T E X T I L E topics

Winter 2001

International Textile Center | Texas Tech University | Lubbock, Texas USA

Sharing current research information and trends in the cotton and textile industries.

International Textile Center
Texas Tech University
Lubbock, Texas
79409 - 5019
phone 806.747. 3790
fax 806.747. 3796
itc@ttu.edu
http://www.itc.ttu.edu

BILL COLE AND JOANN SUMNER RETIRE

Bill Cole joined Texas Tech in 1974, did pioneering work with the emerging open-end rotor spinning technology, then went on to become the ITC's expert in all facets of short staple spinning. JoAnn Sumner has worked at the ITC since 1986; first in the weaving lab and then in the materials evaluation lab. Bill and JoAnn will be missed and we wish them all the best in retirement.

COTTON FIBER PROPERTIES SEMINAR APRIL 3-4

The ITC will offer the Cotton Fiber Properties Seminar for anyone who deals with fiber data. The seminar includes: information on fiber properties, fiber testing, evaluation of fiber data, and how fiber properties impact textile processing. Attendees at the next seminar could also attend the Lubbock Gin Show April 5-6. The Gin Show is a trade show for ginning equipment and for the regional cotton industry to gather and hold meetings before the crop is planted. Registration material is on the back page of this issue of Textile Topics or at www.itc.ttu.edu under professional education.

NEW NONWOVEN EQUIPMENT TO BE INSTALLED

Arrangements have been made for delivery of a new Fehrer H1 Technology Needle-punch Loom, served by a William Tatham Feeding Line. These are to be used in a project, sponsored by the Department of Defense, to develop fabrics that provide protection from chemical and biological agents. This project was developed and will be led by Dr. Seshadri Ramkumar of the ITC.

TEXAS INTERNATIONAL COTTON SCHOOL

The next session of TICS will be held May 14-25, 2001 at the ITC. Some tuition scholarships are available for professionals from certain countries. More information can be obtained from Mandy Howell, Lubbock Cotton Exchange, 806-763-4646, fax 806-763-8647, or email: LCEcotton@aol.com .

STAFF TRAVEL

- Beltwide Cotton Conferences, Anaheim, CA- Dean Ethridge, Eric Hequet, Nourredine Abidi, James Simonton, S.S. Ramkumar, and Pam Alspaugh attended and 11 papers were presented.
- Southern Textile Association, Winter Technical Seminar, Charlotte, NC-Dean Ethridge made a presentation.

IMAGE ANALYSIS ON COTTON FIBER CROSS SECTIONS: RELATIONSHIPS WITH AFIS® MEASUREMENTS AND YARN QUALITY

Eric F. Hequet, Assistant Director
Bob Wyatt, Analytical Chemist

The Texas Food and Fiber Commission and Cotton Incorporated funded the research reported here.

INTRODUCTION

The acknowledged reference method for maturity and fineness measurements on cotton is image analysis of the fibers' cross-sections (Thibodeaux, et al., 2000). However, this technique is too slow to be of practical use in commercial operations or plant breeding programs. The AFIS® instrument is fast enough and repeatable enough to provide the necessary information—if it relates well with the image analysis data.

Previous work has demonstrated the usefulness of fiber length distribution data from the AFIS for yarn quality predictions (Hequet & Ethridge, 2000). This article reports on an evaluation of the relationships among the fineness-maturity measurements obtained with the AFIS and those obtained with image analysis (IA) of the cotton fiber cross-sections.

PROCEDURES

Nine Upland cotton varieties were selected, with each variety represented by 6 independent samples grown in different locations. Therefore, a total of 54 cotton samples were included in the study.

The following HVI and AFIS measurements were performed on these fibers:

- Zellweger Uster HVI 900A: 4 mike measurements, 4 color-grade measurements, 10 length and strength measurements.
- Zellweger Uster AFIS Multidata: 5 replications of 3,000 fibers

The image analysis (IA) method used was developed at the Southern Regional Research Center in New Orleans, Louisiana, USA (Boylston, Evans & Thibodeaux, 1995). It uses a methacrylate polymer to hold approximately 500 cotton fibers. This allows cutting the fibers with a rotary microtome into 1-micron slices, which are then mounted on glass slides.

The slides are viewed with a computerized video microscope and the magnified images are stored in computer files. From these cross-section images the perimeter (*P*) and area (*A*) of each fiber are measured using custom computer software developed by Bugao Xu, University of Texas at Austin. The P provides the estimate of genetic or biological fineness. Results on *P* and *A* are then used to derive the "degree of thickening" of the fiber's secondary cell wall—commonly denoted as θ. This is done according to the following equation:

$$(1) \qquad \theta = 4 \Pi A / P^2$$

This may be converted to a traditional "maturity ratio" (*M*) as follows (Lord):

$$(2) \qquad M = \frac{\theta}{0.577}$$

A brief statistical summary of all fiber data is given in Table 1. An examination of these data reveals that all of the cottons exhibit relatively good fiber properties, with low short fiber content, good length and maturity, and high strength levels.

The cotton fibers from each variety were processed through the Short Staple Spinning Laboratory at the ITC and were made into carded, 36 Ne yarns on both the ring and rotor spinning systems. Figure 1 provides an outline of the mechanical process used.

The following strength and quality measurements were done on the yarns:

- Zellweger Uster Tensorapid: 10 breaks per bobbin and 10 bobbins
- Zellweger Uster UT3: 400 yards per bobbin and 10 bobbins

A brief statistical summary of all yarn measurements is given in Tables 2 and 3.

RESULTS

IA VERSUS AFIS

Table 1 shows that the samples selected provide substantial diversity in the main fiber properties.

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Regarding fineness and maturity:

- The AFIS maturity ranges from 0.85 to 0.97 and the AFIS fineness from 157 to 180 millitex.
- The IA measurements of the fiber cross-sections show a proportionally wider range for maturity than the AFIS, with θ ranging from 0.393 to 0.564 and M ranging from 0.68 to 0.98.

The gravimetric fineness is expressed as the mass per unit length of a fiber. Estimates of gravimetric fineness are provided by the AFIS fineness (expressed in millitex) and the HVI micronaire (arbitrary scale of relative values). The lower the fineness or the micronaire, the higher the number of fibers in the yarn cross-section will be. It has been shown (Hequet, 1998) that neither micronaire nor fineness alone are good predictors of yarn strength.

Gravimetric fineness can be related to standard fineness or biological fineness if the secondary cell wall thickness (i.e., maturity) is known. With the AFIS, dividing the estimated fineness by the estimated maturity ratio gives an estimate of the standard fineness.

Figure 1 shows a cotton fiber cross-section schematic. From it we can deduce the following equations:

$$(3)\quad A_w = \pi \cdot R_2^2 - \pi \cdot R_1^2 = \pi(R_2^2 - R_1^2)$$

With: A_w = secondary cell-wall area (cross-sectional area minus lumen area) in microns

R_1 = inside fiber diameter

R_2 = outside fiber diameter

It follows that:

$$(4)\quad \theta = \frac{\pi\left(R_2^2 - R_1^2\right)}{\pi \cdot R_2^2} = \frac{A_w}{\pi \cdot R_2^2} = \frac{A_w}{\pi\left(\frac{P_2}{2\pi}\right)^2} = \frac{4\pi A_w}{P_2^2}$$

With: θ = degree of secondary wall thickening (no unit)

P_2 = outside fiber perimeter, in microns

We also know that:

$$(5)\quad A_w = \frac{H}{\rho}$$

With: H = fineness in mtex

ρ = cell-wall density in g/cm^3 = 1.52g/cm^3

Furthermore:

$$(6)\quad H_s = \frac{H}{M} = 0.577\ \frac{H}{\theta}\quad \frac{0.577\,A_w\rho}{\theta}$$

$$\frac{0.577\,A_w\rho \bullet P_2^2}{4\pi \bullet A_w}\quad \frac{0.577\,\rho}{4\pi}\quad P_2^2$$

With: H_s = Standard fineness in mtex

Therefore:

$$(7)\quad P_2 = \sqrt{\frac{4\pi}{0.577 \times 1.52} H_s} = 3.7853\sqrt{H_s}$$

We may draw the following inferences from these equations:

- Equation 4 implies that the degree of cell wall thickening (θ) from IA should correlate well with the AFIS maturity ratio.
- Equation 5 implies that fiber perimeter from IA should correlate well with the AFIS fineness.
- Equation 7 implies that fiber perimeter from IA should correlate will with the AFIS standard fineness.

The fundamental empirical issue is to determine how highly correlated are the critical measurements between IA and the AFIS. A secondary issue is determining how well the two measurements replicate, or correspond with, each other. If the first issue (of adequate correlation between the two) is answered in the affirmative, then the second issue (of adequate correspondence between the two) could ultimately be resolved.

It was practically impossible to examine the same number of fibers with IA as with the much more rapid AFIS instrument. As stated above, IA was done on 500 fibers from each of the 6 field locations; therefore, a total of 3,000 fibers per variety were measured. On the AFIS 3,000 fibers were measured each time and 5 replicated measurements were taken on each of the 6 field locations; therefore, a total of 90,000 fibers per variety were measured.

Figure 3 shows the relationship between area (A) estimated with IA and with the AFIS. (The A for AFIS is obtained by dividing AFIS fineness by the average cell-wall density of 1.52 g/cm^3.) The correlation coefficient of 0.83 is highly significant but the slope and offset coefficients are far from the desired levels of 1 and 0, respectively. These results indicate that the AFIS underestimates A relative to IA measurements of fiber cross-sections. But the correlation between the two is high enough to give optimism that an improved calibration between them is feasible.

Although not shown here, it should be noted that A values and HVI micronaire values do not correlate. The simple correlation coefficient was only 0.30, which is far below a statistically significant level.

Figure 4 shows the relationship between P_2 estimated with IA versus the AFIS. (The P_2 values are derived using equation 5.) The coefficient of correlation is highly significant (r = 0.93), but slope and offset are again far from the desired levels of 1 and 0. As with *A*, the AFIS underestimates P_2 relative to the measurements obtained by IA.

Figure 5 shows the relationship between θ estimated with IA versus the AFIS. The coefficient of correlation is significant (r = 0.81), but slope and offset coefficients are again far from the desired levels. In this case, the AFIS overestimates θ relative to the measurements obtained by IA.

On balance, these results are quite encouraging, because the correlation coefficients are high enough to make possible the re-calibration of the AFIS to correspond with the IA reference method. These results do indicate that there is a need to re-evaluate the AFIS algorithms with the objective of achieving an adequate correspondence with IA. The task of doing this would likely be straightforward but time-consuming.

FIBER MEASUREMENTS VERSUS YARN QUALITY MEASUREMENTS

Table 4 shows the simple correlation coefficients between average values obtained on each cotton variety using the three fiber measurement technologies (IA, AFIS and HVI) and the two strength tests done on yarns spun from the fibers. Obviously, the HVI micronaire readings (average of 24 readings: 4 replications per sample and 6 samples) do not correlate with the yarn strength measurements. Both IA and the AFIS provide much better results.

- The P_2 estimates give the highest correlation coefficients, with the AFIS giving extraordinarily high values. In a previous study (Ethridge & Hequet, 1998), the AFIS measurements of H_s were also highly correlated with yarn strength for both ring and rotor spinning.
- The *A* estimates from the AFIS also correlate much better than those from IA, with the correlation coefficients for IA failing to reach statistical significance at the 95% confidence level.
- The θ estimates from the IA correlate much better than those from the AFIS, with the correlation coefficients for AFIS failing to reach statistical significance at the 95% confidence level.

A factor that may impact the relative performance of the IA technology in predicting the yarn strengths in this study is the smaller number of measurements taken with IA. Eventually it will be necessary to amass enough data with IA technology to enable a more valid assessment of this issue.

CONCLUSIONS

Results from this study provide ample encouragement to pursue the objectives of (1) developing an adequate database of reference cottons using IA and (2) calibrating the AFIS based on them. Success in this would provide an accessible reference method, which is not now available. Also, it could elevate the status of the AFIS as a tool for measuring and managing cotton based on maturity and fineness criteria.

Success in this would also be a boon to efforts aimed at improving cotton fibers. Fiber perimeter and standard fineness are known to be highly heritable (Hequet, 1988). Therefore, cotton breeders need measurement technology that enables the effective targeting of these fiber properties.

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Ethridge, M. D. & E. Hequet. 1998. Fineness/maturity results from the latest generation of AFIS. *Proceedings International Committee on Cotton Testing Methods*, Bremen: 73-76.

Hequet E. 1988. Influence of soil type and planting date on yarn quality in Chad. *Proceedings International Cotton Conference*, Bremen, 9pp.

Hequet E. & M. D. Ethridge. 2000. Impacts on yarn quality of AFIS measurements of cotton fiber length distributions. *Textile Topics*, Winter 2000:2-12.

Lord, E & S. A. Heap. 1988. The origin and assessment of cotton fiber maturity. *Interantional Institute for Cotton*, Manchester, England.

Thibodeaux D., K. Rajasekaran, J. G. Montalvo, T. Von Hoven. 2000. The status of cotton maturity measurements in the new millennium. *Proceedings International Cotton Conference, Bremen*: 115-128.

Figure 1.
Outline of the mechanical process

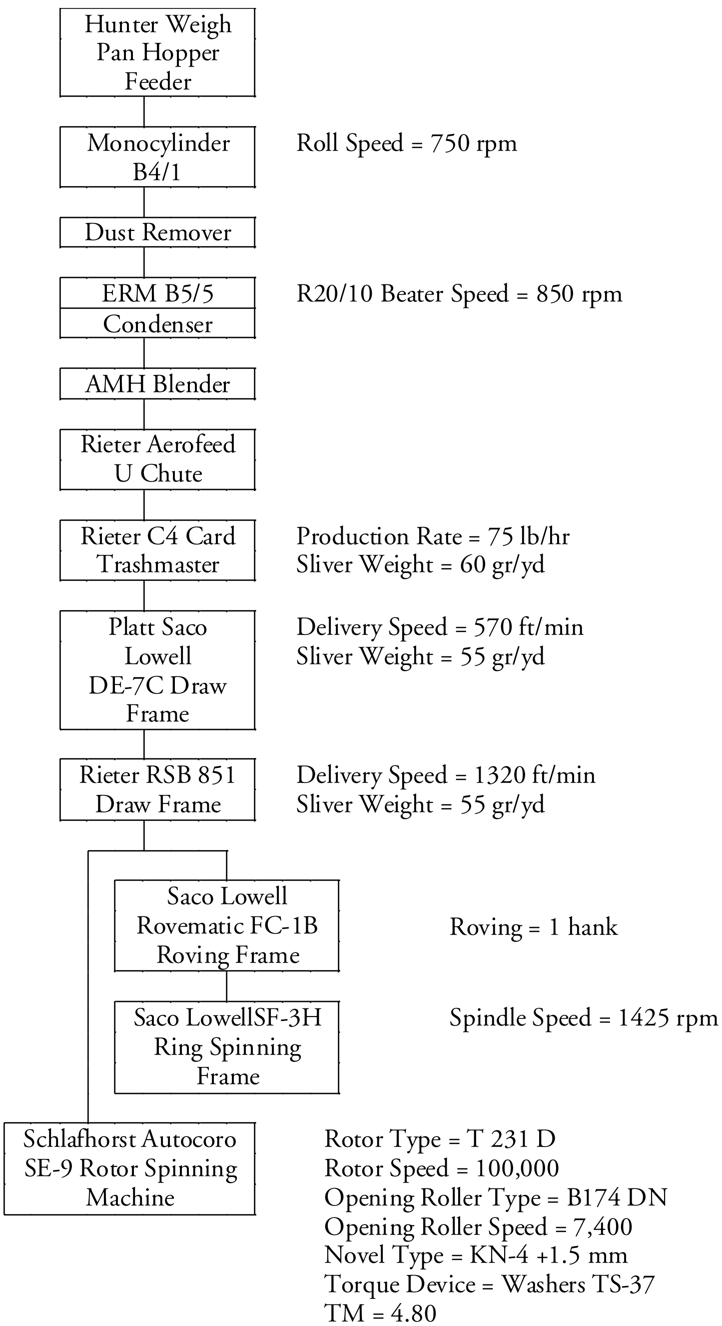

Figure 2.
Cotton Fiber Cross-section Schematic

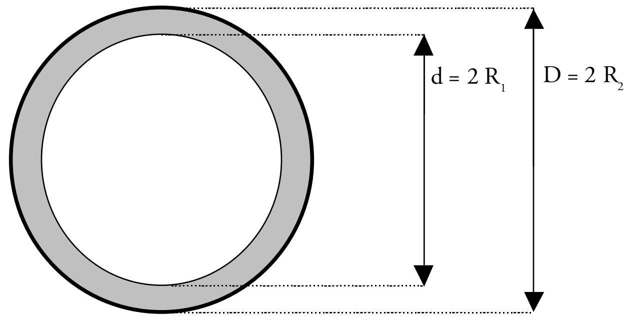

Figure 3.
Fiber Area Measurements: IA Versus AFIS

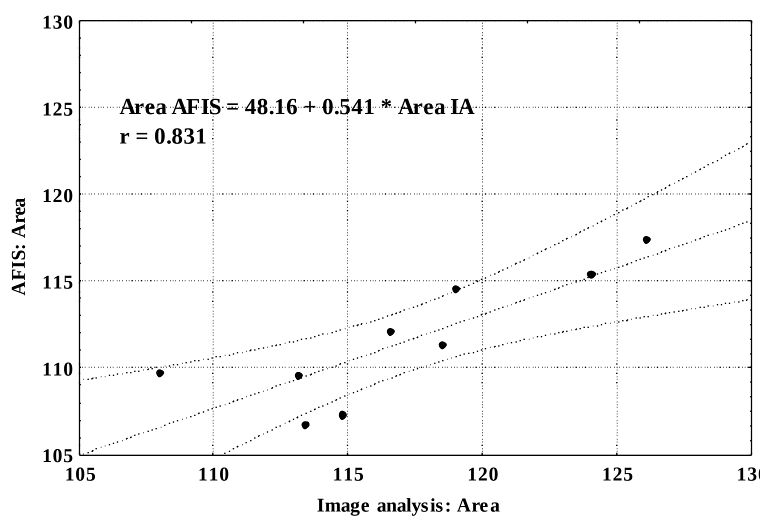

Figure 4.
Fiber Perimeter Measurements: IA Versus AFIS

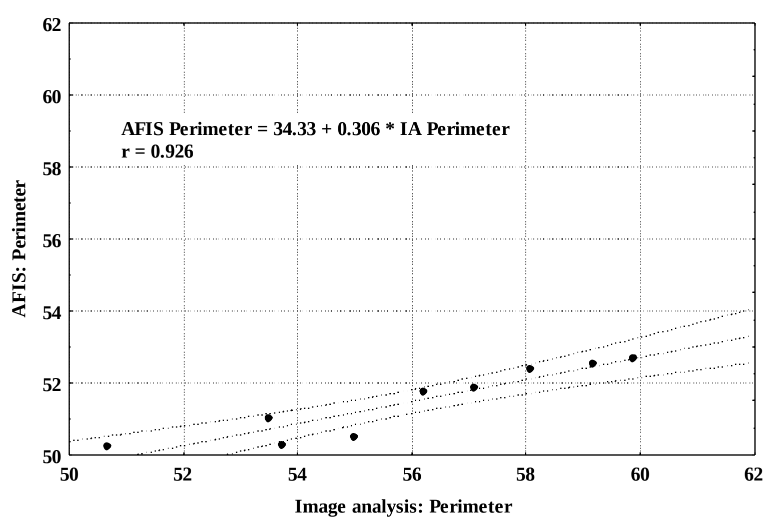

Figure 5.
Fiber Theta (θ) Measurements: IA Versus AFIS

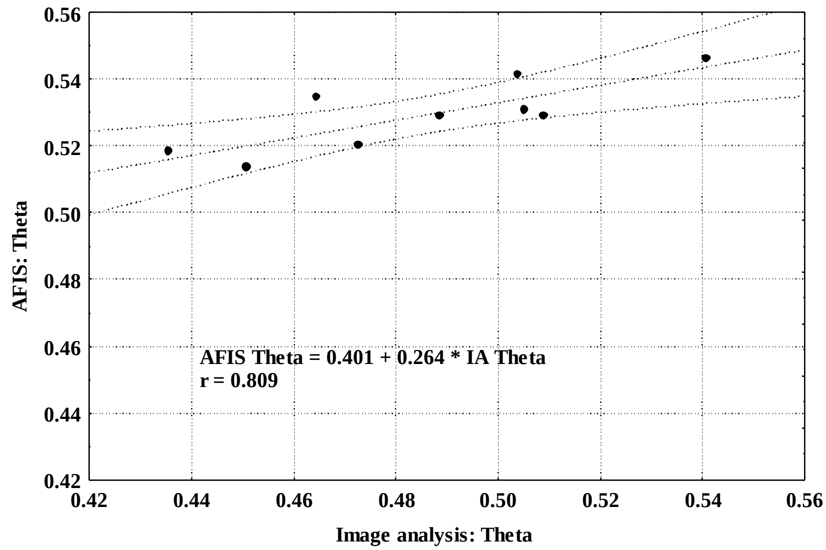

Table 1.
Fiber Data for 54 Cotton Samples

Instrument & Measurement	Units	Mean	Minimum	Maximum
Zellweger Uster HVI 900A				
Micronaire		4.1	3.3	4.6
Leaf Grade		3.4	1.0	5.0
Reflectance	%	75.0	72.0	77.3
Yellowness		7.6	6.8	8.4
Upper Half Mean Length	in	1.18	1.10	1.24
Uniformity	%	83.0	81.3	85.2
Strength	g/tex	32.9	28.7	36.3
Elongation	%	6.1	5.5	6.9
Zellweger Uster AFIS Multidata				
Mean Length (w)	in	1.05	0.97	1.13
Short Fiber Content (w)	%	6.2	3.2	8.7
Upper Quartile Length (w)	in	1.26	1.17	1.33
Maturity Ratio		0.92	0.85	0.97
Immature Fiber Content	%	6.7	5.3	9.1
Fineness	mtex	170	157	180
Standard Fineness	mtex	185	174	197
Neps	cnt/g	250	174	436
Seed Coat Neps	cnt/g	30	13	58
Cross-section Image Analysis				
P_2	μ	55.9	47.7	62.5
P_2 Coefficient of Variation	%	16.1	12.3	20.4
A	μ^2	117.1	97.5	145.2
A Coefficient of Variation	%	31.7	26.0	40.4
θ		0.486	0.393	0.564
θ Coefficient of Variation	%	31.1	25.4	39.4

Table 2.
Rotor-spun Yarn Data for 54 Cotton Samples

Instrument & Measurement	Units	Mean	Minimum	Maximum
Scott Tester				
Count-strength Product (CSP)	Ne x lb	1,971	1,663	2,277
Uster Tensorapid				
Tenacity	cN/tex	12.9	10.9	14.9
Elongation	%	5.6	5.2	6.0
Uster UT3				
Non-uniformity	CV%	17.7	16.7	18.4
Thin Places	cnt/1000yd	168	90	254
Thick Places	cnt/1000yd	333	259	423
Neps	cnt/1000yd	102	54	155
Hairiness		3.48	3.11	3.79

Table 3.
Ring-spun Yarn Data for 54 Cotton Samples

Instrument & Measurement	Units	Mean	Minimum	Maximum
Scott Tester				
Count-strength Product (CSP)	Ne x lb	2,405	1,694	2,997
Uster Tensorapid				
Tenacity	cN/tex	15.2	12.3	18.4
Elongation	%	5.2	4.7	5.8
Uster UT3				
Non-uniformity	CV%	22.8	20.0	26.2
Thin Places	cnt/1000yd	702	222	1,374
Thick Places	cnt/1000yd	1,408	787	2,117
Neps	cnt/1000yd	903	662	1,461
Hairiness		4.50	3.84	5.16

Table 4.
Correlation Matrix

	Ring-spun Yarn 36 Ne		Rotor-spun Yarn 36 Ne	
	Tensorapid Tenacity	Scott Tester CSP	Tensorapid Tenacity	Scott Tester CSP
IA				
P_2	-0.81**	-0.82**	-0.83**	-0.87**
A	-0.56^{ns}	-0.56^{ns}	-0.53^{ns}	-0.59^{ns}
θ	0.79*	0.80**	0.83**	0.86**
AFIS				
P_2	-0.95***	-0.95***	-0.95***	-0.97***
A	-0.74*	-0.72*	-0.72*	-0.74*
θ	0.61^{ns}	0.63^{ns}	0.63^{ns}	0.63^{ns}
HVI				
Micronaire	0.11^{ns}	0.15^{ns}	0.15^{ns}	0.18^{ns}
Strength	0.89***	0.85**	0.92***	0.87**

^{ns} not significant, * significant at 95% confidence level, ** significant at 99% confidence level, *** significant at 99.9% confidence level.

Registration fee:	**$200**
Checks payable to:	ITC, Box 45019 Lubbock TX 79409-5019 Confirmation and schedule will be faxed back on receipt of registration fee
Registration deadline:	**March 30, 2001**
Hotel reservations:	Four Points by Sheraton Hotel, 505 Ave. Q, Lubbock 806-747-0171

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Seventh Annual Cotton Fiber Properties Seminar

April 3-4, 2001

International Textile Center

Texas Tech University

Lubbock, Texas

Cotton fiber properties are the primary research interest of the International Textile Center. Each year the ITC offers an in-depth seminar on cotton fiber properties, fiber testing, evaluation of test data, and how fiber properties impact textile processing. This seminar is designed for cotton breeders, textile mill cotton buyers, merchants, researchers, machinery manufacturers, and others who work with cotton. This year the seminar will be held before the Lubbock Gin Show, April 5-6, allowing attendees to also attend a major equipment show and meet professionals from across the Cotton Belt.

The first day includes: lectures on fiber properties, tests (HVI, AFIS, yarn, stickiness) and interpretation of data. Demonstration of tests will be in the Materials Evaluation Lab. The second day covers how cotton fiber properties impact textile processing with demonstrations in our research textile mill. This session will end at noon.

Sessions will be taught by ITC staff: Eric Hequet, assistant director; Pauline Williams, MEL manager; James Simonton, textile engineer; and SS Ramkumar, research associate.

Seminar fee is $200, which also includes: reference notebook, transportation to and from hotel, and lunch.

Four Points by Sheraton Hotel, 505 Ave. Q, 806-747-0171 is the recommended hotel. Rates for the ITC Cotton Fiber Properties Seminar are $55/night plus a coupon for free breakfast buffet. On arrival at Lubbock International Airport, call the hotel from the dedicated phone in baggage claim and they will pick you up. Pam Alspaugh will meet attendees in the hotel lobby at 8:00 am on April 4 to take you to the ITC. Southwest, Continental, American, and Delta airlines serve Lubbock. Due to heavy attendance at the Gin Show, please make your hotel reservations early.

See website for details: www.itc.ttu.edu/eduopp.htm

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For additional information call Pam Alspaugh at 806-747-3790 or email itc@ttu.edu.

Map available at **www.itc.ttu.edu/map.htm**