FIBER MOISTURE CONTENT MEASUREMENTS OF LINT AND SEED COTTON BY A SMALL MICROWAVE INSTRUMENT

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Abstract

The timely and accurate measurement of cotton fiber moisture content is important, as deviations in moisture fiber content can impact the fiber quality and processing of cotton fiber. The Mesdan Aqualab is a small, modular, microwave-based fiber moisture measurement instrument for samples with moderate sample size. Calibrations and operational protocols for the Aqualab were established for both ginned lint and seed cotton. The Aqualab results were compared to the moisture content results obtained from laboratory oven measurements. Very good agreement between the microwave and oven moisture content measurements were observed for both lint and seed cotton.

Introduction

An important cotton fiber quality and processing parameter is the fiber's moisture content (MC). Several studies have shown that fiber MC can impact fiber physical properties, textile processing efficiencies and product quality, and the quality of stored/warehoused fiber. (Anthony, 1982; Fortenberry, 1965; Lawson, 1976; Lord, 1961; McQuigg and Decker, 1961) Several moisture instruments have recently been evaluated for their ability to measure cotton fiber MC, but the primary method for measuring fiber MC is by measuring the original fiber weight loss upon drying the fiber (the "oven method"). (Montalvo and Von Hoven, 2008; Rodgers et.al, 2010) Mesdan S.p.A. (Italy) recently received official recognition by the International Committee on Cotton Testing Methods (ICCTM) for their microwave-based moisture measurement instrument, the Aqualab. The Aqualab rapidly measures the fiber's MC, moisture regain (MR), and commercial weight. In preliminary evaluations, very good MC agreement was observed between the Aqualab and two oven systems—the USDA-Agricultural Research Service (ARS)-Southern Regional Research Center (SRRC) oven and Mesdan Scirocco oven. (Rodgers and Delhom, 2015) The Aqualab MC measurements yielded high analytical precision and minimal weight impacts at weights above 100 grams.

A program was implemented 1) to expand the preliminary evaluations on cotton lint of the Aqualab's potential and capabilities and 2) to determine the capabilities of the Aqualab to rapidly and accurately measure the MC for seed cotton (before ginning). All evaluations were performed at the USDA-ARS-SRRC. The Aqualab MC results for cotton lint and seed cotton were compared to the SRRC oven reference MC method.

Experimental

A set of 20 lint cotton samples from diverse locations (15 domestic and 5 international) and crop production years (2001-2010) were used for the lint portion of this evaluation. All samples were conditioned for 24 hours at 21±1°C/65±2% RH. In addition, four (4) samples were conditioned at low moisture (15±1°C/45±2% RH) and at high moisture (27±1°C/80±2% RH) conditions. Thus, a total of 28 lint sample measurements were obtained. Lint calibrations previously developed were used to measure the MC of the 28 samples (SRRC oven reference method). Reference MC values were obtained with the standard SRRC oven method (5 replicates per sample, 1.5 grams per measurement), in which the lint cotton samples were heated at 105°C for 24 hours. All Aqualab measurements were made at standard conditions (21±1°C/65±2% RH), with a minimum 125 grams placed into the Aqualab.

For the seed cotton preliminary evaluations, seed cotton calibrations were made, using Mesdan recommended calibration procedures for the Aqualab, with 4 seed cotton varieties provided by the USDA-ARS Cotton Ginning Laboratory in Stoneville, MS (2014 crop year). For each variety, measurements were made on samples conditioned at 5 temperature-relative humidity (RH) conditions that represented different water levels in the atmosphere (standard 21±1°C/65±2% RH and low-to-high conditions from 15±1°C/45±2% RH to 27±1°C/80±2% RH). Aqualab sample weight was a minimum of 125 grams. Reference MC values were obtained with a modified SRRC oven method (3 replicates per sample, 20.0 grams per measurement), in which the seed cotton samples were heated at 105°C for 5 hours. For the preliminary comparative seed cotton MC evaluations, a set of 7 diverse domestic cottons

(2014 crop year) were used to evaluate the Aqualab calibrations. The samples were conditioned at 21±1°C/65±2% RH, 15±1°C/45±2% RH, and 27±1°C/80±2% RH. All Aqualab measurements were made at standard conditions (21±1°C/65±2% RH). A total of 21 seed cotton MC measurements were obtained.

The primary comparison statistics were Standard Deviation of Differences, SDD (the standard deviation of the differences in moisture results between the SRRC oven reference method and the Aqualab method for each sample; a residual analysis) and the percentage of samples in which the differences between the SRRC oven reference and Aqualab MC value agreed within both a >±0.30% moisture (tight limit) and the commonly used >±0.50% moisture limit (outlier analysis). Low SDD and >70% of the samples agreeing within the >±0.30% and >±0.50% moisture limits indicated acceptable method agreement for MC between the SRRC oven and Aqualab.

Results and Discussion

Lint Moisture Content Comparisons

Aqualab lint MC measurements were made on 28 diverse lint cotton samples. Very good MC agreement was achieved between the Aqualab and SRRC oven (Table I). A low SDD was obtained, with 75% of the samples within the ±0.30% moisture limit and over 90% of the samples within the ±0.50% moisture limit. Accurate monitoring of both low and high MC samples was observed (from ~4.5-8.5% MC range). The Aqualab MC measurement was very fast, with a total analysis time of less than 1 minute per sample (measurement, data entry, sample loading).

Table I. Moisture Content (MC) cotton lint comparisons, Aqualab MC vs. SRRC oven MC (SRRC oven calibration).

PARAMETER	OVEN MC (%)	AQUALAB MC (%)
AVG	6.38	6.36
SDD (residuals)	NA	0.35
n	28	28
% Within ±0.3%	NA	75%
% Within ±0.5%	NA	93%

Preliminary Seed Cotton Moisture Content Comparisons

Aqualab seed cotton MC measurements were made on 21 diverse seed cotton samples. The seed cottons samples were module samples, and they contained a high trash content (Figure 1). Due to the high trash content and seeds, higher moisture content at standard conditions were expected for the seed cotton samples compared to the lint cotton samples.

Calibrations and operational protocols for seed cotton MC measurements for the Aqualab were developed. Very good and acceptable preliminary MC agreement was achieved between the Aqualab and SRRC oven, with a low SDD and few outliers (Table II). As expected, higher MC was present for the seed cotton samples compared to the lint cotton samples. Over 75% of the samples were within the ±0.30% moisture limit, and over 90% of the samples were within the ±0.50% moisture limit. The SRRC-Aqualab MC results verified the Aqualab seed cotton calibration's capability to accurately monitor large differences in MC (from ~6.0-12.0% MC range).

Figure 1. Seed cotton sample.

Table II. Moisture Content (MC) seed cotton comparisons, Aqualab MC vs. SRRC oven MC (SRRC oven calibration).

PARAMETER	OVEN MC (%)	AQUALAB MC (%)
AVG	7.24	7.14
SDD (residuals)	NA	0.31
n	21	21
% Within ±0.3%	NA	76%
% Within ±0.5%	NA	91%

Summary of Results

A program was implemented 1) to expand the preliminary evaluations on cotton lint of the Aqualab's potential and capabilities and 2) to determine the capabilities of the Aqualab to rapidly and accurately measure the MC for seed cotton (before ginning). Calibrations and operational protocols, with the SRRC oven as the reference method, were developed for seed cotton. The Aqualab MC measurement was fast, accurate, easy to perform, and required no sample preparation. Very good MC agreement was observed between the Mesdan Aqualab and SRRC oven for both the expanded lint and preliminary seed cotton evaluations, with few outliers, at both the ±0.30% and ±0.50% moisture limits. For both lint and seed cotton samples, the SRRC-Aqualab MC results verified the Aqualab lint and seed cotton calibrations' capability to accurately monitor large differences in MC, from low to high MC levels.

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References

Anthony, W., "Response of Fiber Properties to Gin Machinery and Moisture During Ginning as Measured by HVI." Cotton Gin and Oil Mill Press, Vol 83 (Nov 27), pp. 16-20 (1982).

Fortenberry, W. The American Cotton Handbook, 3rd Edition, D. Hamby, ed. Interscience Publishers, Inc. New York, 1965.

Lawson, R., et. al., "Cotton Fiber Tenacity and Elongation in Rapidly Changing Environments." Textile Research Journal, Vol. 46 (10), pp. 715-719 (1976).

Lord, E., "The Characteristics of Raw Cotton." Manual of Cotton Spinning, Vol II, Part I, Butterworths, London, 1961.

McQuigg, J., and Decker, W., "Humidity and Cotton Harvesting in the Missouri Delta." Agricultural Experiment Station Bulletin 776. University of Missouri, Columbia, MO, 1961.

Montalvo, J, and Von Hoven, T., "Review of Standard Test Methods for Moisture in Lint Cotton." Journal of Cotton Science, Vol 12, pp. 33-47 (2008).

Rodgers, J., Delhom, C., Montalvo, J., Thibodeaux, D., and Cui, X. "Cotton Fiber Moisture Measurement—From the Bale to the Laboratory." *In* Proceedings of the 30th International Cotton Conference, Bremen, Germany, pp. 190-198 (2010).

Rodgers, J., and Delhom, C. "Comparative Fiber Evaluation of the Mesdan Aqualab Microwave Moisture Measurement Instrument." *In* Proceedings of the 2015 National Cotton Council Beltwide Cotton Conference, New Orleans, LA, pp. 63-67 (2015).