Cotton Testing Standardization and Interlaboratory Harmonization

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19th Meeting of the CSITC Task Force
Raleigh, NC, USA, June 19, 2013
Standardization / Harmonization

- Aim of Cotton Testing Standardization / Harmonization
  - Laboratories all over the world should, for the same cotton samples, come to “the same“ test results (not exceeding unavoidable tolerances)
  - Test results have to be a reliable, objective estimate of the quality of the cotton samples
    - For production (breeding, growing, ginning): Improve, obtain better price
    - For trading in global markets
    - For processing: economic production: produce suitable yarn quality on lowest input
CSITC Task Force

• ICAC Task Force for the Commercial Standardization of Instrument Testing of Cotton (CSITC Task Force)
• Formed in December 2003; Chairman: Andrew Macdonald
• Objective: Introduction of a *worldwide* acceptable, adoptable and reliable instrument based cotton quality assessment, finally replacing manual classing as basis for trading
  – with defined test rules and operating practices
  – based on reliable instrument test results
  – based on a worldwide cotton testing laboratory evaluation system
• Several related activities implemented by the Task Force / its members through the last years
Standardization / Harmonization

• Steps for Standardization / Harmonization
  – Standardization
    • Standardized test and calibration procedures
    • Approved, valid cotton calibration material
  – Harmonization
    • Suitable laboratory quality management (*)
    • Guideline for standardized instrument testing (*)
  – Verification
    • Instrument qualification
    • Within-lab verification
    • Interlaboratory Round Trials (**) 
    • Re-tests (*)
Several factors are determining the reliability of the test data

**Guideline for Standardized Instrument Testing of Cotton**

- Detailed elaboration (44 pages) plus short version reduced to the most important prerequisites
- Covering all topics from the laboratory building to the data handling
- Editors: Axel Drieling (FIBRE), Jean-Paul Gourlot (CIRAD, France), James Knowlton (USDA-AMS)
- Contributions from 12 contributors from all continents
- Replaces given ITMF and USDA User Guides
- Published in English, French, Chinese, Spanish, Portuguese, Russian
- Available for free on CSITC and ICAC and ITMF websites

Reports on proper climate control, conditioning, power supply …
Guideline for Standardized Instrument Testing of Cotton

ICAC Task Force on Commercial Standardization of Instrument Testing of Cotton (CSITC) and ITMF International Committee on Cotton Testing Methods (ICCTM)

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- www.icac.org
- www.itmf.org

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Version: LONG
Verification: Round Trials

• How do laboratories know that they are producing results that are comparable to results from other labs?
• How do labs know that they have to improve their performance in order to comply with other labs?
• How do labs know where they have to improve in testing?
• How can labs prove that their results are more reliable than those of other labs?

→ Participate in Round Trials !
# Round Trials in Comparison

<table>
<thead>
<tr>
<th>Attribute</th>
<th>USDA HVI Checktest</th>
<th>ICA Bremen Round Trial</th>
<th>CSITC Round Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realization</td>
<td>USDA-AMS</td>
<td>FIBRE</td>
<td><strong>FIBRE and USDA-AMS, Headed by ICAC</strong></td>
</tr>
<tr>
<td>Number of participants</td>
<td>50 to 80 HV instr.</td>
<td>110 to 150 HV instr.</td>
<td>125 registered labs (2013)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>112-160 HV instr. (2012)</td>
</tr>
<tr>
<td>Kinds of instruments</td>
<td>Restricted to High Vol. Testing</td>
<td>Every kind of Testing instrument</td>
<td>Restricted to High Volume Testing</td>
</tr>
<tr>
<td>Cottons: Origin and type</td>
<td>USA; Upland</td>
<td>World; broad range of properties</td>
<td>4 US Upland; (plus 1 other origin or processing if demanded)</td>
</tr>
<tr>
<td>Costs</td>
<td>Annual fee</td>
<td>Free of charge</td>
<td>Annual fee: 2013: 1000 USD</td>
</tr>
<tr>
<td>Frequency</td>
<td>12 times/year each 2 samples</td>
<td>3 times/year each 1 sample</td>
<td>4 times/year each 4 / 5 samples</td>
</tr>
<tr>
<td>Number of tests per sample</td>
<td>Asked for 12 tests per sample</td>
<td>Proposed: 6 tests per sample</td>
<td>30 tests per sample (fixed)</td>
</tr>
</tbody>
</table>
# Round Trials in Comparison

<table>
<thead>
<tr>
<th>Attribute</th>
<th>USDA HVI Checktest</th>
<th>Bremen Round Trial</th>
<th>CSITC Round Trial</th>
</tr>
</thead>
</table>
| Aim                  | Information for the laboratory | Information for the laboratory | a) Official laboratory evaluation  
|                      |                    |                    | b) detailed analysis for the laboratory |
| Evaluation of        | Laboratory average | Laboratory average | Laboratory average and all single data |
| Evaluation of        | Accuracy only      | Accuracy only      | Accuracy and precision |
| Additional benefit   |                    |                    | Calibration Material delivered with the RT samples |
CSITC Round Trials

Aims

1. Evaluation of the test methods / test result variation → Improvement
   - Within-instrument variation
   - Inter-instrument variation
   - Possible additions as the variations between instrument types etc.

2. Rating of the participating laboratories, based on the accuracy of the results

3. Detailed analysis of laboratory results to achieve more accurate results, based on accuracy and precision
CSITC Round Trial Participation

Participants in the CSITC Round Trials

Number of participants

CSITC Round Trial
- Participating Instruments
- Participating Labs
## CSITC Round Trial Participation

**Registered participant laboratories 2013**

- Asia: 48
- South America: 25
- North America: 19
- Africa: 17
- Europe: 12
- Australia: 4

**Countries with highest no. of registered labs**

- Brazil, India, USA, Uzbekistan

**Types of Labs 2013**

- Production/Assoc.: 40 %
- Control: 14 %
- Spinning: 9 %
- Research / Manuf.: 15 %
- Others / not specified: 22 %

Currently CSITC is focused on Cotton production, Participation from spinners‘ side is limited
## Performance of Laboratory 115

<table>
<thead>
<tr>
<th></th>
<th>Micronaire</th>
<th>Strength</th>
<th>Length</th>
<th>Uniformity</th>
<th>Color Rd</th>
<th>Color +b</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton 1</td>
<td>3,83</td>
<td>32,82</td>
<td>1,207</td>
<td>82,42</td>
<td>76,31</td>
<td>12,14</td>
</tr>
<tr>
<td>Cotton 2</td>
<td>5,17</td>
<td>28,22</td>
<td>1,136</td>
<td>81,90</td>
<td>78,06</td>
<td>11,53</td>
</tr>
<tr>
<td>Cotton 3</td>
<td>4,40</td>
<td>25,54</td>
<td>0,948</td>
<td>78,53</td>
<td>74,86</td>
<td>10,86</td>
</tr>
<tr>
<td>Cotton 4</td>
<td>3,81</td>
<td>32,89</td>
<td>1,177</td>
<td>83,65</td>
<td>76,08</td>
<td>10,98</td>
</tr>
<tr>
<td><strong>Laboratory Average of All Days</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton 1</td>
<td>3,80</td>
<td>33,62</td>
<td>1,207</td>
<td>82,71</td>
<td>75,37</td>
<td>11,38</td>
</tr>
<tr>
<td>Cotton 2</td>
<td>5,23</td>
<td>28,50</td>
<td>1,134</td>
<td>81,44</td>
<td>76,05</td>
<td>10,82</td>
</tr>
<tr>
<td>Cotton 3</td>
<td>4,36</td>
<td>26,11</td>
<td>0,969</td>
<td>76,13</td>
<td>73,62</td>
<td>10,41</td>
</tr>
<tr>
<td>Cotton 4</td>
<td>3,79</td>
<td>32,72</td>
<td>1,182</td>
<td>83,83</td>
<td>75,29</td>
<td>10,17</td>
</tr>
<tr>
<td><strong>Rel. Distance to Reference</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton 1</td>
<td>-0,03</td>
<td>0,80</td>
<td>0,000</td>
<td>0,29</td>
<td>-0,94</td>
<td>-0,76</td>
</tr>
<tr>
<td>Cotton 2</td>
<td>0,06</td>
<td>0,28</td>
<td>-0,003</td>
<td>-0,46</td>
<td>-2,00</td>
<td>-0,71</td>
</tr>
<tr>
<td>Cotton 3</td>
<td>-0,04</td>
<td>0,57</td>
<td>0,021</td>
<td>-2,40</td>
<td>-1,24</td>
<td>-0,45</td>
</tr>
<tr>
<td>Cotton 4</td>
<td>-0,02</td>
<td>-0,18</td>
<td>0,005</td>
<td>0,18</td>
<td>-0,79</td>
<td>-0,81</td>
</tr>
<tr>
<td><strong>Mean Absolute Distance to Reference</strong></td>
<td>0,04</td>
<td>0,46</td>
<td>0,007</td>
<td>0,83</td>
<td>1,24</td>
<td>0,68</td>
</tr>
<tr>
<td><strong>Scale Factor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Based on USDA Reproducibility Limits except Rd)</td>
<td>0,10</td>
<td>1,50</td>
<td>0,02</td>
<td>1,00</td>
<td>1,50</td>
<td>0,50</td>
</tr>
<tr>
<td><strong>Summary Evaluation for Each Property</strong></td>
<td>0,38</td>
<td>0,31</td>
<td>0,36</td>
<td>0,83</td>
<td>0,83</td>
<td>1,37</td>
</tr>
<tr>
<td>(=Mean Abs. Distance divided by Scale Factor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relevance of Property</strong></td>
<td>1,00</td>
<td>1,00</td>
<td>1,00</td>
<td>1,00</td>
<td>1,00</td>
<td>1,00</td>
</tr>
<tr>
<td><strong>Summary Evaluation of All Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(=Average of all properties)</td>
<td>0,68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CSITC Round Trials: Laboratory Evaluation (Combined Properties)

Evaluation Results
- Combined Properties -

Best performance → ... → ... Worst performance

Typical median: 0.44 to 0.55:
50% of all labs show an evaluation result lower = better than 0.5
CSITC Round Trials: Laboratory Evaluation (Combined Properties)

Evaluation
Combined Prop.

Obvious reason:
Introduction of additional labs with specific problems

Reason:
Improvements at all participating labs

Year
CSITC Round Trials: Detailed Analysis for Each Instrument

![Graph showing deviation from reference value for cotton length analysis.](image)

- **Cotton 1-4**
- **Single Days**
- **Cotton 5**
- **Trend (Cotton 1-4)**

\[ R^2 = 0.9803 \]
CSITC-RT: Interlab SD for Micronaire

Cotton Sample (from RT 2007-1-1 to 2013)
CSITC-RT: Interlab SD for Strength

Cotton Sample (from RT 2007-1-1 to 2013)
CSITC-RT: SDs and Comm. Trade Limits

All results are based on 104 cottons from 2007-1 to 2013-2
Restricted to US Upland
Average: 102 High Volume Instruments per Round Trial
Each instrument with 30 tests for each sample

<table>
<thead>
<tr>
<th>Property / Parameter</th>
<th>SD inter-instrument (30)</th>
<th>SD inter-instrument (1)</th>
<th>Proposal for Commercial Trade Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronaire</td>
<td>0.071</td>
<td>0.086</td>
<td>2<em>SD(1)? 2</em>SQRRT(2)*SD(1)?</td>
</tr>
<tr>
<td>Strength, g/tex</td>
<td>1.00</td>
<td>1.25</td>
<td>2?</td>
</tr>
<tr>
<td>UHML, Inches</td>
<td>0.012</td>
<td>0.017</td>
<td>0.03?</td>
</tr>
<tr>
<td>Uniformity Index</td>
<td>0.53</td>
<td>0.81</td>
<td>2?</td>
</tr>
<tr>
<td>Color Rd</td>
<td>1.03</td>
<td>1.09</td>
<td>1.5?</td>
</tr>
<tr>
<td>Color +b</td>
<td>0.36</td>
<td>0.41</td>
<td>1?</td>
</tr>
</tbody>
</table>
CSITC Round Trials: Currently Achievable Improvements

How far will the SD be improved by only choosing the better 50%* of the laboratories?

<table>
<thead>
<tr>
<th>Property / Parameter</th>
<th>All laboratories</th>
<th>50%* best laboratories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronaire</td>
<td>0.092</td>
<td>0.074</td>
</tr>
<tr>
<td>Strength, g/tex</td>
<td>1.40</td>
<td>1.13</td>
</tr>
<tr>
<td>UHML, Inches</td>
<td>0.0171</td>
<td>0.0137</td>
</tr>
<tr>
<td>Uniformity Index</td>
<td>0.81</td>
<td>0.68</td>
</tr>
<tr>
<td>Color Rd</td>
<td>1.03</td>
<td>0.80</td>
</tr>
<tr>
<td>Color +b</td>
<td>0.38</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Possible reduction of SD interlab: approx. 20% for each property

Data based on CSITC RT 2007-1 to 2008-2 (24 cotton samples)

* 50% of the best labs were chosen based on their overall RT Evaluation in each RT
Verification: Re-Tests

• How does the laboratory know and prove that the results measured every day are meaningful / true?

→ External RE-TESTS ON DAILY SAMPLES
  – Send a fixed subset of the samples tested in one laboratory to another for a second, more intense test

• Given at USDA with reproducibility check
• In other countries perhaps not possible on over-night basis, but still extremely useful
Verification: Re-Tests

![Bar Chart]

**Strength**

- **Frequency**: 0, 1, 2, 3, 4, 5, 6, 7
- **Difference from reference (x = g/tex)**: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0
- **Legend**: Red, Green, Blue

The chart displays the frequency of different differences from the reference value in g/tex.
Support: Regional Technical Centers

• Laboratories need support
  – Information / trainings / expertise
  – Reference
    • Re-tests
    • Regional Round Trials on cottons from the region
  – Central (national / regional) cotton result data base, including result verification

• Central Quality Management Structure in US given with USDA-AMS
• Central Quality Management Structure given e.g. in Australia, Uzbekistan, and under construction in Brazil (ABRAPA)
• Regional Technical Centers for lab support installed in Africa (Mali, Tanzania) based on CFC/EU project
Next Step: Adaption of Instrument Testing to Other Origins

- The standard test method was developed basing on experience for US Upland
- The CSITC RT is based on USDA Upland cotton bales to assure homogenous bales
- Cotton from other origins may show different variation between test results
  - Based on field size
  - Based on mix of varieties
  - Based on the type of gin (saw / roller)
  - Based on gin management
- With this, different number of samples / tests per samples might be necessary
Variability Study for African Cotton

Realized by J.P. Gourlot, CIRAD, with Modest Aboe (Benin) and Everina Lukonge (Tanzania)

Cotton production analyzed
- in 14 African countries (West/Central and East/Southern Africa)
- 63 gins
- 2 crop seasons
Variability Study for African Cotton

- Based on pre-defined litigation risks and defined criteria
- Suitable numbers of samples per bale and of tests per sample analyzed

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Nb of samples per bale</th>
<th>Type of sampling</th>
<th>Nb of replicates</th>
<th>Nb of measurements per sample</th>
<th>Total Nb of measurements per bale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micronaire</td>
<td>2</td>
<td>Composite</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>UHML</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>UI</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>STR</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Rd</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>+b</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Proposition for Africa for saw-ginned cottons

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Nb of samples per bale</th>
<th>Type of sampling</th>
<th>Nb of replicates</th>
<th>Nb of measurements per sample</th>
<th>Total Nb of measurements per bale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micronaire</td>
<td>2</td>
<td>Composite</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>UHML</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>UI</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>STR</td>
<td>2</td>
<td>Cluster</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Rd</td>
<td>2</td>
<td>Composite</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>+b</td>
<td>2</td>
<td>Composite</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Trade Rules

- Trade rules are still very much defined based on manual classing
- For trading based on instrument test results, many details have to be regarded
  - Use of instrument results without transformation to manual classing grades / staples
  - Which control limits have to be applied
  - Which number of digits / rounding have to be applied
  - Combined interpretation of results (Color Rd and +b)
  - Trading based on sales lot result averages and variations (SD)
- Relying solely on laboratories with suitable quality management – and proven performance (in CSITC Round Trials)
With the given steps, it will hopefully be possible to continue the way towards trading based on reliable instrument test results, and with this improving cotton competitiveness in global markets.

All project partners like to express their thank the financial contributors CFC and EU, who made these activities possible as part of the CFC/ICAC/33 project.