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FIBER PROPERTY MEASUREMENTS AS AFFECTED BY SAMPLE CONDITIONING SYSTEMS

Andrew G. Jordan, Harrison Ashley, and Dale Thompson
National Cotton Council of America
Memphis, TN

Abstract

The USDA Agricultural Marketing Service is charged with the responsibility of performing cotton quality evaluations of U.S. farmers' cotton. Proper moisture conditioning of fiber samples is essential for accurate machine measurements of length and strength. To maximize timeliness and efficiency to provide quality data to producers, the AMS has employed the use of rapid conditioning technology in many classing offices. The objective of this study was to evaluate the effectiveness of the active rapid conditioning system in comparison with traditional passive systems. Study methodology consisted of two parts. The first was a retrospective study of 1379 commercial gin samples in 1999 of which original classing data were compared with reclass data, assessing if their were consistent concomitant directions of movement of length and strength covariants. The second was a three-year laboratory study comparing length and strength measurements of samples that had been dried excessively and then conditioned under traditional or rapid conditioning methods. All studies showed that accuracy of fiber evaluations utilizing rapid conditioning systems are no different than those employing traditional conditioning systems.

Background

The USDA Agricultural Marketing Service performs a service of classing cotton samples to determine important quality factors for farmers to know the value of their crop. The service provides for fair and orderly marketing. Nearly all cotton produced in the United States is voluntarily submitted to the USDA for classing. Length, strength, Uniformity ratio, color and micronaire are measured by use of high volume instruments (HVI). The USDA charges a user fee to help offset USDA classing costs.

HVI fiber length and strength measurements are generally known to be sensitive to fiber moisture content. One of the first references of the influence of moisture on HVI length and strength was made by Anthony (1982) in which both fiber length measurements and fiber strength measurements increased linearly as fiber moisture increased from 3.7 to 9.4%. The USDA AMS Cotton Division has established standards for sample moisture levels which require cotton fiber moisture to be between 6.75 to 8.25 percent dry basis (Knowlton and Alldredge, 1995). The USDA requires all HVI tests be conducted under the required ASTM standards.

Cotton fiber samples will reach the desired equilibrium moisture content when exposed to ambient air conditions of 70F and 65% relative humidity (standard test conditions). The length of time required to reach equilibrium depends on several factors including relative airflow around and through cotton fiber samples. Two conditioning methods are employed by the USDA—active and passive systems. The active or Rapid Conditioning System (RCU) operates by forcing air of standard test conditions through cotton samples enclosed in a special plenum chamber. Typical time for RCU conditioning is from 5 to 10 minutes. The passive system (Rack) requires cotton samples to be stored in trays or racks in an atmosphere of standard test conditions. Relatively motionless conditioned air allows fibers to reach standard test requirements. Typical time for Rack conditioning is 48 hours. Previous AMS research (Knowlton and Alldredge, 1994) has shown RCU to be as effective as Rack systems. By employing RCU, the timeliness for returning data to producers is improved and employing RCU minimizes fee costs.

Recent declines in quality, especially staple length, raised questions as to potential causative factors. It is commonly believed that changes in varieties and environmental factors are the primary reasons for a decline in staple length and increases in micronaire. Additional factors, which are temporally related to extremely dry harvest/ginning conditions, led some to question the adequacy of the RCU for restoring moisture in excessively dry samples.

The National Cotton Council (NCC) staff was instructed to further investigate whether rapid conditioning systems may indirectly be the cause of short fiber length readings by poor conditioning.

Retrospective Case Study

In early-season, harvesting condition in the Mid-south in 1999 was extremely arid. The dry fall followed a growing season in which cotton plants were subjected to severe heat and drought stresses. The average staple length of the mid-south crop, was unusually short, causing many bales to be discounted for short staple based on official USDA loan schedule. The arid conditions were conducive to a situation that extremely dry cotton samples were delivered to the AMS Memphis Classing Office. Furthermore, later during the harvest season, average quality of some growths improved. The improvement was believed to be related to increase in ambient humidity. Also upon re-testing of discounted bales, the staple length readings for many of the bale samples were higher than the original class. Some believed that the improvements in mid-harvest samples and re-classed staple measurement data were because the atmospheric humidity had increased, allowing for natural sample moisture equilibration. The combination of the factors--short staple, dry early fall, improvement in mid-fall, improvement in retest samples provided reason to test an hypothesis that the RCU did not fully restore moisture to the required levels for testing.

Methods and Rationale

In considering methodology for analysis, two approaches were taken. First a retrospective look at existing original and re-class data and, second, a laboratory experiment designed to test explicitly for effectiveness of the two different conditioning methods. Simple comparison of means was not statistically valid for a retrospective analysis to be legitimate.

It is common knowledge among experts of testing that length and strength are strongly affected by sample moisture; when sample moisture changes, length and strength measurements change accordingly. The fact that length and strength changes are both strongly and positively correlated to moisture changes provides for a robust analysis to determine if improvements in length after retest could have been related to poor moisture in original samples.

Figure 1 and Figure 2 were developed from unpublished AMS data (Robbie Seals, 2002) from studies conducted to quantify the relationships among, moisture, length and strength. Coefficients of determination are 0.98 and 0.99 for length and strength respectively when related to moisture. The slope of the strength/moisture regression line of Figure 1 is nearly three times as steep as the length/moisture line. Such relationship shows that a small change in length, when due to moisture as the hypothesis assumes, will be accompanied by nearly three times the change in strength. Figure 2 demonstrates the close association of length changes with strength changes when caused by moisture changes. In 91 % of all occurrences, both length and strength moved simultaneously and in the same positive direction as sample moisture. The high covariant relationship between length and strength further reinforces the validity of using strength changes as a retrospective proxy for moisture changes.

Data and Analysis

Populations of 1379 samples having both original class data and reclass data from 1999 were made available by a cooperating ginner and producer. Prior to the authors' involvement, the samples had been pre-selected for re-test by the producer because of their original short staple (and possibly other discount factors) causing loan discounts. Examination of data showed a large number of staple length retest measurements were higher than the original tests. Considering the fact that samples were chosen because of their original low value, such increase was not unexpected.

Taking into consideration the hypothesis that length changes on reclass increased because of incomplete conditioning of original samples, strength readings should be expected to increase dramatically with each sample with an increase in length. To test the hypothesis that low moisture content (poor conditioning) of original samples was the cause of short length, it is a necessary condition that concomitant strength increases be demonstrated at a high level.

To evaluate that relationship, net differences between original and reclass length were calculated by subtracting the original measurement value from the reclass value. Data plots of the differences are provided in Figure 3. Data supporting directions of movement are shown in Table 1. Only 46% of the length and strength pairs of the case study moved positively and simultaneously, a level dramatically less than the expected 91%.

Conclusion Case Study

Considering the known robust relationship between moisture and length-strength measurements, there is no retrospective evidence that moisture levels of the original samples were any different than that of the reclass samples.

Laboratory Studies

Three laboratory experiments were designed and conducted on samples from Midsouth gin locations in 2000 and 2001. The objective of this phase of the study was to evaluate if there were difference in HVI values of extremely dry samples when re-conditioned on RCU and Rack methods. The premise was that extremely dry samples would be less responsive to conditioning via the RCU than by the Rack system. A difference in length and strength values would prove a difference in performance of the RCU and Rack system. Likewise, if length and strength values are consistently the same after the two methods of conditioning, it must be assumed that performance of the two systems is equal.

Materials and Methods

Samples in test 1 were obtained from a population of bales known to have short staple lengths. Samples for tests 2 and 3 were selected without regard to any preconceived notion as to fiber quality characteristics. Through additional random selections, 110 samples were selected for test 1, 158 samples for test 2 and 127 samples for test 3. Preparation prior to submitting for fiber measurements consisted of drying samples to 4.5 to 5% moisture content db. Drying was accomplished by storing uncovered samples on shelves in a dedicated room of the National Cotton Council offices of which windows and doors sealed with polyethylene film and tape. Air was kept at a near constant humidity level with a Sears brand dehumidifier. Relative humidity and temperatures were monitored for several days to several weeks, maintaining relative humidity levels at approximately 30% or less and temperature at from 70F to 80F.

Each sample was divided into two subsamples to create sample pairs. Each half of a sample pair was destined to be conditioned either by RCU or Rack system. Fiber quality evaluations would be conducted on each sample pair such that quality data could be compared for each of the original samples. Division was made without removing samples from arid room chamber. Sample pairs were coded, and only the National Cotton Council staff knew the sample identification. Each pair half was sealed in triple layers of polyethylene film bags to assure against moisture gain.

For each test, samples were delivered to the Memphis Classing Office by NCC staff. Upon receipt of the samples, the MCO personnel opened the sample pair halved dedicated for Rack conditioning and placed on racks for conditioning. When Rack sample moisture levels equilibrated to ambient conditions, the pairs dedicated for RCU conditioning were removed from the sealed containers, placed on RCU conditioning trays, run through RCU in normal rapid manner. RCU and Rack conditioned samples were run on parallel HVI lines simultaneously. Halfway though each test run, HVI lines were switched to remove any potential line effect. Half of each subsample population was run on each of two lines, thus blocking to remove HVI line effects. NCC staff observed all tests.

<u>Analysis and Conclusions of Laboratory Studies</u>

Raw HVI data was provided to the National Cotton Council staff. Analysis of Variance (ANOVA) two-factor replications and blocking by HVI line were used to separate means. There were no differences between RCU and Rack means for length, strength, micronaire and length uniformity when tested at the 0.01 level of significance. Means statistics and associated F statistic are reported in tables 2, 3 and 4.

Summary and Conclusions

Exhaustive analysis and laboratory studies reported in this paper support the conclusion that the RCU system is just as effective as the more costly and time consuming Rack method of conditioning. While questions remain as to exactly why some quality factors have declined over the past few years, the influence of genetics and environmental conditions during the growth period for cotton should be more thoroughly studied. Additionally, while the USDA AMS classing offices are well staffed and equipped, prudence dictates that the USDA continue the high levels of quality control, monitoring of classing offices, diligent instrument calibration and machinery maintenance. Finally, increased communications from the classing office management to its stakeholder community of producers and other users of data is recommended. A better understanding of USDA quality check programs and fundamentals of sampling, instrument limitations will lead to high confidence of data and how best to use it in marketing and processing.

References

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Table 1. Comparison of concomitant relationships of length and strength changes between original and reclass test values for 1379 producer samples compared with expected values.

	Number	Actual %	Expected %
Samples for which length and strength changed in positive direction	628	46	91
Samples for which length and strength do not both change in positive direction	751	54	9

Table 2. Anova table for Test 1 (2000) comparing HVI test data of samples conditioned on RCU and Rack methods.

	Treatment Means		
	RCU	RACK	F Statistic
Length (in.)	1.001	1.003	*
Strength (g/tex)	25.3	25.4	*
Micronaire	4.54	4.54	*
Length Uniformity (%)	80.0	80.1	*

ANOVA Blocked by HVI line.
* Treatment means not statistically different at the 0.01 level.
N=110 pairs.

Table 3. Anova table for Test 2 (2001) comparing HVI test data of samples conditioned on RCU and Rack methods.

	Treatment Means		
	RCU	RACK	F Statistic
Length (in.)	1.055	1.056	*
Strength (g/tex)	27.2	27.4	*
Micronaire	4.71	4.72	*
Length Uniformity (%)	81.1	81.1	*

ANOVA Blocked by HVI line.
* Treatment means not statistically different at the 0.01 level.
N=157 pairs.

Table 4. Anova table for Test 3 (2001) comparing HVI test data of samples conditioned on RCU and Rack methods.

	Treatment Means		
	RCU	RACK	F Statistic
Length (in.)	1.068	1.070	*
Strength (g/tex)	27.6	27.3	*
Micronaire	4.6	4.61	*
Length Uniformity (%)	80.9	81.1	*

ANOVA Blocked by HVI line.
* Treatment means not statistically different at the 0.01 level.
N=128 pairs.

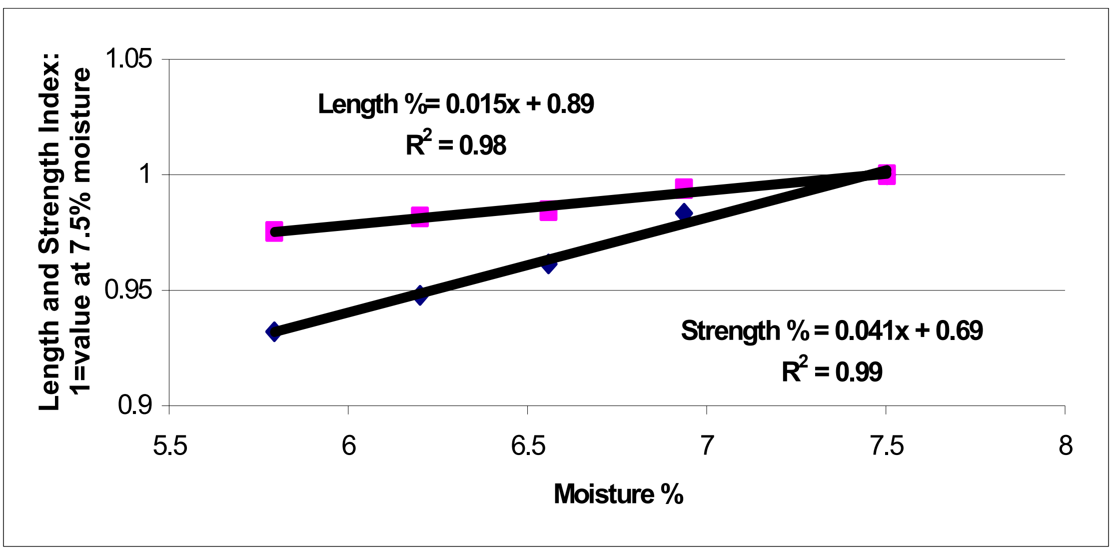

Figure 1. Length and strength response to moisture interpolated from AMS equilibrium moisture studies.

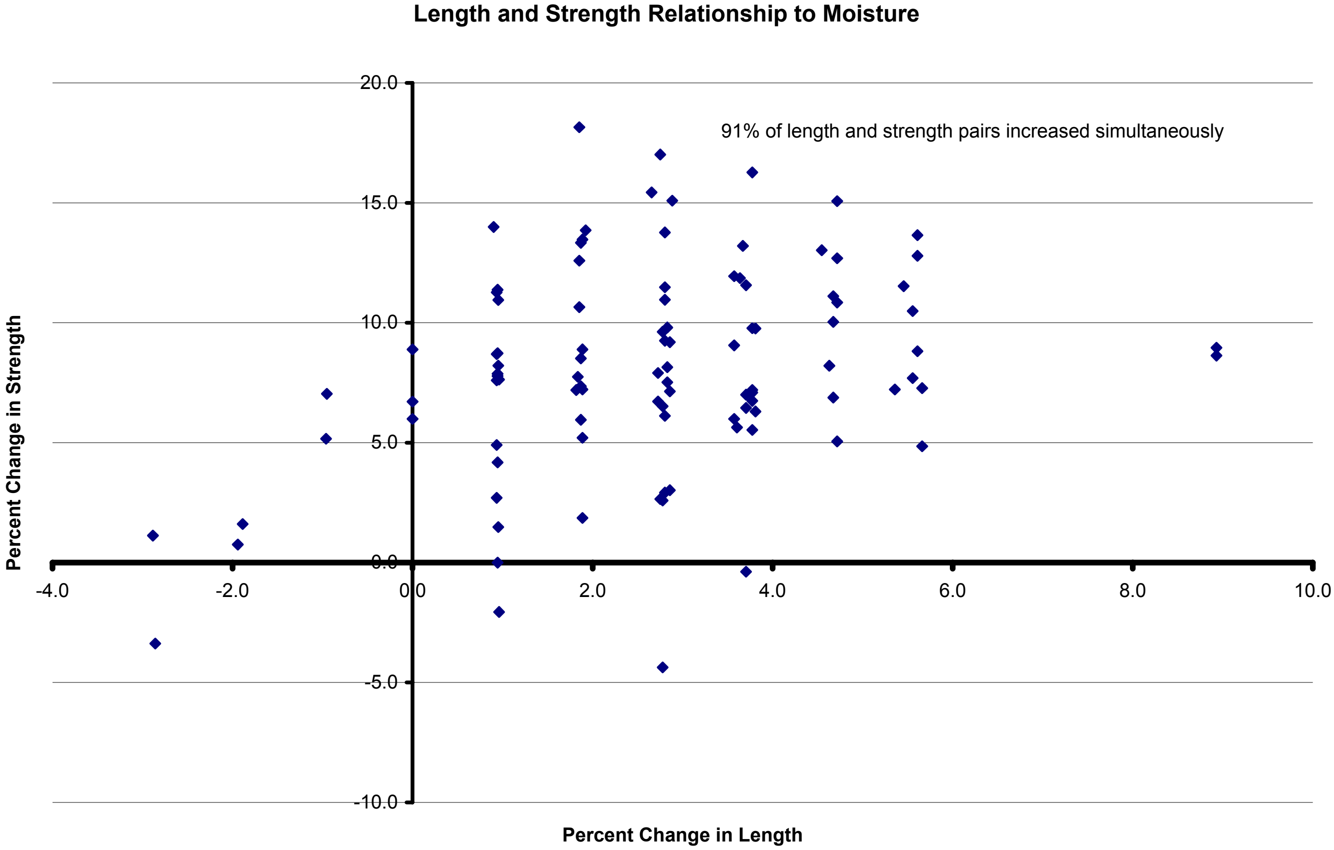

Figure 2. Relationship of direction of movement of length and strength changes with changes in moisture plotted from AMS unpublished data.

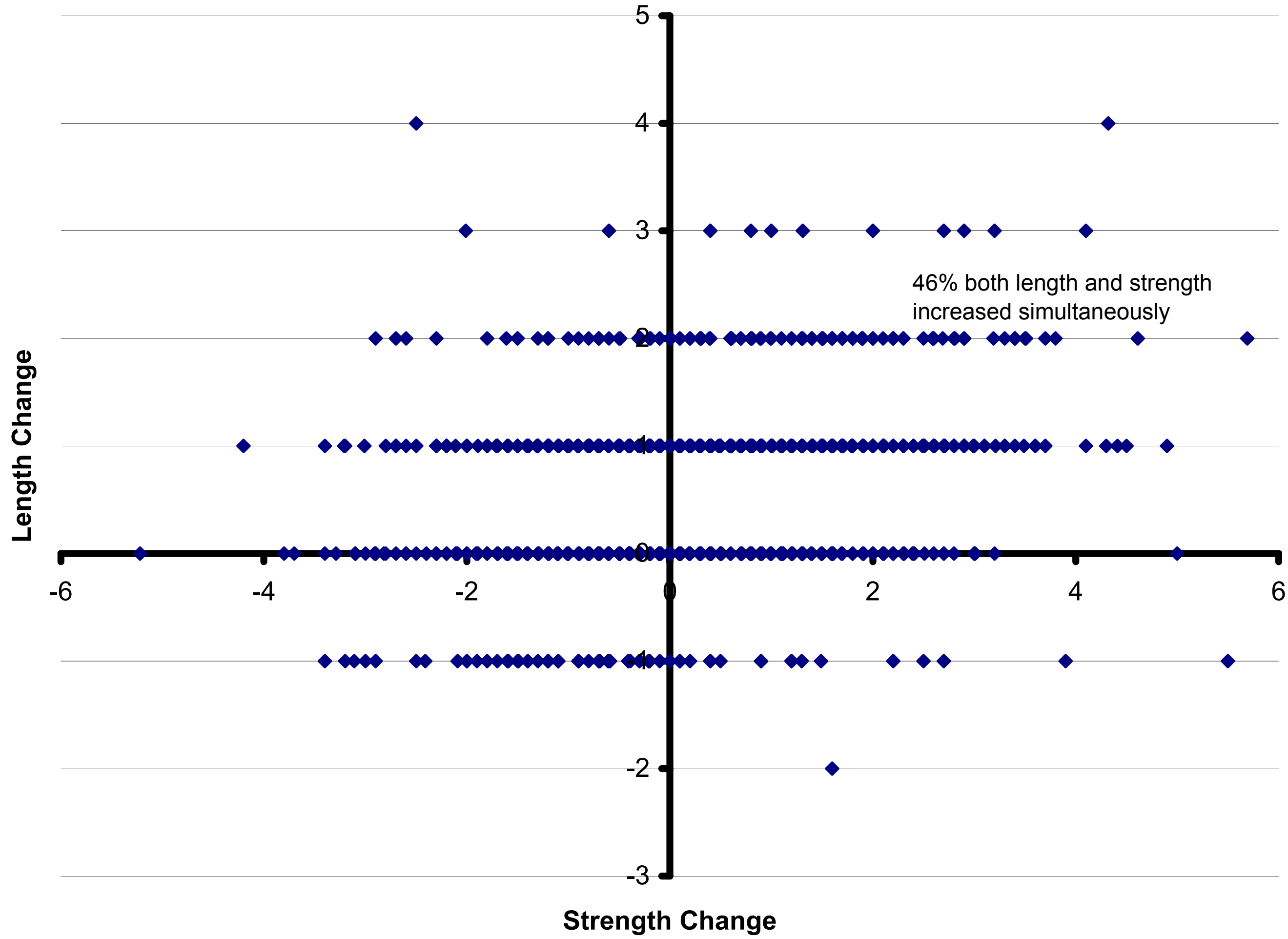

Figure 3. Direction of length/strength changes from original class to reclass—Case study of 1379 sample data pairs.