2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

# MICRO-SPINNING AND SMALL-SCALE SPINNING: A PRELIMINARY ASSESSMENT AND COMPARISON

**John B. Price**
**USDA-ARS**
**Southern Regional Research Center**
**New Orleans, LA**
**William D. Meredith, Jr.**
**USDA-ARS**
**Stoneville, MS**

## Abstract

The development of the micro-spinning test for cotton is briefly reviewed. The changes in procedure and equipment to accommodate the small quantity of cotton are identified. Some relationships between the strengths of yarns produced by micro-spinning and small-scale procedures are examined.

## Brief History of Development of Micro-Spinning

It is reasonable to suppose that textile mills have conducted spinning tests since the birth of the industrial revolution. In such cases, the tests would have been conducted to optimize machine parameters. However, it was not until 1920 that Dr. W. H. Balls described a standard procedure for a spinning test, specifically with the cottonseed breeder in mind. Undoubtedly, the need for a spinning test had roots in the realization that measures of the strength of yarn and a visual assessment of its appearance, were indicators of quality that were superior to the information provided by the limited number of fiber tests that were available at that time.

Balls' test was based on the use of standard industrial machinery. His ideas generated interest, because several research facilities were constructed with the capabilities of performing such spinning tests specifically for breeders. In 1924, the Indian Central Cotton Committee was performing spinning tests at its Technological Laboratory in Bombay, as was the Shirley Institute in Manchester, England. In 1935, the Egyptian Ministry of Agriculture built a spinning mill at Giza to operate in close cooperation with cotton breeders.

All three sites differed in their respective test protocols. Not only were there differences in the number and types of processes, the quantities required also varied. Weights of 10 lb. (4.5 kg), 2.2 lb. (1 kg), and a minimum of 5 lb. (2.2 kg) were stipulated requirements for the tests in Bombay, Giza, and Manchester, respectively. Despite these variations in technique, each research facility was satisfied that the results of their particular test procedure were representative of the combined effect of all fiber properties, measured and unmeasured. This parameter has been variously described as spinning quality, spinning value, and spinning performance. A major component of this parameter was yarn strength.

Researchers in Egypt and India claimed that the results of their spinning studies were useful to the industry. Nine years experience in Egypt demonstrated that yarn strength data from the kilogram test were consistent with the results of evaluations conducted by the spinning industry.

Other than the kilogram test developed by the Egyptians, all of the tests used standard industrial machinery and processes with some adaptation to cater for the reduced quantity of cotton used. For this reason, they may be termed 'small-scale' spinning tests.

While the small-scale spinning test was accepted as a valuable tool, cotton breeders were aware that its value would be greatly increased if the required quantity could be reduced. If the amount of cotton were about 50 grams, then the product of one or two plants could be characterized, allowing the breeder to use spinning test data at least one year earlier in the selection process. Possibly because the protocol of the test used in Egypt did not involve the use of an accepted opening or cleaning machine and the quantity of cotton used was already less than the test methods used in England and India, research work at Giza lead to the establishment of the micro-spinning test in 1939. It was demonstrated that there was a very high correlation (r= 0.998) between strengths of yarn from the 60-gram and the standard kilogram tests. The micro-spinning test was shown to produce slightly weaker yarn but was four-times faster to perform. Consequently, it quickly replaced the kilogram test in evaluations for Egyptian cotton breeders, and was adopted by the Egyptian Ministry of Agriculture as a means of cotton crop control, to eliminate lots with contaminated seed. Tests, such as the kilogram tests and those requiring larger quantities, were relegated to being used for confirmatory purposes only.

By 1941, the Shirley Institute had begun to evaluate cottons with their version of a micro-spinning test that was conducted with machinery constructed by Platt, a major textile machinery manufacturer at that time. Similarly, the Indian Central Cotton Committee's Technological Laboratory began to use its version of the micro-spinning test by 1950 culminating in the award of a patent by 1959.

Both of these test methods appear to have been developed to spin at least two yarns rather than the single yarn number (9.8 tex or Ne 60) spun in the Egyptian test, to cater for the evaluation of lower quality cottons.

Beginning in 1946, the USDA performed spinning tests annually for over forty years. The procedure involved the use of conventional equipment and testing methods, and required 2.3 to 4.5 kg (5 to 10 lb.) of cotton. Two yarn numbers were spun. The protocol was used as a basis for the development of a 450g (one pound) test by 1959, which was soon judged to be too slow. Two years later, a 225 g (one-half pound) test was developed, judged to be the smallest quantity that could be handled using conventional machinery. The reduction in the amount of cotton required the use of a modified skein strength testing procedure. Further work, involving the development of a sliver-to-yarn spinning machine, miniature draw frame and granular card resulted in a procedure for a 50 g test. Other than the replacement of the original spinning machine, it is this equipment that forms the basis of the micro spinning machinery at the Southern Regional Research Center.

In the absence of a readily available measure of fiber strength, the determination and provision of yarn strength was very important for the cotton breeder. Micro-spinning allowed a strength-related parameter to be made readily available for a greater number of cottons earlier in the cotton breeding program. Nevertheless, the act of producing yarn also provided an opportunity to assess the regularity and imperfections of yarns, albeit visually. Since the 1940s, testing equipment has improved. High volume instrument testing of cotton fiber has been introduced and automated. New fiber testing instruments provide distribution data for cotton fibers. Advances in yarn testing have resulted in more detailed information about the tensile and topographical properties.

There has also been a rejuvenation of interest in the micro-spinning process. Recently, studies have been reported at CIRAD, Montpellier, France and the International Textile Center, Lubbock, Texas.

## Comparison of Spinning Procedures

The differences in procedures prompted a number of comparisons between new and old protocols, most of which used small-scale spinning as the reference state, implying, perhaps, that it was considered to be representative of industrial spinning. In particular, there is a detailed comparison of skein strength data in studies conducted in India. Cottons were spun into at least one of four yarn numbers by micro-spinning and by small-scale testing from 4.5kg (10 lb.) samples. The association between the Count Strength Products (CSP) of yarns spun by the two protocols is shown for 30 tex (Ne 20) yarn in Fig. 1. The correlation coefficient for the association is 0.834. The dispersion of the data is fairly wide as indicated by the error coefficient of variation of 5.6%

The results showed that the relationship between the strengths of yarn provided by the two protocols (micro-spinning and small-scale spinning) varies according to the yarn number. Figure 2 shows the regression lines for the four different yarn numbers (42 tex, 30 tex, 20 tex and 15 tex). In general, the coarser yarns had higher strength when spun according to the small-scale protocol, whereas finer yarns were stronger when spun by micro-spinning. Like the data for the 30-tex yarn, the dispersions of the data about the regression lines for each yarn number were quite large, as shown in Figure 3.

On the other hand, a comparison of the strengths of 10-tex (Ne 60) yarns spun by the 60-gram and kilogram tests performed in Egypt yielded a correlation coefficient of 0.998. Although the data were not presented in the report, the high correlation implies a much lower dispersion about the regression equation. This marked difference in association noted in the Egyptian study relative to the Indian study may be attributed largely to the significantly greater number of opening treatments used in the small-scale Indian test protocol. The two Egyptian procedures were very similar in terms of machinery used, merely adjusting lengths of material used and number of spindles to accommodate the difference in quantity.

## Recent Studies by USDA

A set of 36 genetically diverse cottons grown in Stoneville MS, were evaluated by both micro-spinning and small-scale spinning 27-tex (Ne 22) yarn. Again there was considerable difference between procedures in terms of machinery. Micro-spinning was performed at a commercial test laboratory from each of the four replications of cotton that were grown. The replications were combined to form each lot of cotton processed at the Southern Regional Research Center. The average of the mean single yarn tenacity of the four yarns per lot of cotton produced by micro-spinning was compared to the single yarn tenacity of yarn spun according to the small-scale protocol. A graph is shown in Figure 4. The correlation coefficient is 0.939, and the coefficient of variation of error, 4.3%. This is a better result than that obtained for any of the four yarn numbers spun in the Indian studies, although it should be noted that the replications and measurement method for yarn strength differed in the two studies.

In most cases yarn failure involves fiber breakage to a very significant degree. Consequently yarn strength is determined by fiber strength. A graph of yarn tenacity plotted against fiber strength is shown in Figure 5 for yarn spun by both procedures. Yarn spun by the micro-spinning processing route was generally weaker than that spun by the small-scale method. The reason for the disparity may lie in differences between locations other than procedural. However, the dispersion of the points around the respective regression lines shows considerable similarity. In both cases the coefficient of determination was about 78%, although the spread of the data around the regression line for small-scale was greater.

The ranking of the thirty-six cottons on the basis of strength, depended on the definition of the strength parameter used. Discrepancies in rank were most apparent in the middle orders, where the differences in value are small and changes in order can be attributed to errors of measurement. Overall, the ranking given by the strength of yarn produced by micro-spinning was similar to those seen between the rankings of the strengths of three yarns spun in the small-scale test (37, 27 and 20 tex).

## Conclusions

1. Micro-spinning was introduced to provide cotton breeders, as rapidly and expeditiously as possible, with data that bore a close relation with an industrially controlled parameter, particularly yarn strength.
2. Experience with textile industry and seed quality control substantiated the credibility of the test.
3. Testing facilities evolved different procedures for spinning tests, to cater for the type of cotton produced in their respective areas, and the machinery at their disposal.
4. Use of different procedures should be expected to create differences in the quality of yarn spun, particularly when there is a change in the principle or nature of the machinery used in a particular process, e.g. opening.
5. The ranking of cottons in terms of the strength of yarn is quite similar, irrespective of the scale of the spinning test when ring spinning is used.

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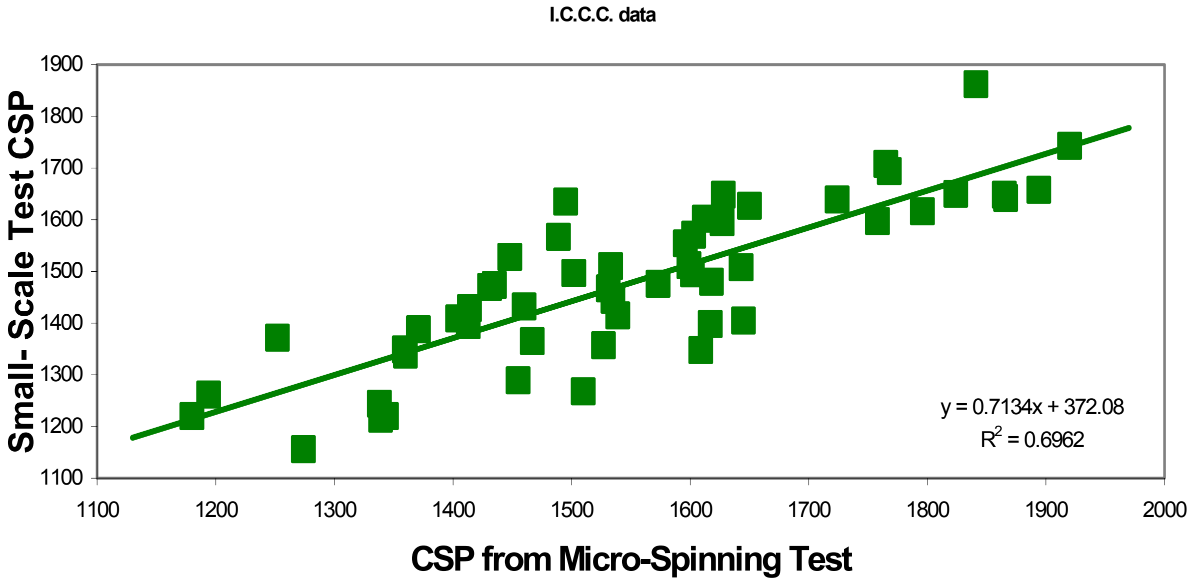


Figure 1. 30 tex Spinning Test Comparison.

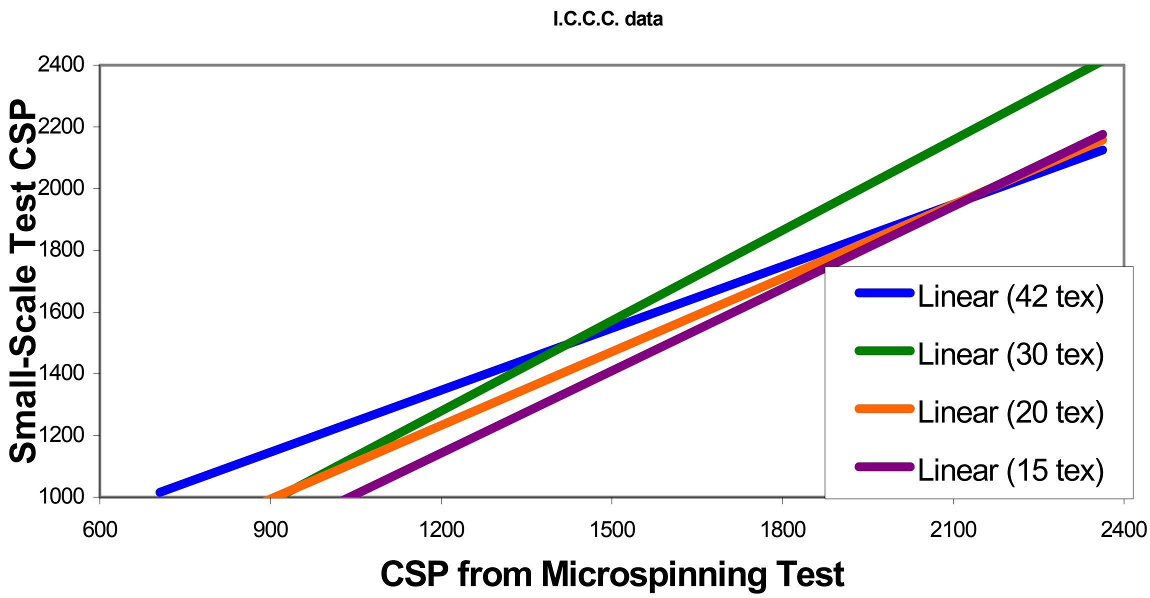


Figure 2. Spinning Data Comparison.

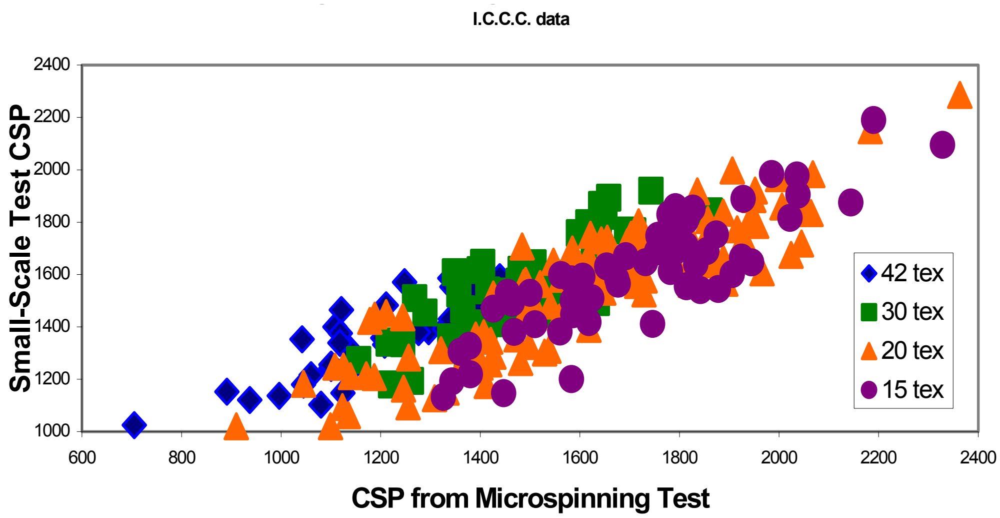


Figure 3. Spinning Data Comparison.

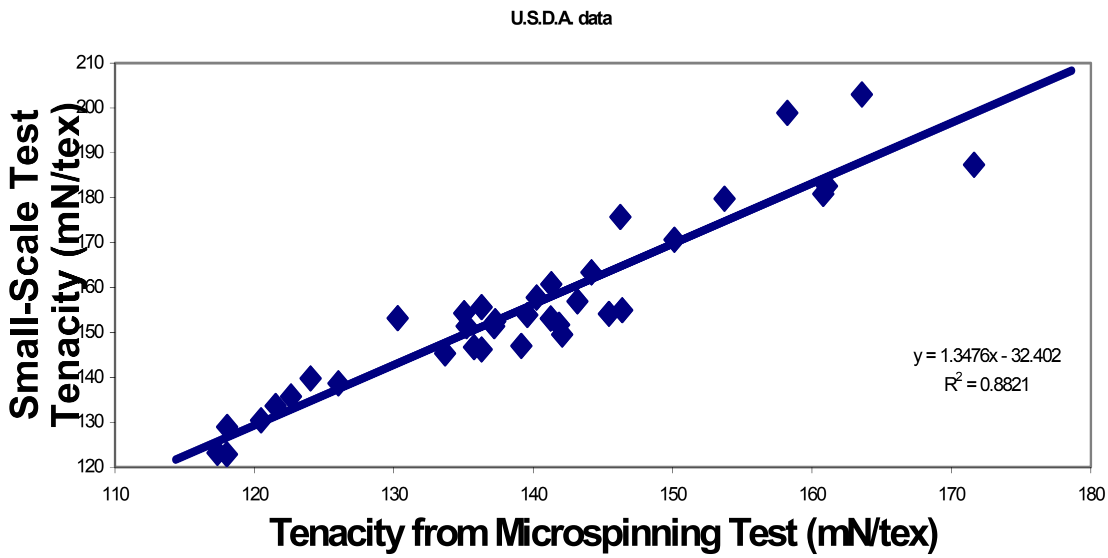


Figure 4. Spinning Data Comparison.

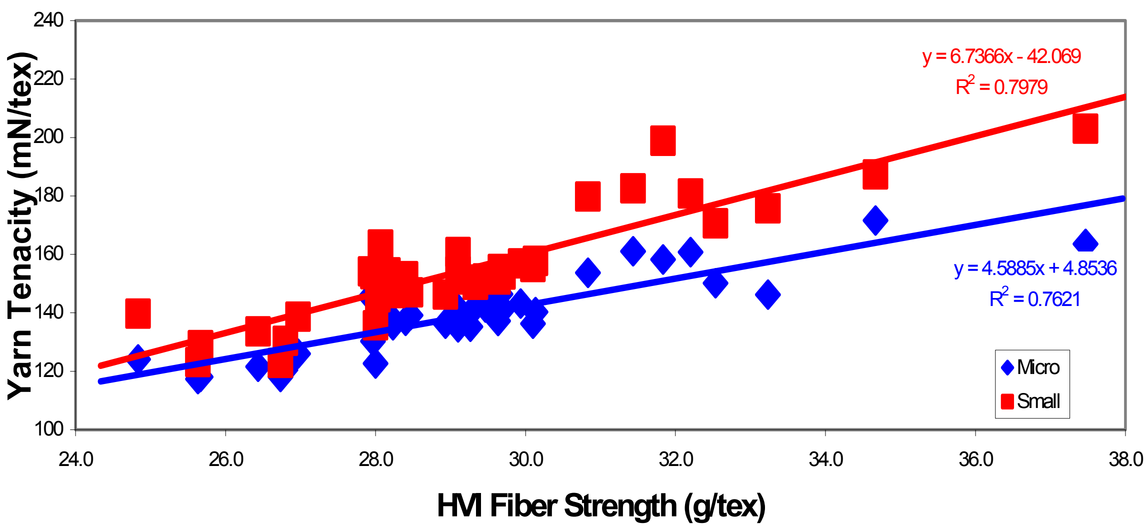


Figure 5. Yarn Tenacity on Fiber Strength.