TEXTILE topics
Summer 2005
International Textile Center | Texas Tech University Lubbock, Texas USA

Sharing current research information and trends in the fiber 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

International Textile Center Hosts Trade Mission from Pakistan

ITC Managing Director M. Dean Ethridge takes questions from trade mission members in an ITC laboratory

In May, the International Textile Center, in cooperation with the Lubbock Cotton Exchange, hosted the visit of the Special Trade delegation from Pakistan. The group, sponsored by Cotton Council International, Cotton Incorporated and the Foreign Agricultural Service of the United States Department of Agriculture, spent two days in Lubbock, Texas. On the heels of their stops in Washington, North Carolina and Tennessee, the eleven executives from textile mills across Pakistan (accompanied by brokers and CCI officials) attended a dinner sponsored by the Lubbock Cotton Exchange and the Texas Cotton Association. During the dinner, ITC Managing Director M. Dean Ethridge presented a history of the High Volume Instrument. Other speakers at the dinner included Plains Cotton Growers Executive Vice President Steve Verett and Texas Cotton Association President Peter Weirzba. In addition, mission members spent the following morning at the ITC, taking an extensive tour of the facility and participating in an in-depth question and answer session.

Cochran Fellowship to Bring Egyptian Contingent to Center

Under the auspices of the Cochran Fellowship/Foreign Agricultural Service/International Cooperand and Development programs of the United States Department of Agriculture, a group of Egyptian textile executives, merchants and educators will participate in an intense two-day program at the International Textile Center. The topics covered in the seminar, conducted as an extension of the Texas International Cotton School by the Lubbock Cotton Exchange and the ITC, include detailed instruction on Cotton Pest Management, Risk Management, Futures and more. The group's visit to the ITC will follow their stops in Washington D.C., at the New York Cotton Exchange, Cotton Incorporated, Cotton Council International and the National Cotton Council, among others.

Impacts of Fiber Length Distribution on Market Value and Yarn Quality: Implications for U.S. Cotton.

Eric F. Hequet and M. Dean Ethridge,
International Textile Center, Texas Tech University, Lubbock, TX, U.S.A.

The shrinking U.S. textile manufacturing industry has created an increased reliance on the international market for selling U.S. cotton. In turn, this process is transforming the requirements on fiber properties. This is illustrated well by the existing "base levels" of fiber properties shown in Table 1.

Table 1. Base Levels of Cotton Fiber Properties, U.S. Versus International

	U.S.	International
Staple Length (inches)	34	35
Tenacity (g/tex)	26	28
Micronaire	3.5-4.9	3.8-4.6
Uniformity Index (%)	80-82	82-83
Color	41	31
Leaf	4	3

A look at the percentage of the U.S. cotton crop that equals or exceeds the international base quality (Table 2) makes it clear that progress is needed.

Table 2. Percentage of U.S. Crop that Reaches or Exceeds Base Qualities

Crop Year	United States	International
2003-04	54.8%	7.1%
2004-05	49.7%	7.9%

The foregoing data does not adequately reveal the emerging emphasis (and market premium) for longer and more uniform fiber lengths. The U.S. industry has long been focused on the production of medium and coarse yarns and has long emphasized open-end rotor spinning, rather than ring spinning. But the focus of the dominant international textile industries is on the finer yarns and on ring spinning. Thus, global textile mills interested in sourcing cotton from the global market emphasize those cotton growths with longer fiber lengths.

A less-appreciated fact is that the focus on fiber length is shifting away from the traditional staple length (a measure of the "dominant long fibers") and toward the length distribution (which measures the lengths of all fibers included in the cotton). This shift is obscured by the lack of a high-volume measurement for length distribution. Alternatively, it is revealed by a growing number of international customers preocupation with the "short fiber content" (SFC) of cotton--the percentage of fibers with a length of ½ inch or less--that higher SFCs result in greater losses at the carding machine, reduced spinning performance and yarn quality and increased fabric defects [1].

MEASURING FIBER LENGTH DISTRIBUTION

The only generally available instrument that provides fiber length distribution data is the Uster® Advanced Fiber Information System (AFIS®). It is not a high-volume instrument and it is not feasible to obtain reliable market-wide measurements with it. Nevertheless, within a carefully controlled laboratory it is possible to get repeatable and reliable measurements [2]. At the International Textile Center (ITC), standard cottons were developed and are used every day to maintain calibrations on the two AFIS instruments in its laboratory. These "check cottons" are described in Table 3, which shows for each cotton the upper quartile length (UQL), the short fiber content by weight (SFC(w)), and the short fiber content by number (SFC(n)).

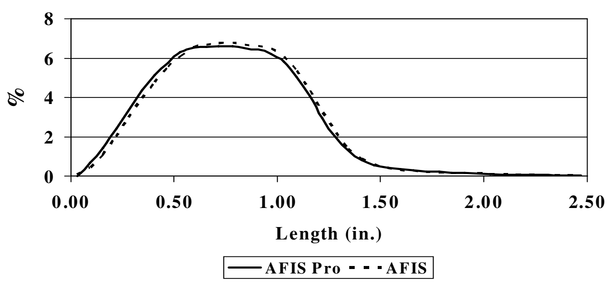
Table 3. AFIS Check Cottons Used at the International Textile Center

	#3116	#3291	#3212
UQL	1.01	1.16	1.30
SFC (w)	22.1	13.8	8.6
SFC (n)	43.5	33.1	24.3

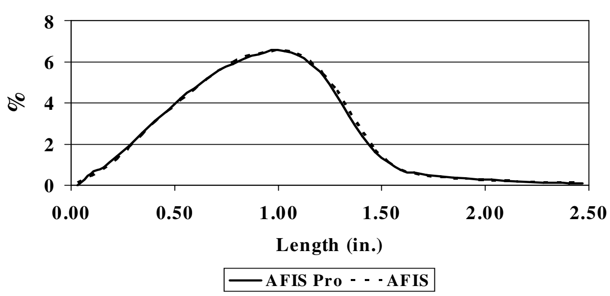
Using these ITC protocols, the precision of these instruments over time has proven to be quite good. Furthermore, results have proven that good repeatability of fiber length distributions is obtained between the two instruments at the ITC. (These two AFIS instruments span two generations; the older one is called "AFIS" and the newer one is called "AFIS Pro".) As shown in Figure 1(a)-(c), the shapes of the cotton fiber length distributions are repeatable for all check cottons.

Figure 1. Length Distributions by Weight for Three Check Cottons at the ITC

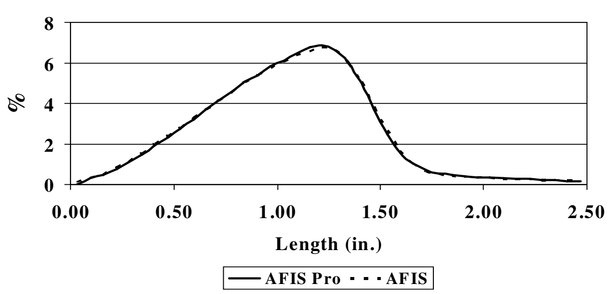
(a)Check Cotton 3116:



(b) Check Cotton 3191:



(c) Check Cotton 3212:



These results clearly show that fiber length distributions vary for different cottons and that the distributions are repeatable. Therefore, it is a strong hypothesis that length distributions are heritable, which would mean that varieties with superior length distributions could be developed using traditional selection techniques of plant breeders.

ALTERATIONS OF FIBER LENGTH DISTRIBUTION

The natural genetic length distribution of cotton fibers on the seed is inevitably altered by fiber breakage due to mechanical and other stresses placed on the fibers by harvesting, ginning, and manufacturing.

Indeed, even the AFIS® instrument breaks substantial numbers of fibers in the process of opening the cotton sample and individualizing the fibers. (Thus, the AFIS® may be used as an indicator of the propensity of fibers to break.).

Two critically important factors for predicting the fibers' propensity to break are *maturity* and *fineness* [3]. Use of the micronaire measure is frequently misleading because it inherently measures a combination of maturity and fineness. Thus, a coarse, immature fiber may offer the same micronaire value as a fine, mature fiber. Furthermore, as illustrated by the cross-sectional images of a multitude of cottons, there is a clear distributional behavior for both fineness and maturity. This fact is illustrated in Figure 2 using the bivariate distributions between fiber perimeter (a measure of the fineness) and "theta", which describes the degree of thickening of the fiber cell wall (a measure of maturity). While the two cotton varieties shown have the same micronaire reading (4.28), they show divergent patterns of fineness and maturity.

Since an immature fiber is weaker than a mature one, it is more susceptible to being broken under stress. Therefore, an average maturity measurement should be a better predictor of a fibers' propensity to break than micronaire.

TEXTILE TOPICS
a research bulletin on fiber and textile industries.
Summer 2005 - Issue 3

Published quarterly
Texas Tech University
International Textile Center
P.O. Box 45019
Lubbock, TX 79409-5019

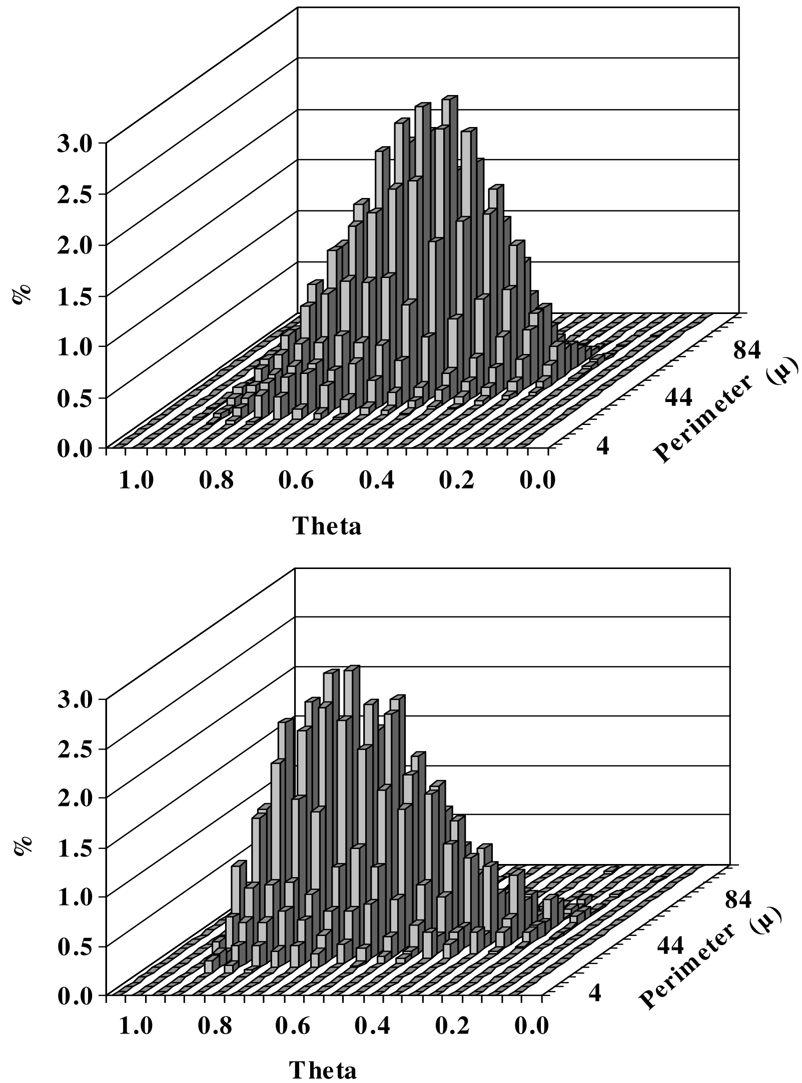


Figure 2. Bivariate Distributions of Perimeter Versus Theta, for Two Cottons with the Same Micronaire Value of 4.28

Since the stresses in mechanical operations like ginning, cleaning, opening and carding are being placed on individual fibers or groups of few fibers (rather than on bundles of fibers), the distributional characteristics of maturity should greatly impact the propensity to break.

Using AFIS® measurements of short fiber content by number (SFC(n)) and by weight (SFC(w)), the distinctive behaviors of mature versus immature of two cottons having the same Upper Quartile Length (UQL) are illustrated in Figure 3. This data was collected from hand-ginned cottons, in order to ensure minimal damage to the native length distributions of the cottons.

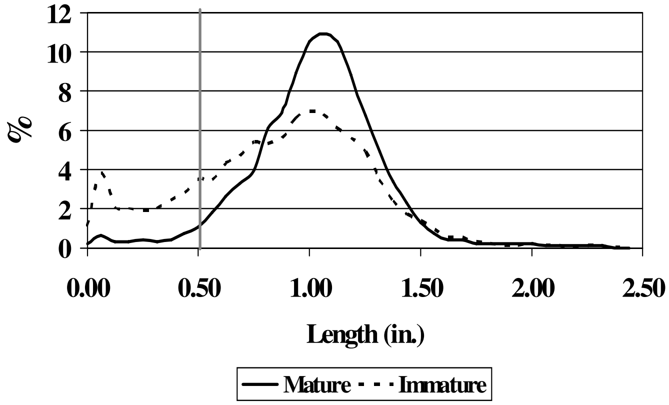
The SFC(w) is the more common frame of reference for the cotton/textile industry. But the SFC(n) is often preferred for research purposes, due to its greater sensitivity to movements in SFC. The SFC(w) is less sensitive because short fibers (whether caused by native length distribution or by the breaking of fibers) must logically comprise a small portion of the total weight of fibers. The increased *number* of short fibers for the immature cotton (Figure 3(a)) is relatively much larger than is the increased *weight* of short fibers (Figure 3(b)). Nevertheless, with the cottons used in this example, the differences between mature versus immature in short fibers are quite clear.

Note that Figure 3 shows the hand-ginned mature cotton has very low amounts of short fibers. For the immature cotton, however, the short fibers are greatly increased. This is probably due to fiber breakage, both by the hand ginning and the opening device on the AFIS®. This observation is sufficiently repeatable with immature fibers and lends support to the common hypothesis that short fibers are few within an unharvested boll of cotton and that the vast majority of short fibers come from breakage due to mechanical stresses.

Further evidence is obtained by comparing fiber length distributions with hand-ginning against breeder saw-ginning.

Figure 3. Length Distributions for two cottons

(a) Short Fiber Content by Number (SFC(n))



(b) Short Fiber Content by Weight

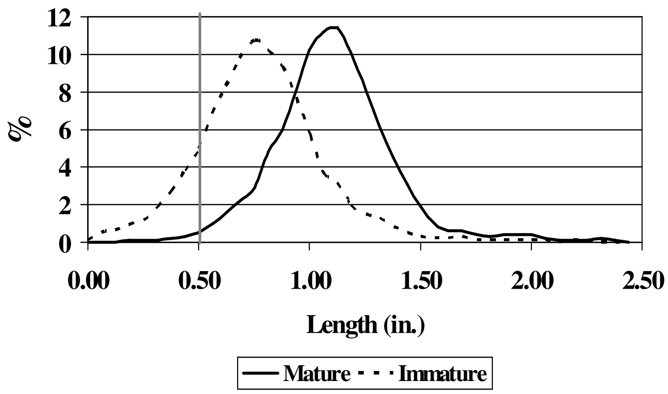
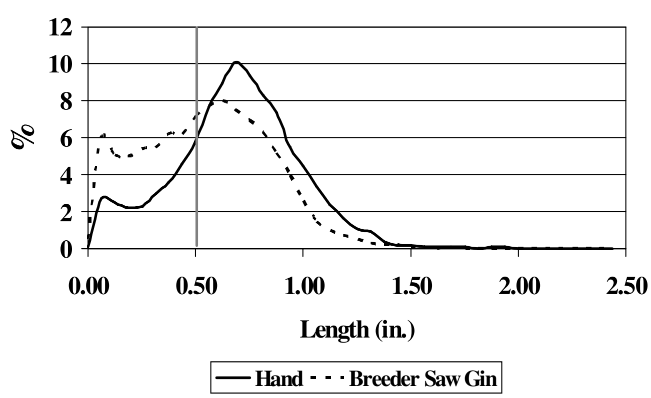


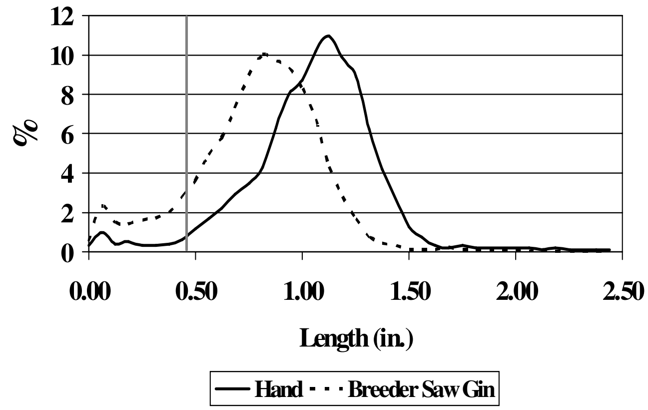
Figure 4(a) shows results for an immature cotton (AFIS® maturity ratio = 0.87). Figure 4(b) shows results for a mature cotton (AFIS® maturity ratio = 1.04).

Figure 4. Cotton Fiber Length Distributions by Number:

(a) Hand Ginning Versus Saw Ginning For an Immature Cotton (MR = 0.87)



(b) Hand Ginning Versus Saw Ginning For a Mature Cotton (MR = 1.04)

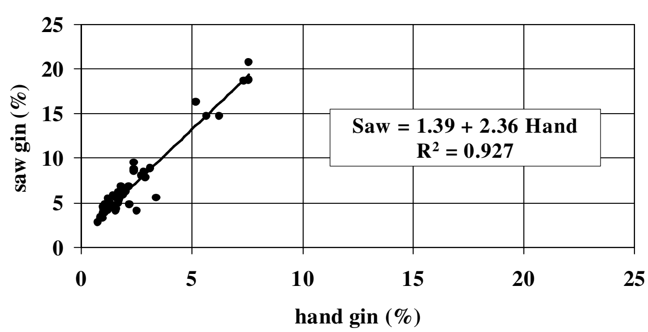


Results show the following:

- With hand ginning the short fiber content is much greater for the immature cotton.
- The use of a breeder saw gin increases the short fiber content for both cottons, but the increase is much more for the immature cotton.

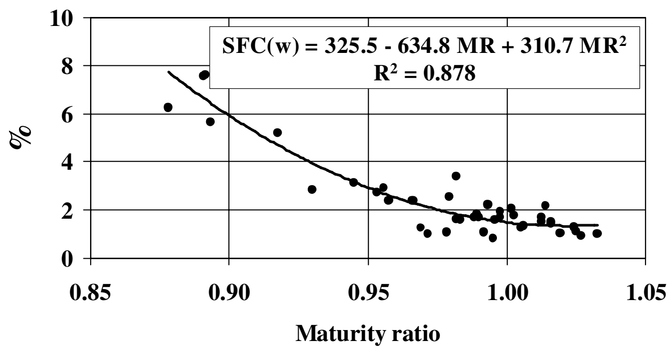
Comparing breeder saw ginning versus hand ginning over multiple cotton samples reveals a consistent relationship between short fiber contents (Figure 5). In this example, a short fiber content by weight of about 5% with hand ginning would be expected to increase to 12-13% with the breeder saw gin.

Figure 5. Short Fiber Content by weight: Breeder saw gin vs. Hand gin

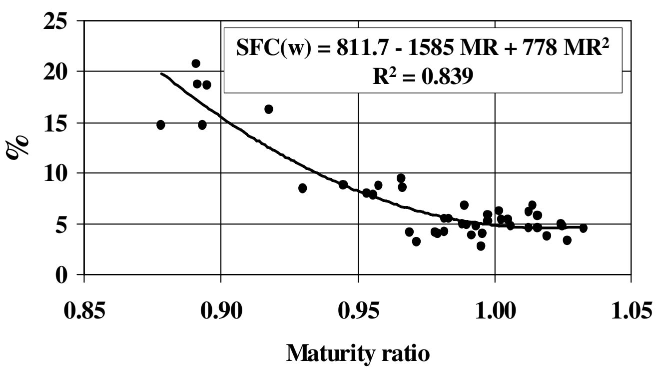


Plotting multiple measurements of short fiber content after hand ginning against fiber maturity ratios reveals a consistent inverse relationship (Figure 6(a)), with an asymptote for short fiber content at about 1%. Doing the same thing using a breeder saw gin shows the same inverse relationship, but with a short-fiber asymptote closer to 5% (Figure 6(b)).

Figure 6. Short Fiber Content Versus Maturity Ratio
(a) Hand Ginning



(b) Breeder Saw Ginning



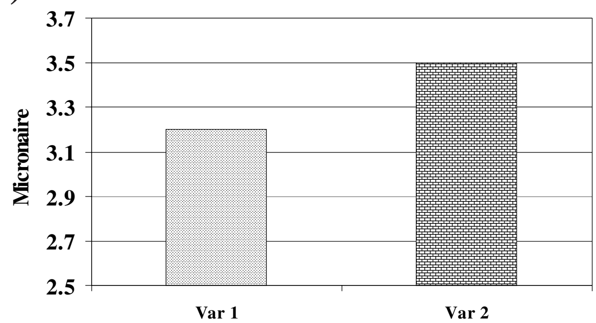
IMPACTS ON YARN QUALITY

A look at two varieties studied at the International Textile Center illustrates how distributional properties may determine the success or failure of cotton varieties in yarn spinning. The spinning tests were done using ring spinning and the yarn size was 40 Ne. Thus, the test procedure was set to evaluate performance in higher-valued, finer-count yarns.

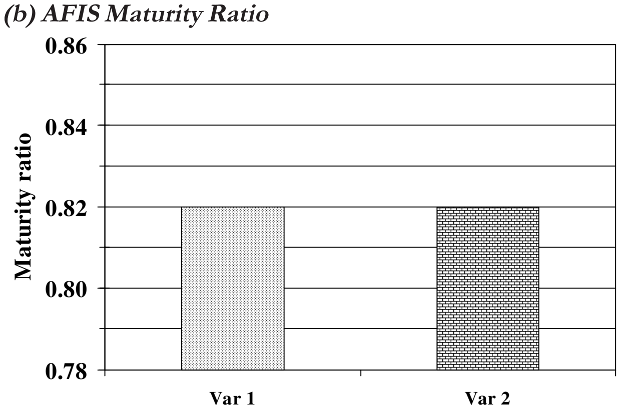
Fiber Properties

The critical fiber properties are summarized in Figures 7 and 8. Figure 7 shows fiber fineness and maturity data: micronaire, AFIS maturity ratio, and AFIS fiber perimeter estimates. Note that both varieties have low micronaire readings but that both are equally mature; taken together, these results indicate that these are relatively fine fibers, appropriate for making finer yarns. The AFIS estimates of the average perimeters of the fibers verify this. Variety 1 has the smaller perimeter, which explains its lower micronaire value.

Figure 7. Fineness and Maturity Data for Two Varieties
(a) Micronaire



(b) AFIS Maturity Ratio



(c) Average Fiber Perimeter (AFIS)

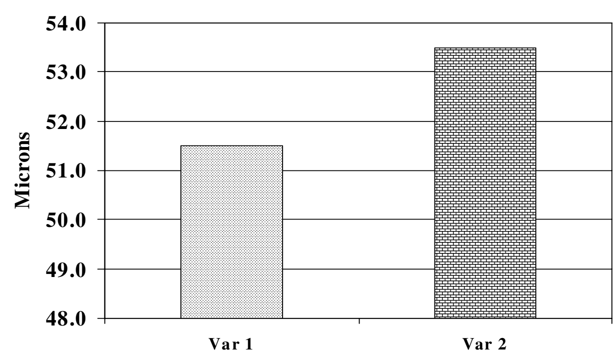
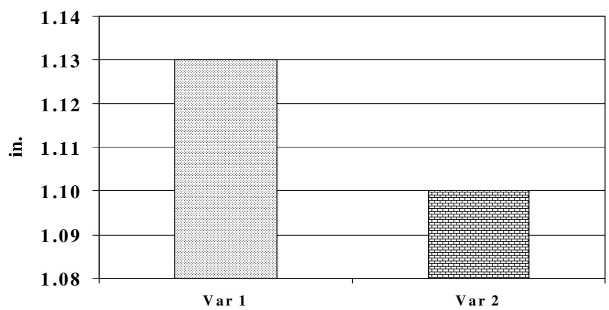


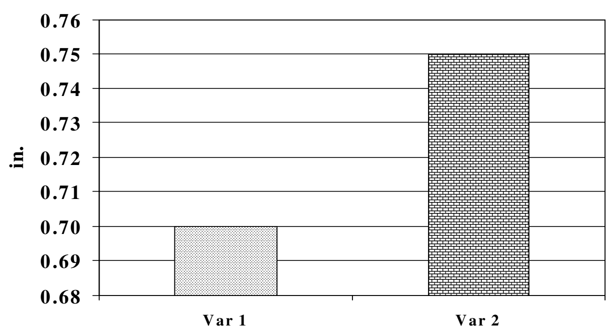
Figure 8 shows HVI upper half mean length (UHML), AFIS means length by number (ML), and AFIS short fiber content by weight (SFC(w)). Variety 1 has a significantly longer UHML; however, Variety 2 has a significantly longer ML. Furthermore, Variety 1 exhibits a much higher SFC(w). Based on measurements like these, the expectation is that Variety 2 will perform much better in ring spinning.

Figure 8. Length Parameters for Two Varieties

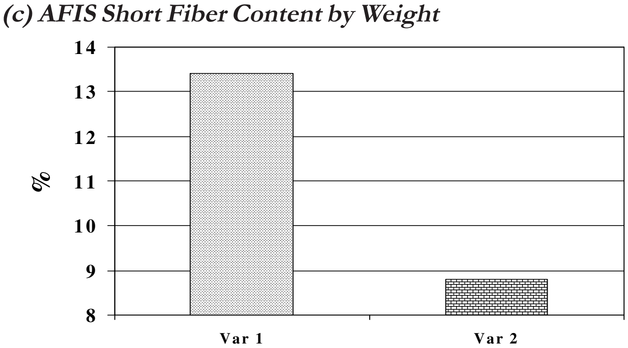
(a) HVI Upper Half Mean Length



(b) AFIS Mean Length by Number

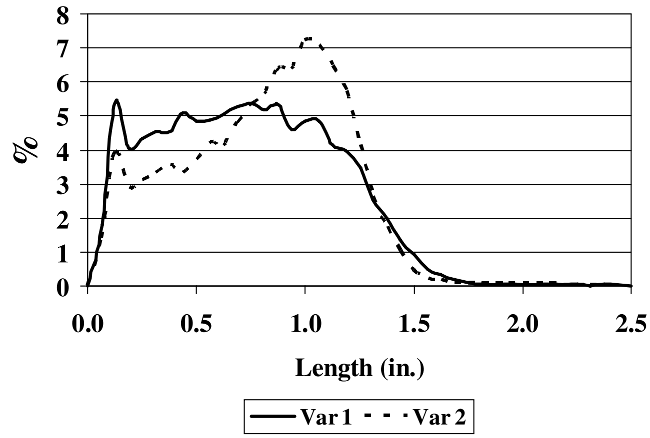


(c) AFIS Short Fiber Content by Weight



A look at the length distributions for each of these varieties helps understand what is causing these length measurements. Figure 9 clearly shows that variety 1 has no "peak" near the mean length of the distribution and that it has an excess of fibers in the short length categories.

Figure 9. Fiber length distribution by number for two varieties

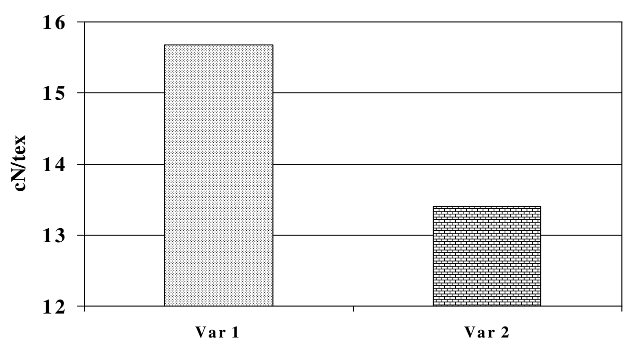


Yarn Quality

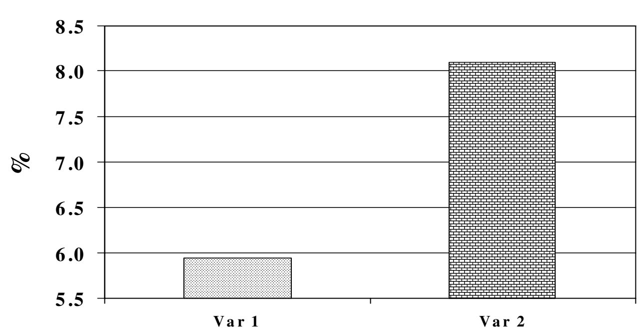
A summary of key yarn quality parameters for these two cotton varieties completes the story. Figure 10 provides results on yarn tensile properties. The first chart (Figure 10(a)) shows yarn breaking strength (tenacity)--it reveals that variety 1 is better in this regard. However, variety 2 has a much better elongation (Figure 10(b)). Therefore, the work-to-break, which is a critical indicator of weaving performance, is greater for variety 2 (Figure 10(c)).

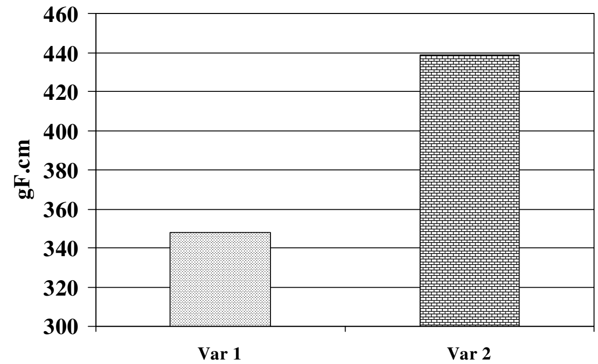
Figure 10. Yarn Tensile Properties for Two Varieties (Ring-Spun, 40 Ne Yarns)

(a) Yarn Tenacity



(b) Yarn Elongation





(c) Yarn Work-to-Break

Figure 11 shows that variety 2 exhibits better yarn evenness, which means that it has a smaller yarn coefficient of variation (CV%).

Figure 11. Yarn Evenness for Two Cotton Varieties (Ring-Spun 40 Ne Yarns)

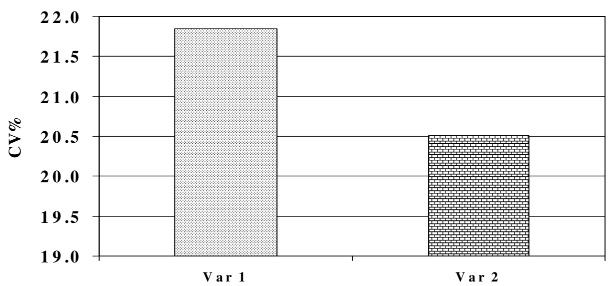
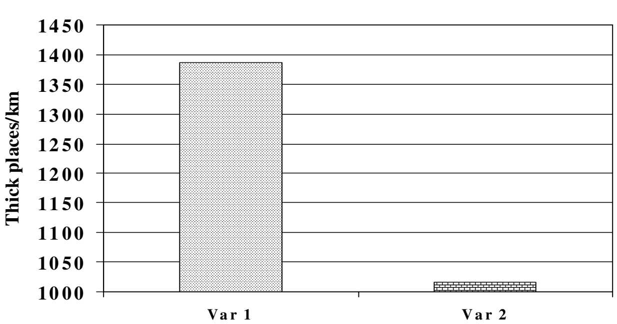


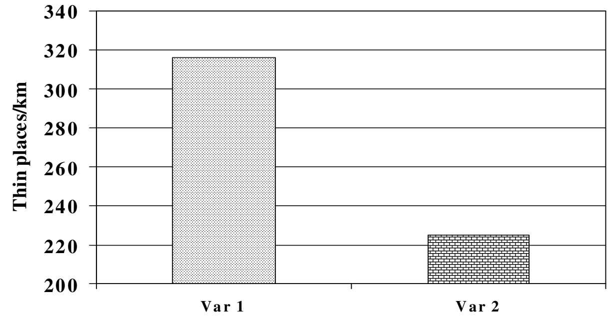
Figure 12 shows that yarn imperfections are less with variety 2. Thus, both *thick* (Figure 12(a)) and *thin* places (Figure 12(b))are significantly lower for the yarn spun with variety 2. Also, yarn neps are almost 30% less with variety 2 (Figure 12(c)). Finally, the hairiness of the yarn spun with variety 2 was significantly lower (Figure 12(d)). All of these yarn properties are critical for high-quality, ring-spun yarns.

Figure 12. Yarn Imperfections for Two Cotton Varieties (Ring-Spun 40 Ne Yarns)

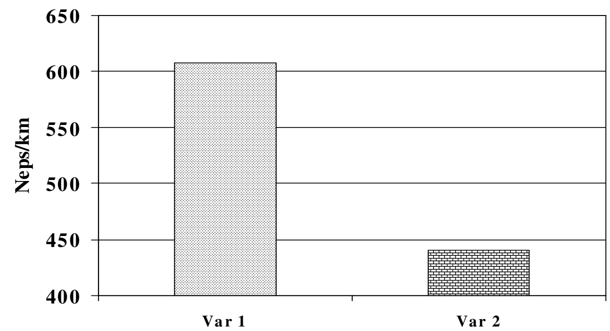
(a) thick places



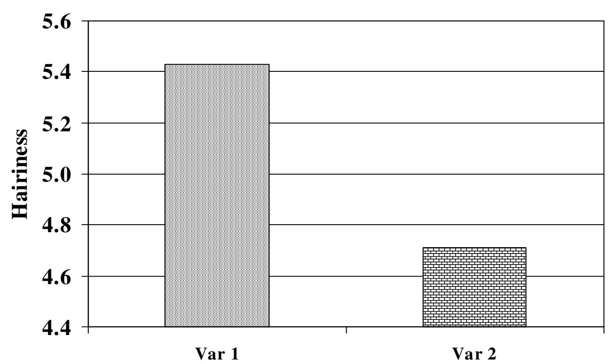
(b) thin places



(c) Neps



(d) Hairiness



A version of these results were presented by Dr. Hequet during the 18th Annual EFS System Conference, held 6-8 June, 2005 in Memphis, Tennessee.

CONCLUSION

It is important that both the research and commercial sectors focused on cotton and textiles realize that:

- Length distribution (as distinct from staple length) is critically important for good spinning performance and high yarn quality, and,

- Length distribution is highly correlated with strength of individual fibers (therefore, with strength distribution), and,

- Individual fiber strength is highly correlated with fiber fineness and fiber maturity, and,

- Even though the distributional characteristics of either length or maturity are not yet candidates for high-volume measurements, careful measurement and evaluation of these can give indispensable guidance to applied scientists trying to develop superior cotton fibers.

Another implication of these results is that the process of realizing the market potential of cotton varieties with longer fiber lengths will likely require adjustments in crop termination, harvesting, and ginning practices. The juncture of greatest marginal gains will likely be the ginning.

The researchers would like to thank Cotton Incorporated and the Texas Food and Fiber Commission for providing financial support for this project.

Works Cited

1. Hequet, E.F, "Application of the AFIS Multidata," *Proceedings of the Beltwide Cotton Conference*, 1999. Vol. 1: 666-670, NCC, Memphis, Tennessee.

2. Hequet, E.F., Ethridge, D. "Cotton Quality Evaluation for Cotton Breeders and Biotechnologists," *15th Annual EFS Conference Proceedings*, 2002. 95-112, Memphis, Tennessee.

3. Krifa, M., Hequet, E.F. "Experimental Assessments of Cotton Fiber Behavior During Opening and Cleaning," *Proceedings of the Beltwide Cotton Conference*, 2005. New Orleans, Louisiana