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Impacts of Micronaire on Water Retention Part I

The micronaire reading on a bundle, or "plug", of cotton fibers is a measure of the resistance to air flow; it is a result of the combined influences of fiber fineness and fiber maturity (1). Fiber fineness may be directly measured either by the weight per unit length or by the circumference of the individual fibers. Maturity may be directly measured by the ratio of cell wall thickness to fiber circumference.

Cotton fiber grows in two stages from the outer coat of the seed. In the first stage (a period of 10 days from flowering) it elongates as a thin tube. Then, for a period for a period ending about 45 days after flowering, the hollow center fills with successive layers of cellulose. If this process of deposition of cellulose is hindered – due to adverse weather conditions, insect damage, plant disease, premature harvest, etc. – the cotton fiber does not attain full maturity.

Within a given variety, or among closely related varieties, fibers with low micronaire values have less cellulose deposition than those with high micronaire values. Moreover, since the fiber diameter varies little among similar varieties, there is more empty space i.e., larger cavities) in low micronaire cotton than in high micronaire cotton. If water, or other aqueous solutions, can collect in these cavities, then the cotton may be able to contain relatively large quantities for enough time to be useful in certain applications.

The foregoing reasoning implies that low micronaire cotton should retain more water than high micronaire cotton. But information on impacts of micronaire on water retention is not available in the literature. Here we present results of water retention of cotton fibers over a wide range of micronaire values.

Procedure:

Nine samples of cotton fibers were used in this investigation, eight were US Upland cotton varieties and one was an Asiatic variety. A minimum of three

replications were done for each sample, with more being done whenever enough cotton fiber was available to allow it. Measurements of micronaire, maturity, percent maturity, and fineness were measured on the FMT High Volume Fineness Maturity Tester (2). Exhibit 1 summarizes the average values of these measurements for each sample. It reveals that micronaire values ranged from 2.7 to 7.1, percent maturity from 49% to 92%, and fineness from 130 millitex to 299 millitex.

Exhibit 1: Samples Used for Water Retention Study

Type of Cotton	Micronaire	Maturity (%)	Fineness (mtex)
American Upland	2.7	49	148
American Upland	3.1	68	137
American Upland	3.4	84	130
American Upland	3.8	78	156
American Upland	3.9	94	134
American Upland	4.2	82	170
American Upland	4.3	82	180
American Upland	4.9	89	187
Asiatic	7.1	92	299

Major procedural steps were the following:

Scouring: Cotton fibers were treated, at boil for 90 minutes in absence of air, with 4% sodium hydroxide on the weight of the fibers with a 1:20 material to liquor ratio. Fibers were thoroughly washed with deionized water to achieve a neutral pH, then allowed to dry at room temperature. They were **not** "soured" (neutralized with a diluted acid), to avoid any tendency to reduce absorbency of the scoured fibers.

Determination of Water Retention: The Centrifuge Method was used, as per ASTM Standard Test Method D 2402-78. Approximately one gram of fibers was taken from each sample and soaked in

distilled water for one hour. The sample was drained for 2–3 minutes and placed on a perforated stainless steel disk supported by a stainless steel bolt in a 50 ml centrifuge tube so that water could be collected in the tube below the disk without touching the fibers. The capped tubes were placed in the centrifuge and run for 15 minutes, stopped long enough to remove the free water from the centrifuge tube, then run for 45 minutes more. The centrifuge was run at a speed needed to attain radial acceleration of 1000 g. The weight of the water retained by the cotton fibers after this process was expressed as a percentage of the oven-dried mass of the fibers.

Results:

Exhibit 2 shows the average water retention values of the cotton fibers for the different micronaire values. For the 2.7 micronaire value, water retention averaged 67.2%. For the 3.1 micronaire value, water retention dropped to 58.6%. For micronaire values between 3.4 and 4.2, average water retention ranged between 51.8% and 56.1%. For micronaire values between 4.3 and 7.1, average water retention ranged between 44.8% and 45.0%.

Exhibit 3 clearly reveals that measurements of water retention are non-linear and that they are inversely related to micronaire values, at least through the 5.5 micronaire level on the American Upland varieties. The 7.1 micronaire value for the Asiatic variety introduces a different mix of maturity versus fineness (see the “coarse” measurement for

this cotton in Exhibit 1). Nevertheless, it is to be expected that the functional relationship between water retention and micronaire will be non-linear, since micronaire is an inherently non-linear measurement.

The “best fitting” regression line for the scatter plot of data in Exhibit 3 is a quadratic functional form. The regression equation estimation is the following:

(1) $w = 116.79 - 24.44 m + 2.00m^2$; $R^2=0.83$,
 where w represents percent water retention and m represents micronaire value. The multiple correlation coefficient (R^2) indicates that the regression equation explains 83% of the variation in water retention measurements.

In contrast to the results for micronaire, functional relationships between water retention and either maturity or fineness are expected to be approximately linear. Exhibit 4 shows the plot of water retention versus fiber maturity, and Exhibit 5 shows the plot of water retention versus fiber fineness. Both reveal inverse, linear relationships. Simple regression results are as follows:

(2) $w = 90.06 - 0.47 z$; $R^2 = 0.65$,
 and

(3) $w = 67.87 - 0.085 f$; $R^2 = 0.36$,
 where z represents maturity values and f represents fineness values. Clearly, the explanatory power of fineness alone (accounting for only 36% of variation

Exhibit 2: Effect of Micronaire on Average Water Retention Values

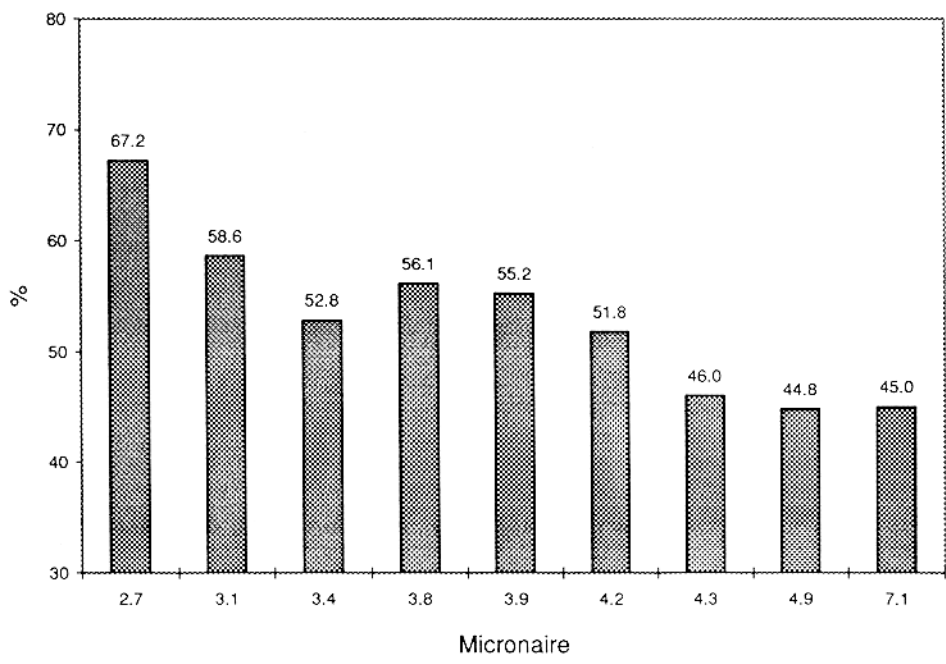


Exhibit 3: Water Retention versus Micronaire

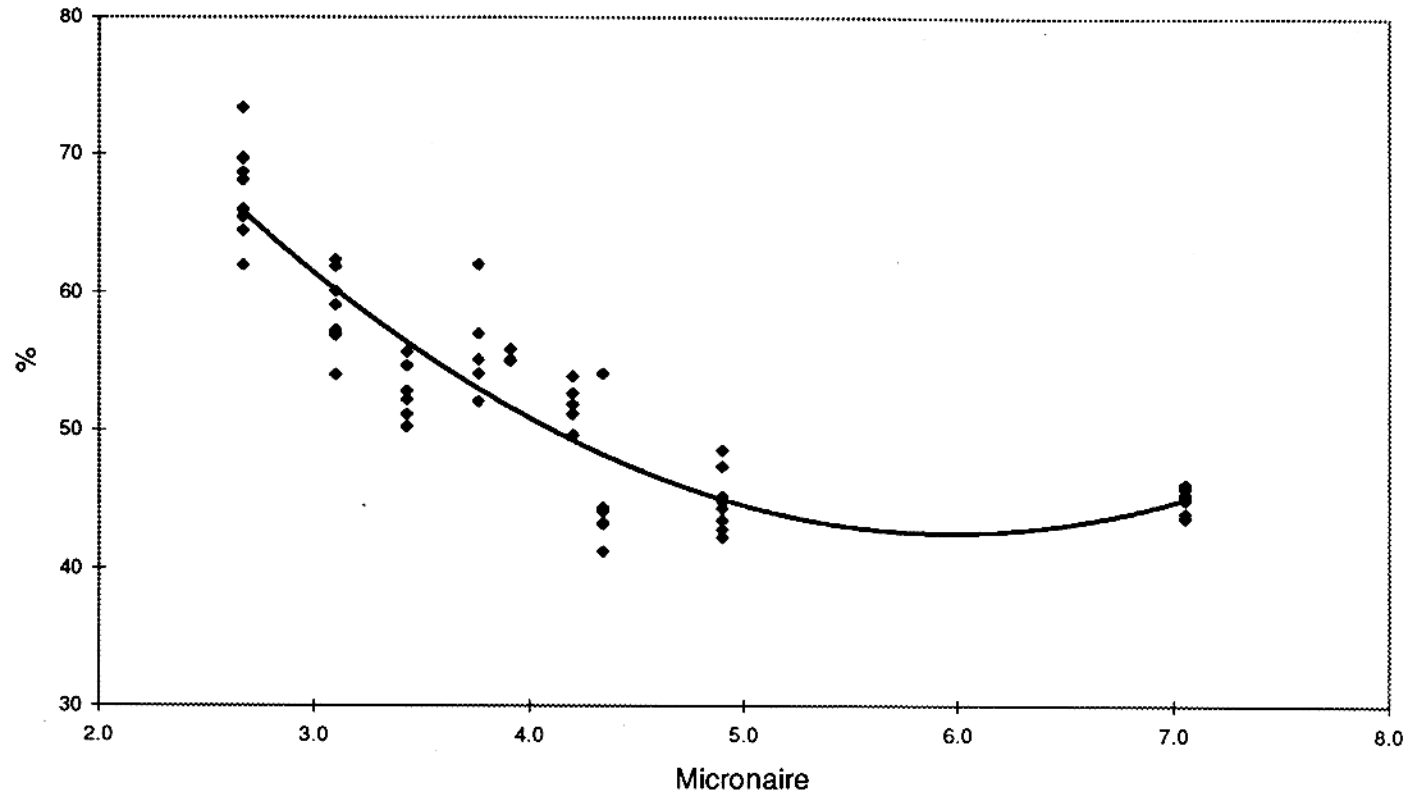


Exhibit 4: Water Retention versus Maturity

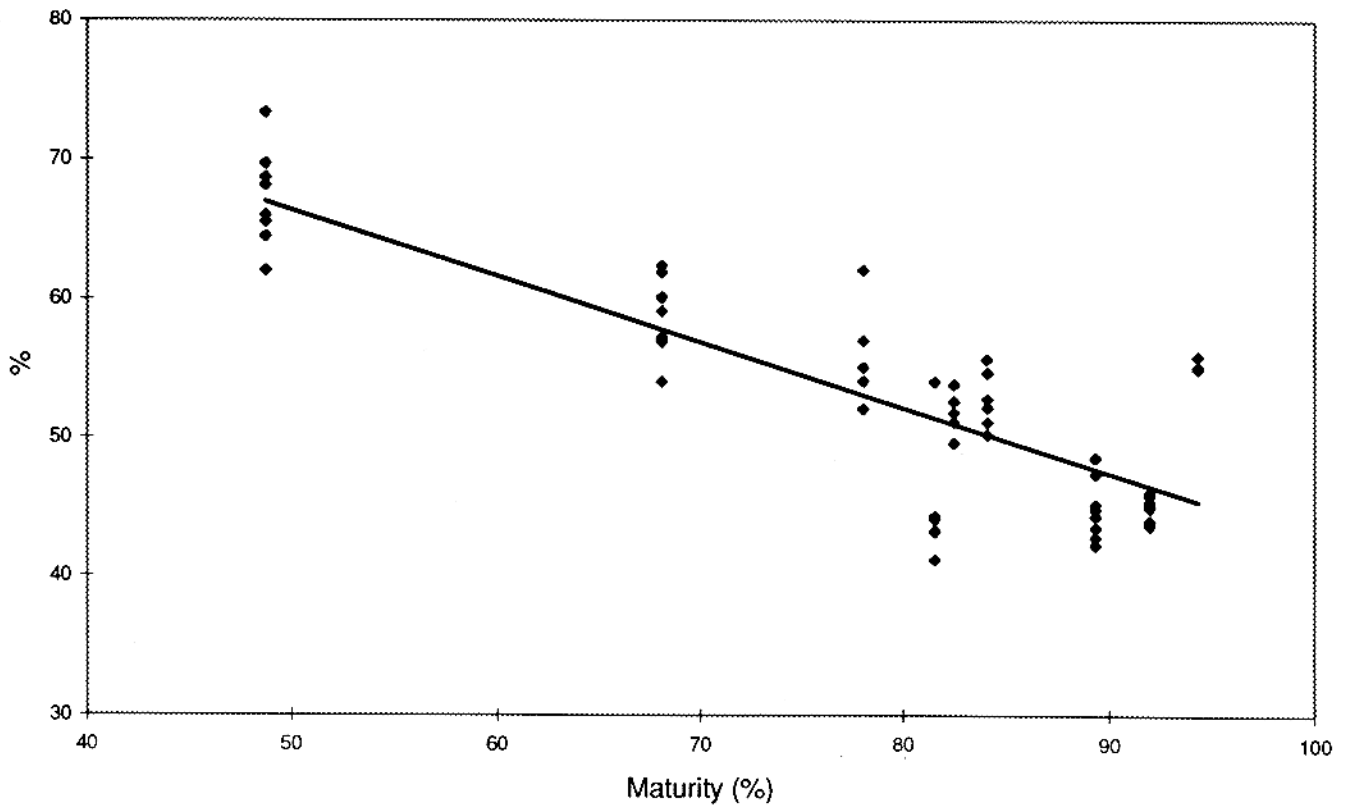
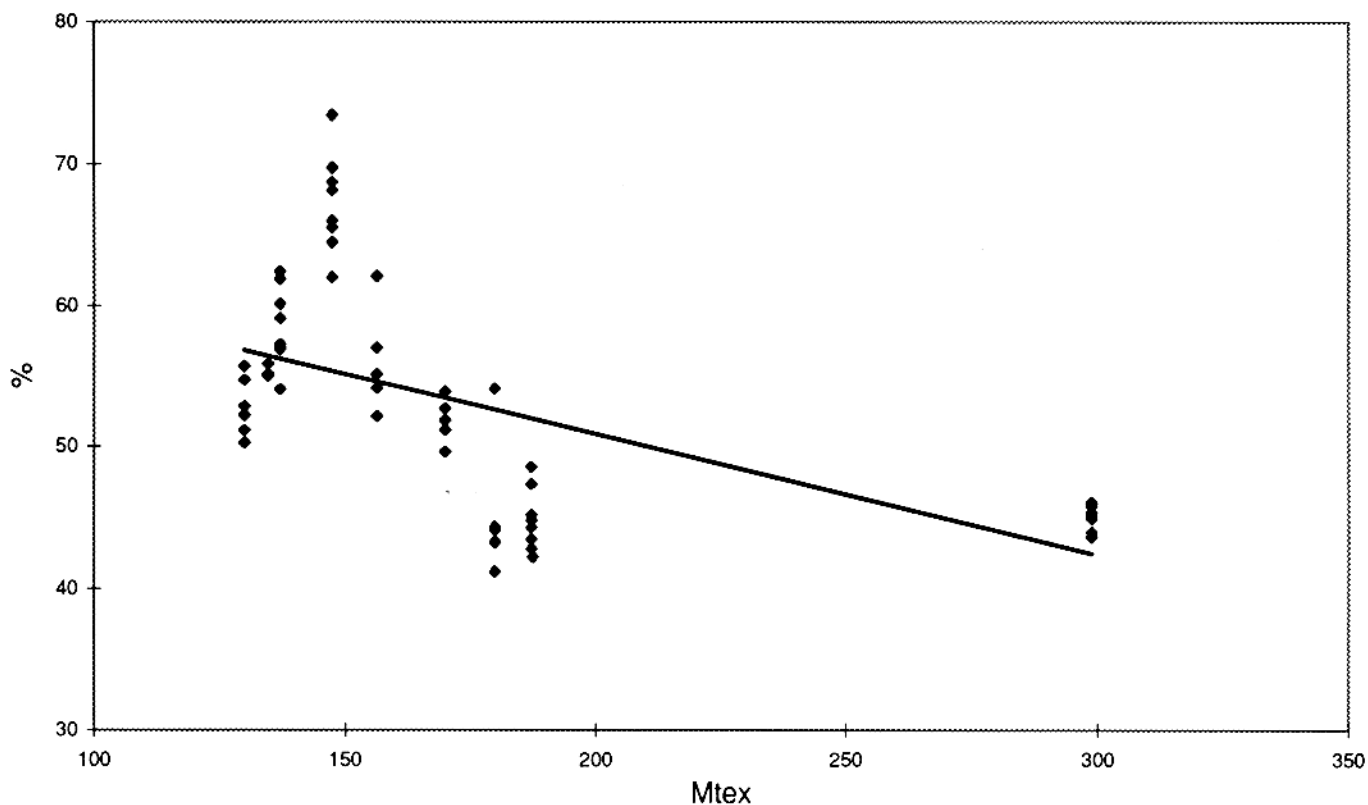


Exhibit 5: Water Retention versus Fineness



in water retention) is quite low. As our foregoing logic indicated, fiber maturity embodies most of the explanatory power between these two independent variables.

Using both maturity and fineness as explanatory variables, the multiple regression equation for water retention is as follows:

$$(4) \quad w = 91.02 - 0.40 z - 0.04 f \quad ; \quad R^2 = 0.73.$$

Therefore, the explanatory power of these two variables together is somewhat less than that of micronaire alone, at least for the sample of cotton used in this study. Inspection of the error terms for this regression revealed a slight non-linearity in them; therefore, alternative functional forms were examined and the following was estimated:

$$(5) \quad w = 183.76 - 65.80 \log z - 0.04 f \quad ; \quad R^2 = 0.75.$$

This provided a slightly better fit to the data, but still not as good as for micronaire alone. Unfortunately, answering the question about non-linearity for the impact of fiber maturity will require using larger samples.

Summary and Conclusions:

There is a strong inverse relationship between water retention (as measured by the centrifuge method) and micronaire values of cotton fibers. The combination of fiber fineness and fiber maturity does not appear to explain as much of the total variation in water retention as does micronaire alone. Given that (1) micronaire results from the combined influences of fineness and maturity, and (2) micronaire is a readily available commercial measurement on cotton fibers, it provides a good basis for selecting cotton to use in hydrophilic applications where water retention is of paramount importance.

The focus of this report is on the differential abilities of scoured cotton fibers to retain water within them. Obviously the results reported here do not enable conclusions about rates of water absorption. Neither do they reveal anything about the water holding capacity of alternative cotton textile **products** used for specific purposes.

The water retention capacity for cotton may be enhanced by graft polymerization of vinyl monomers to the cellulose. The differential impacts of such chemical alteration on cotton with different micronaire values is of both scientific and practical

interest. Results from further investigation of this will be reported in the next issue of *Textile Topics*.

The research reported here was funded by the Texas Food and Fibers Commission and was conducted by **Dr. R. D. Mehta**, Head of Finishes/Chemical Research at the ITC. A paper on these results was presented at the 1994 American Association of Textile Chemists and Colorists (AATCC) International Conference & Exhibition, in Charlotte, North Carolina. Reprinted with permission from AATCC.

References:

1. Hamby D. S., The American Cotton Handbook, Vol. 1, Third Edition (1965), p. 135.
2. Instruction Manual SDL 89C, FMT3 High Volume Fineness Maturity Tester, Shirley Developments Ltd., Stockport, Manchester, UK.

Texas International Cotton School

Eighteen students from six countries attended the tenth session of the Texas International Cotton School, conducted October 3 through 14, 1994. The school is sponsored by the Lubbock Cotton Exchange and held at the International Textile Center twice a year. Students, their countries, and the companies they represented, were:

from Colombia: Joaquin Antonio Galeano, FIBRATOLIMA, Tolima;

from India: Dhiren N. Sheth, C. A. GALIAKOTWALA & CO., Ltd., Bombay;

from Indonesia: Ms. Rosalina, PAN BROTHERS GROUP, Jakarta; and Thomas Young, P. T. YOUNG INDONESIA TEXTILE IND., LTD., Jakarta;

from Malaysia: Laurence David, KIB TEXTILES BERHAD, Kamunting, Perak, West Malaysia; and Juraini bin Muslim, WOODARD TEXTILE MILLS SDN., Penang;

from Thailand: Turong Krobthong, THAI TEXTILE INDUSTRY PUBLIC CO. LTD., Samutprakan; and Dalad Saphavichaiikul, SAHA-UNION PUBLIC CO., LTD., Bangkok;

from the United States: Patrick Packnett, USDA-FAS, Washington, DC; Marsha Hudson and Qaiser Waraich, OLD WORLD TRADING CO., Northbrook, IL; Christopher Ackiss, SARA LEE KNITS, Winston-Salem, NC; Jeff Register, SURRY INDUSTRIES, Pilot Mountain, NC; Mona Quad, ZELLWEGE USTER, Knoxville, TN; Angie Goodman, AGRICULTURE INVESTMENTS MARKETING, Lubbock, TX; Joe Hanslik, HORIZON INTERNATIONAL COTTON CO., Lubbock, TX;

Cade Underwood and Josh Underwood, UNDERWOOD COTTON COMPANY, Lubbock, TX.

Instructors for this session of the school included several International Textile Center and Lubbock Cotton Exchange staff members. Others who shared their expertise included John Abernathy, John Gannaway and Kater Hake, Texas A&M Agricultural Research Station, Lubbock, TX; Roy Baker and Alan Brashears, USDA-ARS, Lubbock, TX; Wendell Wilbanks, Steve Grantham and Terry Kuhlert, USDA-AMS Classing Office, Lubbock; Emerson Tucker and Jane K. Dever, Plains Cotton Growers Cooperative Association, Lubbock, TX;

Visiting lecturers included Ed Hughs, USDA-ARS, Mesilla Park, NM; Joseph J. O'Neill, New York Cotton Exchange, New York, NY; Ed White, Zellweger Uster, Knoxville, TN; Keth Henley, Cotton Outlook, Memphis, TN; Onnie Sumangil, NationsBank, Dallas, TX; A. A. "Tony" Ball, Rieter Corporation, Spartanburg, SC; Terry Townsend, International Cotton Advisory Committee, Washington, DC; and LaRhea Pepper, Cotton Plus, Tahoka, TX.

Ethridge Travels to Egypt and Israel

Dr. Dean Ethridge, director of the ITC, has returned from three weeks of international travel. In Egypt, he worked with the Ministry of Public Enterprises of the Government of Egypt to develop a plan for restructuring, deregulating, and privatizing the public sector textile companies. A visit was also made to Israel, in order to examine new technology for the detection and measurement of stickiness on cotton fibers.

Visitors

Visitors to the International Textile Center during the past three months have included:

- Stephanie Meyer and Bobby A. Smith, Watson Paper Co., Albuquerque, NM;
- El-Sayed Shalaby, Assiut University of Agriculture, Assiut, Egypt;
- Sherif El-Halawany, Cotton Research Institute, Ministry of Agriculture, Cairo, Egypt;
- Hiroko Fay and Yuki Brumley, Katan House Japan, Inc., San Antonio, TX;
- Noboru Ishizaka, Shinko Sangyo Co., Ltd., Osaka, Japan;
- Chie Saitoh, Avanti, Inc., Tokyo, Japan;
- Bobby Dunn, Zellweger Uster, Charlotte, NC;

- Louise Barnett, Portales, NM;
- Alan Russell and Roberto Escarcega, TECMA, El Paso, TX;
- Jose Luis Hernandez, Grupo Industrial Miro, S.A. de C.V., Mexico City, Mexico;
- Luis Sanchez, Textiles Zaga S.A., Mexico City, Mexico;
- Ronald F. Spicer, International Paper Veratec Division, Walpole, MA;
- Dan B. Goetz, Goetz & Sons, Inc., Dallas, TX;
- Duncan Whitehead, Quaker Fabric Corporation, Fall River, MA;
- Edward S. Owen, Reed Chatwood, Inc., Greenville, SC;
- Christine Nielson, Coyuchi, Point Reyes Station, CA;
- Hermann Dörflinger, Ray Hatcher and James Shirrell, Schlafhorst Inc., Charlotte, NC;
- Larry Teague, Motion Control, Dallas, TX;
- Enrique Martinez, Tejidos Imperial, Villa Nueva, Guatemala;
- Eileen Hallman, Simi Valley, CA.

The following groups also visited the ITC recently :

- Thirty-five members of a World War II veteran's group;
- Nine participants in the Elderhostel program conducted by Texas Tech University;
- Sixty students from Idalou High School, Idalou, TX, accompanied by their teacher, Christi Perkins;
- Five Roosevelt High School students, Lubbock, TX, with their teacher, Janet Mims;
- Seven students from Lubbock Christian University home economics department, accompanied by their instructor, Linda Cash;
- Sixteen home economics students from Eastern New Mexico University, Portales, NM, accompanied by their instructor, Merline Olmstead;
- Forty-five members of the San Antonio Farm and Ranch Association, San Antonio, TX;
- Thirty-seven participants in the Texas Agricultural Lifetime Leadership 1994 class, a program sponsored by the Texas Department of Agriculture;
- Seven home economics students from New Castle High School, New Castle, TX, with their sponsor, Kim Stevens;
- Twenty-five members of the Junior League of Lubbock Provisional Class;
- Sixty-five individuals attending the International Organic Cotton Exposition, held in Lubbock.

Notice:

We Will be Closed for the Holidays!

As an auxiliary of Texas Tech University, the International Textile Center, along with the rest of the University, will be closed for the holiday season from December 26, 1994 through January 1, 1995. We will resume our regular hours on January 2, 1995.

We take this opportunity extend to all our friends our most sincere wishes for a Happy Holiday Season.