just one more demonstration of the effects of processing on nep levels.

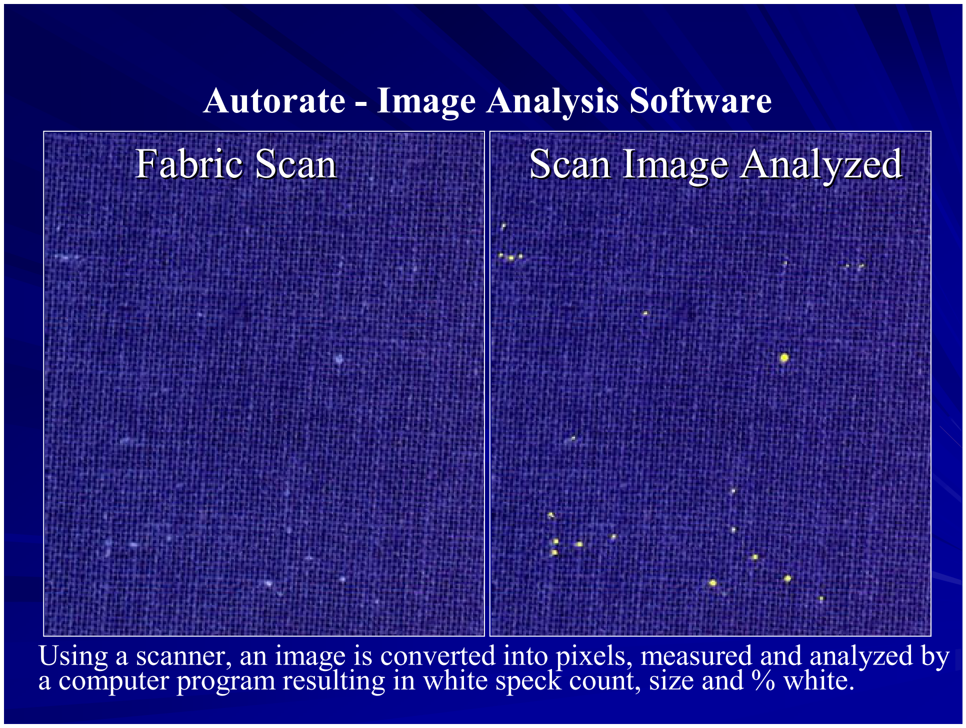


Figure 2: Fabric Analyzed by Autorate Version 2.03 (AR2-03)

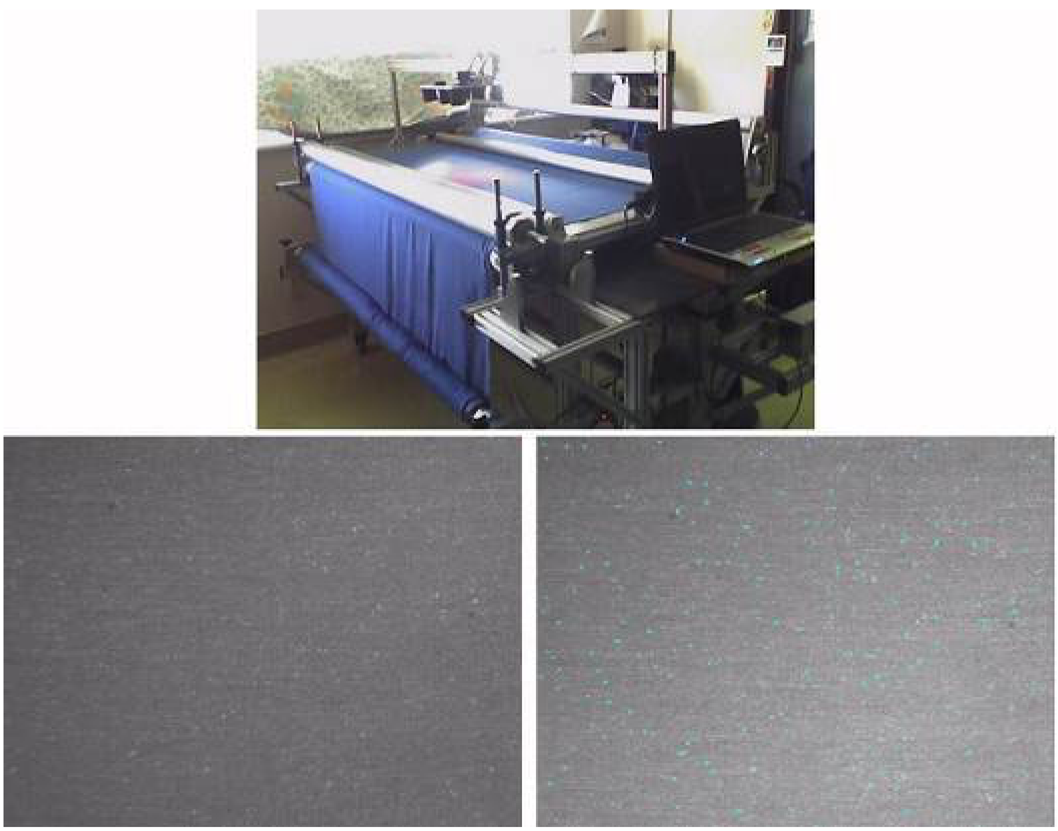

Figure 3: WSA- White Speck Autorate by Fabrate, LLC and a white speck fabric before and after analysis by WSA.

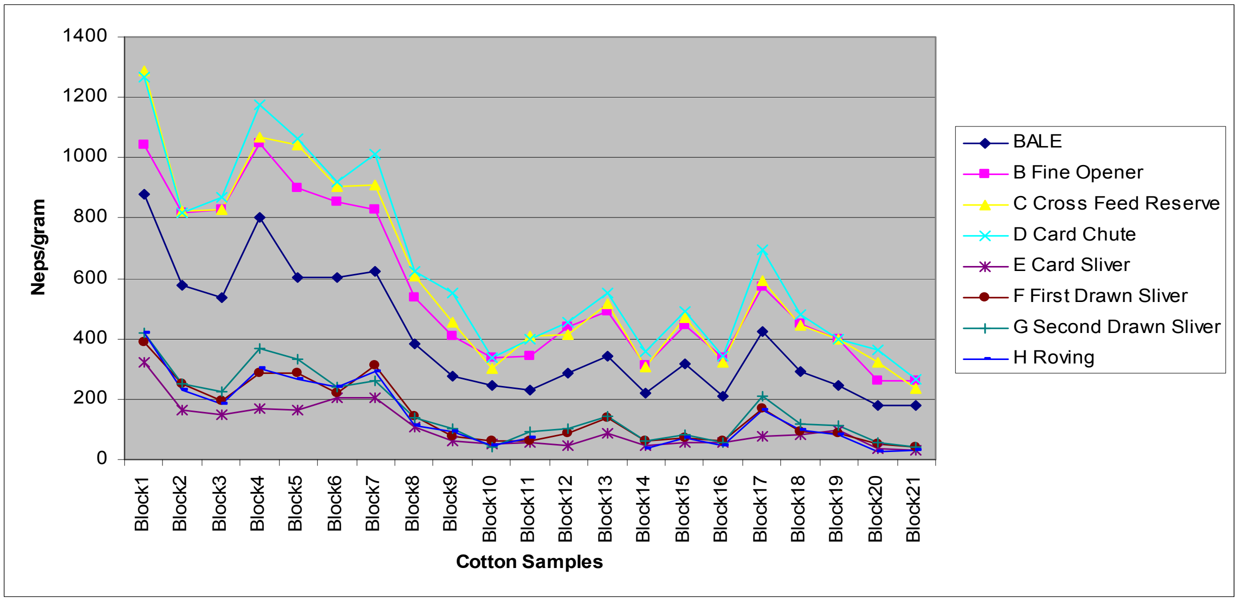


Figure 4: AFISPro Neps in Mill Processing

A card loading study (30, 15 & 10 lbs.) was run at SRRC using the most immature cotton (Figure 5). There was no significant difference for white speck levels between the three different weights processed at SRRC.

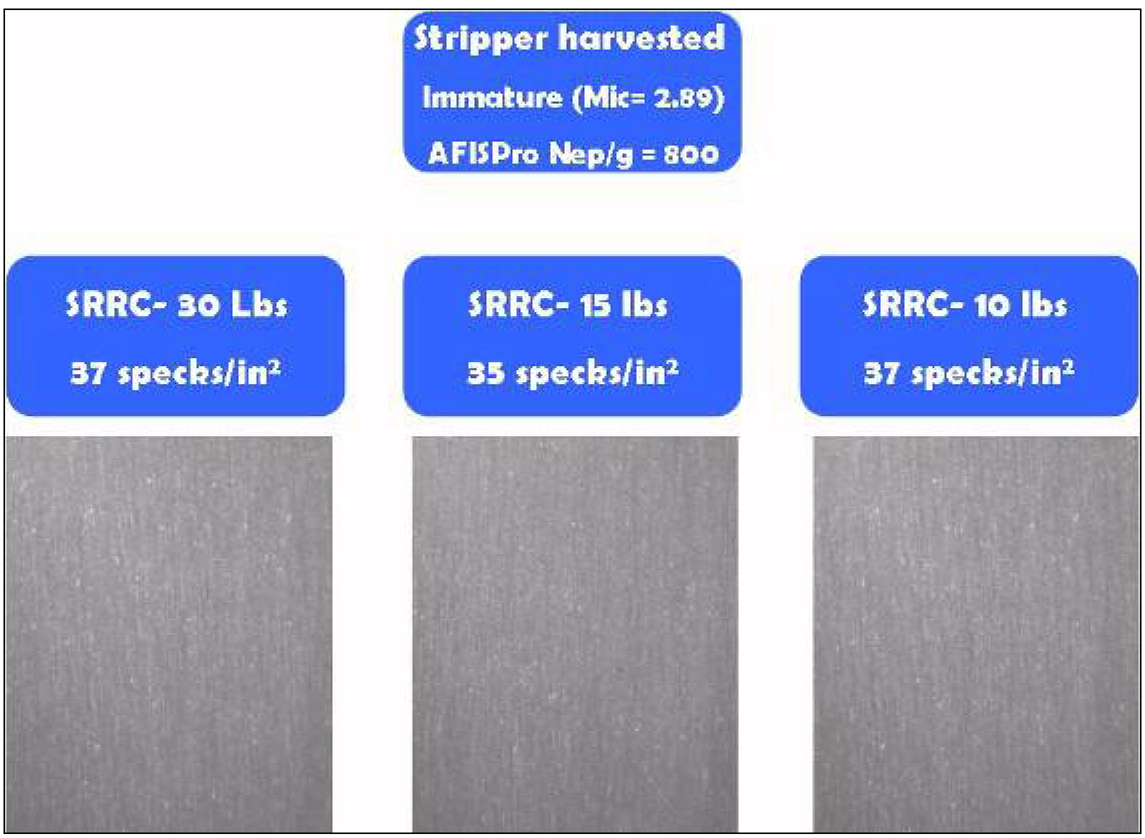


Figure 5: Fabrics produced from the same bale fibers processed at three different weights at SRRC.

The SRRC Card loading study, the CQRS US bale, 30 lb lots and the International 15 lb lots were woven on a common warp and dyed in one run and analyzed on the new White Speck Autorate (WSA) system (Figure 6). The

SRRC card loading fabrics were not significantly different from the fabrics produced from full bales at CQRS, but the CQRs 30 lb samples were almost half the level of white specks as measured by WSA and a visible difference upon inspecting the fabrics side by side**.** (Figure 7).

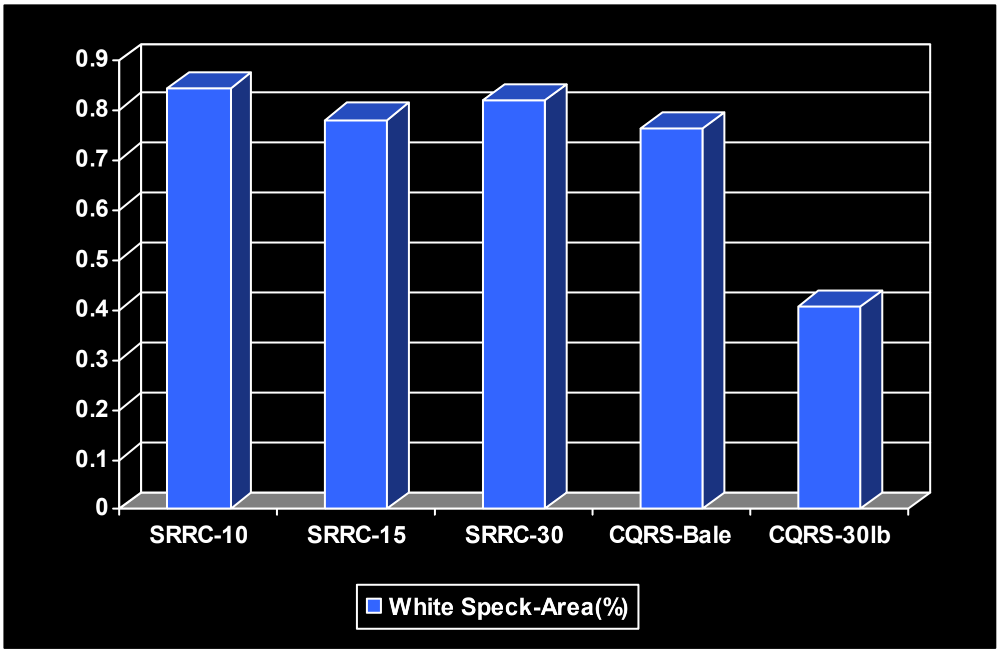


Figure 6: % White Measured by WSA, for card loading study and mill comparisons.

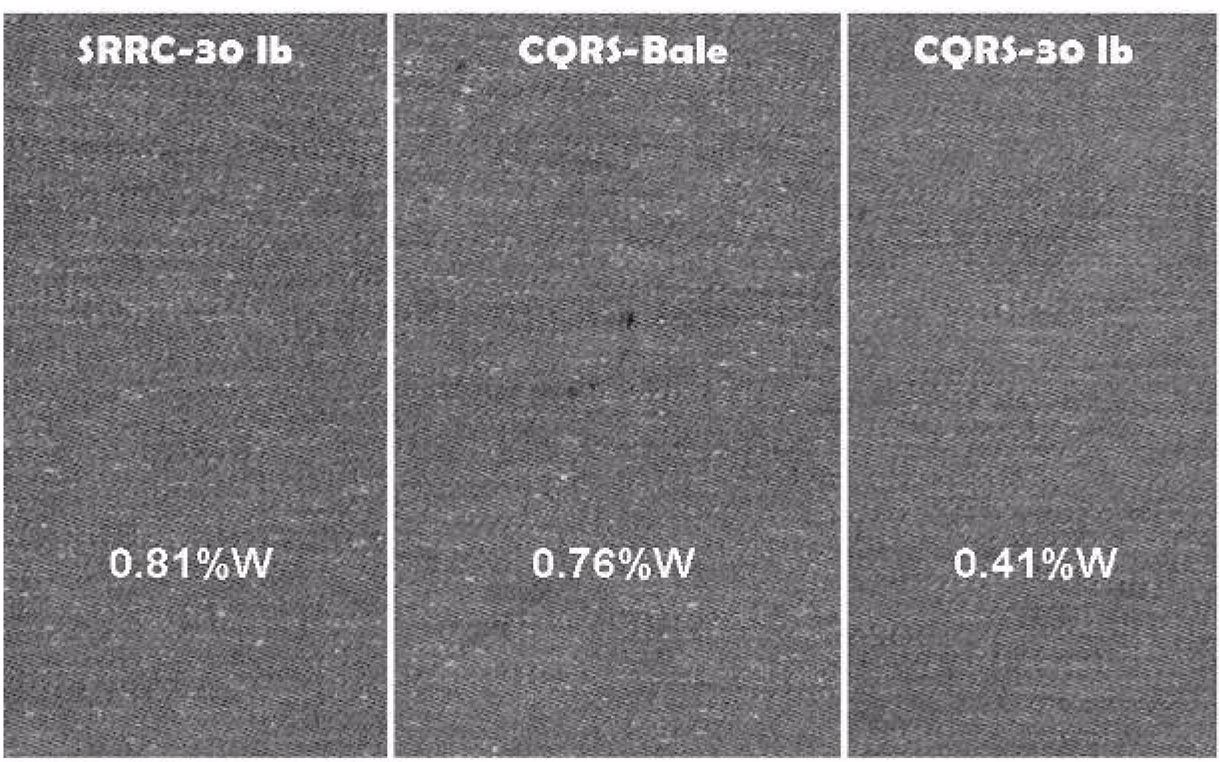


Figure 7: Visible Processing Differences –SRRC 30 lb sample fabrics are similar to CQRS bale sample fabrics, but CQRS 30 lb sample fabrics are significantly and visibly about half the level of the other fabrics.

Percent white as measured by both image analysis systems is compared in Figure 8. Percent white as measured by AR2-03 (from scans of fabrics made from bale quantities) is related to percent white as measured by WSA 12-08 (from live video) on fabrics made from full bale lots and 30 lb lots. Strong R-square values are seen for both the bale fabrics and the 30 lb lot fabrics as measured by the WSA system as compared to the %White on the bale fabrics as measured by the AR system. This shows the WSA system is doing a relatively good gob of distinguishing between the good and the poor white speck fabrics.

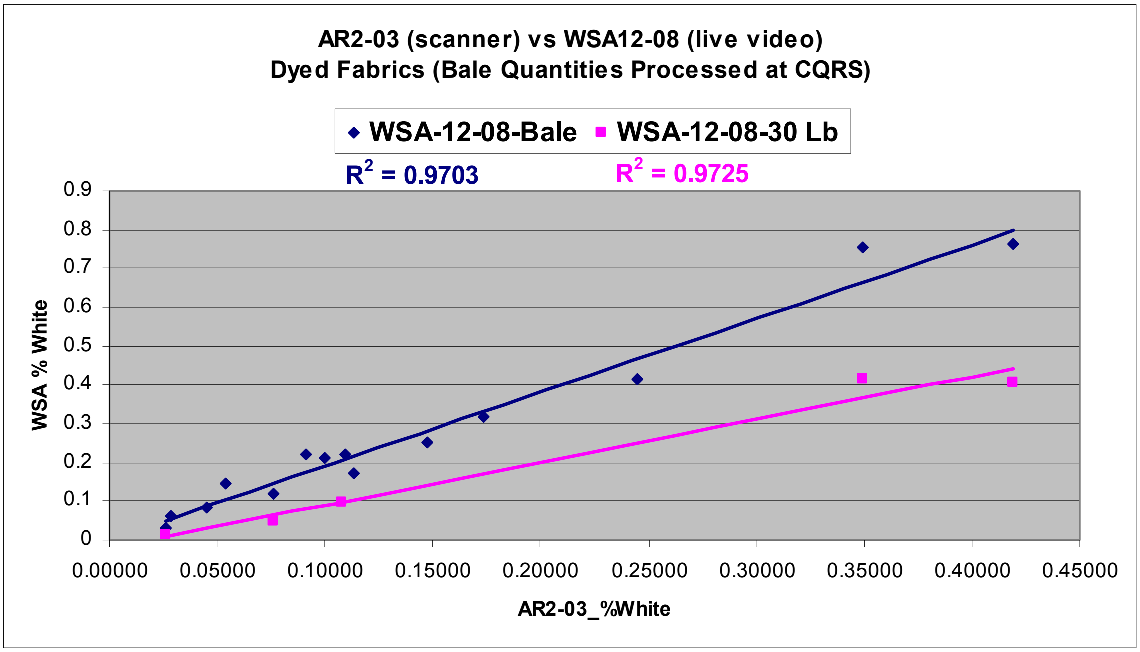


Figure 8: White Speck-Area (%) – AR2-03from CQRS Bale vs. WSA12-08 from CQRS Bale and 30 lb lots

The WSA system is still undergoing refinement and although it is doing a relatively good job it is not as accurate as we would like to see and the lighting system is being redesigned.

There is a significant difference between the percent white seen in the fabrics (ATMI cottons from 1st and 2nd year of the study) processed at CQRS from bale and 30 pound quantities (Figure 9). The 30 lb fabrics have significantly fewer white specks than the bale fabrics. Figure 9 also shows a significant difference in white specks due to harvesting systems (The first four sets (left) of cottons are stripper picked and the second four sets (right) are spindle picked). Stripper harvesting includes immature “top crop cotton” that is left behind in spindle picking. These fibers can increase the amount of immature fiber in the bale and eventually the level of white specks seen in the dyed fabrics.

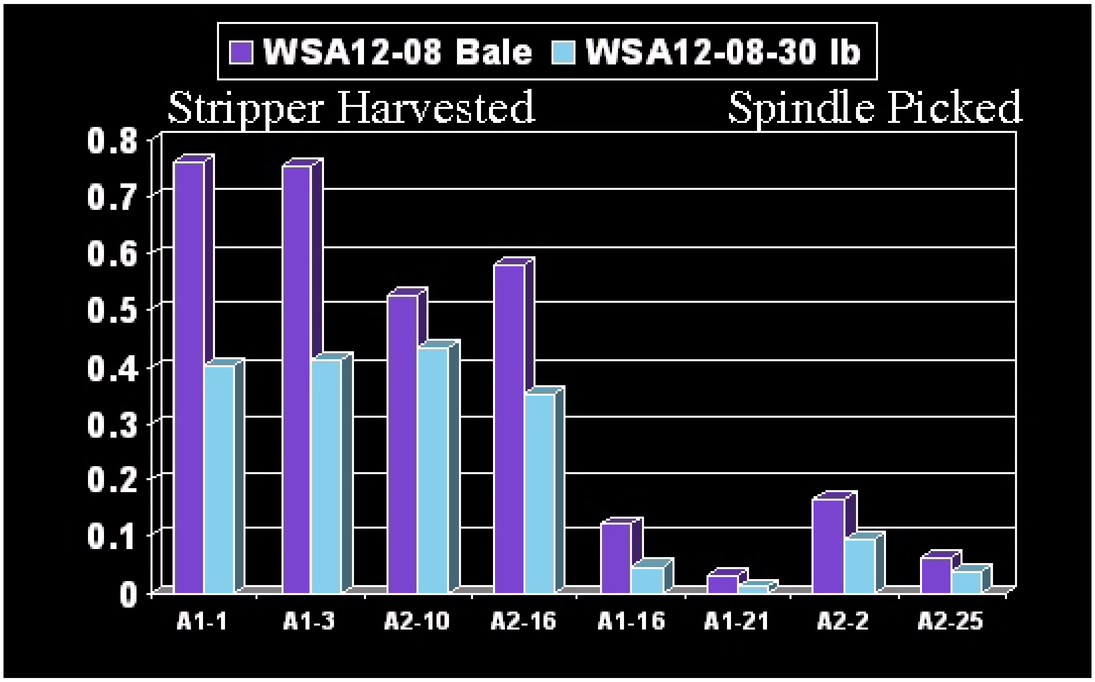


Figure 9 White Speck-Area (%) WSA12-08- from CQRS Bale and 30 lb lots

Figure 10 shows two different varieties grown in three different states using both stripper and spindle picking. The proportion of white area on the fabrics was significantly higher for the stripper-picked cottons. There is not as much difference between the Texas cottons probably because drought contributed to the high levels of immature fiber. The stripper-picked seed cottons generally have so much more trash that they need extra precleaning and two lint cleaners in the gin to bring the cotton up to grade. The level of white specks in the Texas stripper-picked cottons was almost double that of the spindle picked from the other regions, due to the combination of higher levels of immature cotton and harsher processing at the gin. These results are illustrated in Figure 10. The combination of higher levels of gin cleaning, which are required to remove extra foreign matter, and immature fibers results in higher levels of white specks in fabrics from the stripper harvested cotton than the spindle harvested cotton.

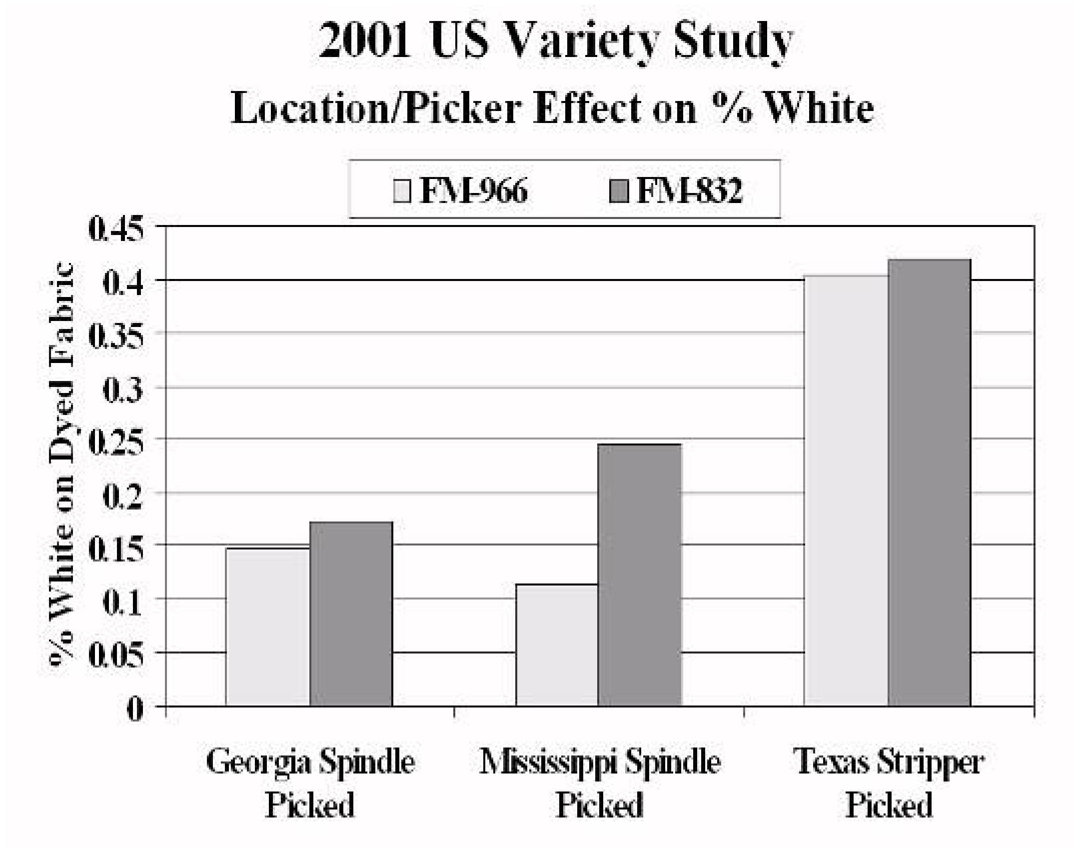


Figure 10 Stripper and spindle picking effects on white speck levels.

**Buckling Coefficient -** Mechanical entanglements develop when cotton is exposed processing (harvesting, ginning and mill). As Alon and Alexander (Alon, 1978) pointed out the fiber tangles on itself during processing and the longer the length and more immature, the more the fiber is prone to nepping.

**Buckling Coefficient = $L^2/\mu^2$**
**$\mu$ = Micronaire Value**
**L = 2.5% Span Length of Fibrograph**
**Predicted %W from HVI = 3.516205 *(UQL2/mic2) - 0.11382**
R-Square = 0.8914
When considering all available data, linear regression indicated a strong relationship for the Buckling coefficient (HVI data) and AFISPro Neps (Figure 11).

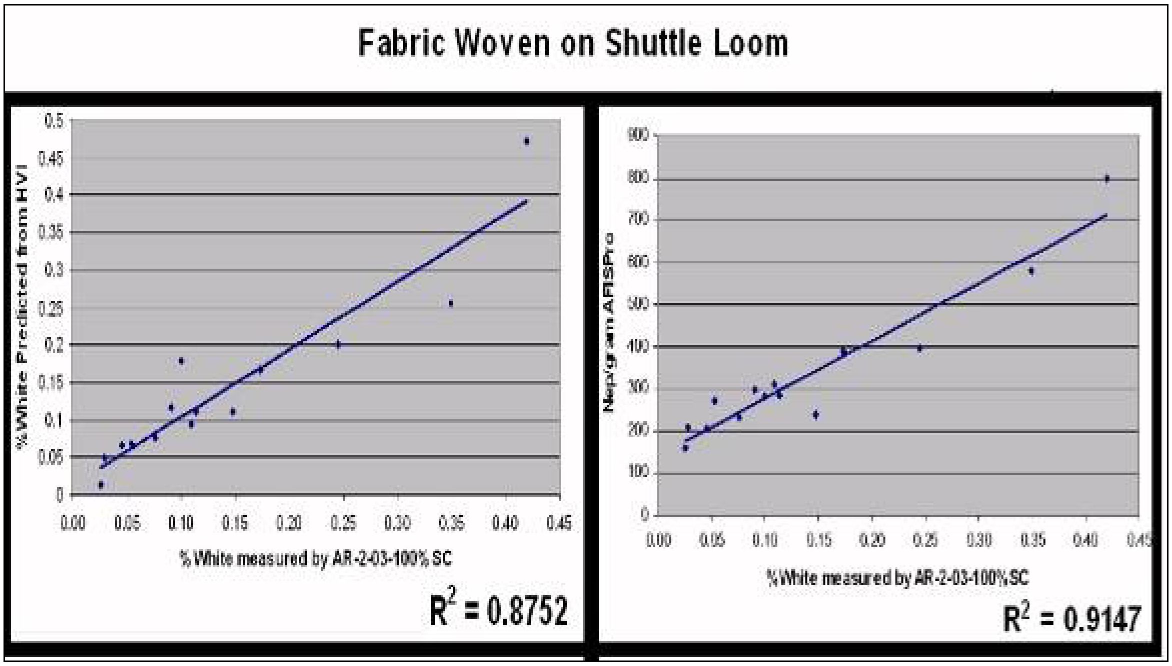


**Figure 11:** :% White Predicted from HVI Data and AFISPro Neps/Gram vs. %White measured by AR-2-03

- The AFISPro Nep Test showed a range of 55 to 800 Nep/g for US and International cottons (Figures 12 & 13).
  - Excellent = Below 200
  - Good= 200-250
  - Questionable (but may be appropriate for some product lines) = above 250
  - Poor = above 400 (but still good for whites) Stripper harvested cottons fell in this range
- Further studies will be run using mini-spinning and the dyed fabrics will also be measured using a colorimeter. The studies will include hand picked cottons and mill processing will remain
- constant.

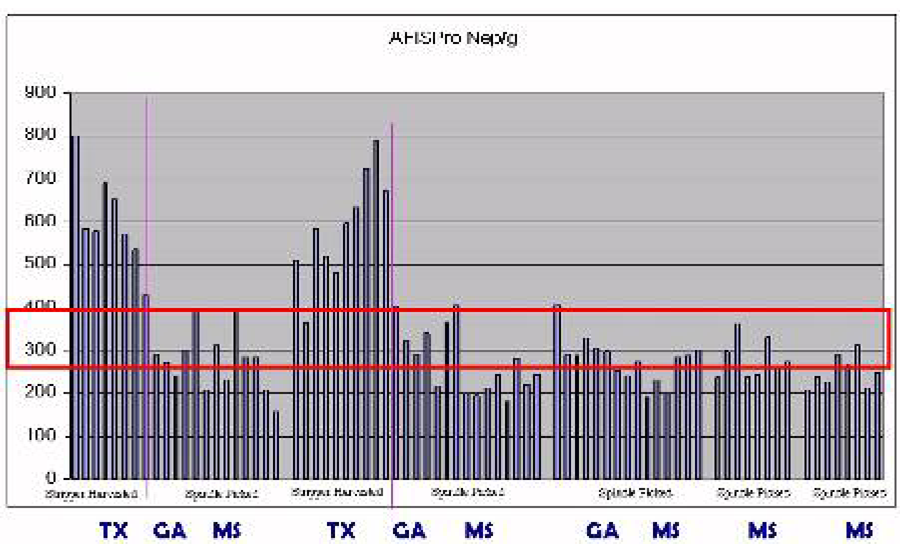


Figure 12: AFISPro Neps/gram for US Cottons over 5 study years

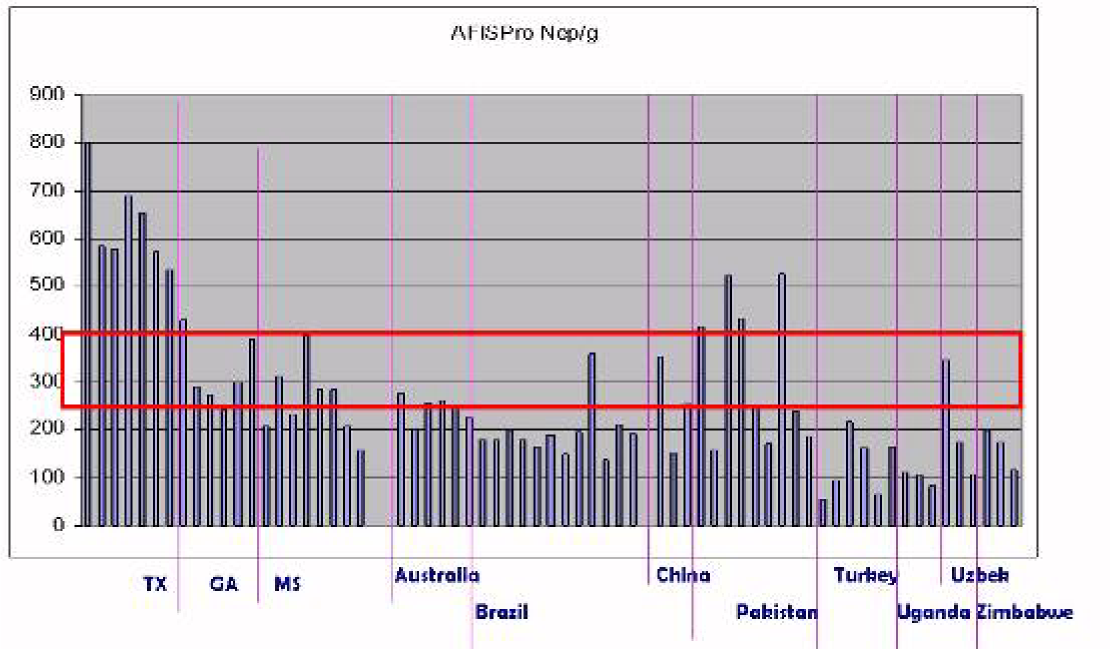


Figure 13 : AFISPro Neps/gram for mechanically harvested and hand picked cottons: US (Year 1) and Australian cottons are mechanically harvested, all other International cottons are hand picked.

Figure 14: a) Cotton stripper harvesting cotton (Wright, 2003). b) Spindle picking cotton (Nance, 2003) c)Hand picking (Exploring Africa, 2009)

The spindle picked cotton (Figure 14b) have much lower levels of AFIS Neps and white specks than the stripper picked cottons (Figure 14 a) for these studies, but drought may have had a roll in the high levels of immature cotton for the Texas stripper picked cottons. The stripper harvested cottons can have a very high level of white specks (and AFIS Neps) due to immature fibers being harvested that spindle picking would have left in the field. For US (Year 1) the problem was further compounded by drought creating even higher levels of immature fiber. Stripper harvest's excess immature "top crop cotton" increases the amount of immature fiber in the bale, which causes white specks in the dyed fabrics. The hand picked international cottons (Figure 14c) have several cottons with AFIS Neps in the same range as the stripper picked cottons, bust most fall in the range of the spindle picked cottons, with several much lower in levels of AFIS Neps.

## Summary

The CQRS 30 lb fabrics have significantly fewer white specks than the CQRS bale fabrics, which may be due to the fact that the card was rewired and reset, thereby improving the fiber quality of the card sliver and reducing neps. The 15 lb lots had fewer white specks than the 30 lb lots with similar AFIS Nep levels, this was obvious when comparing the spindle picked US cottons to the spindle picked Australian cottons with similar AFIS Nep levels. White specks were much more difficult to see in these 15 lb fabrics because the rewired card along with a light load (15 lbs) individualized the immature cotton fibers during carding and they were blended into the yarns rather than nepping. This resulted in a shade difference that can be seen when comparing the very low AFIS Nep fabrics to the ones with higher levels, The immature fibers still have lower dye uptake, causing a heather effect making the shade lighter.

Research shows that mechanical processing affects the level of white specks, so if the fiber to fabric processing protocol is held constant, a large data base can be established and then quality predictions can be developed from high speed fiber measurements, yarn and fabric data. SRRC is building a database with fiber from around the world and to actually compare these cottons we need to run 2 lb lots on the SRRC Mini-spinning system. The Mini-spinning system historically had high levels of neps. If the new system proves to process in a similar manner it would be a good tool to study small samples for breeders and other research and start a data base on small lots. The data would be a tool to determine changes due to breeding changes etc. Mini-spinning is known for higher levels of neps, which may not give an accurate comparison to a mill's yarn and fabric quality, but more of a worse case scenario such as when card wire is worn down. These predictions would be able to indicate if a fiber could be problematic. For instance, if a fiber is predicted to have high levels of white specks in the fabric it may not be a problem if the mill is running with low defects and light shades or white fabrics are produced, but if dark fabrics are being produced with tight shade specifications, the mill might want to pass on that fiber, or if the cards are nearly ready to be rewired, the mill might want to pass on the fiber regardless of shade due to higher levels of neps, and particularly white specks in dark fabrics.

We will be improving fabric analysis using the new Autorate system that will use image analysis to automatic and accurately measure white speck and dark specks to analyze both dyed and greige fabrics for white specks and seed coat fragments. We are currently working on consistency in lighting and imaging and debugging the program. Colorimeter will also be used in measurements of fabrics to relate to fiber quality. Once a White Speck Potential (WSP) value can be developed from this type of research it can be used as a tool by the mills. Bales with high WSP can be put into a special class for whites only, or use for combed or rotor spun yarns, maximizing the fiber's potential and minimizing mill losses due to white specks.

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