WITHIN-BALE VARIABILITY STUDY ON COTTON PRODUCED IN AFRICA

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ABSTRACT

Most of the cotton bales produced in the world are sold according to the analysis of their technological characteristics using standardized instrument for testing cotton (SITC). In the United States of America, periodical studies of the results variability allow to accompany the results with commercial tolerances in order to limit the frequency of claims. In Africa, no such study was conducted to our knowledge. Therefore, we studied the within-bale variability of fiber length and of its uniformity, of fiber strength, of micronaire, of reflectance and of yellowness. We took 8 samples per bale within over 400 cotton bales produced in 13 African countries during two crop seasons. Our representative sample is then composed of over 3200 fiber samples which were analyzed in controlled conditions by SITC in a laboratory fully respecting the international recommendations. We then achieved an estimation of the within-bale variability of cotton fiber technological characteristics in most of the African cotton producing countries.

Key words: cotton, fiber, within-bale variability, sampling, testing, repeatability, classification

INTRODUCTION

Standardized Instruments for Testing Cotton (SITC) are instruments used for cotton classification and trading. SITC were first designed for the United States of America (USA), where they have been used since 1991 for commercial purposes. They are now used on 50% [1] of the cotton traded in the world, either in addition or instead of the manual and visual classing [2]. These instruments test samples (around 200 grams) taken out from every cotton bale (around 228 kg) which is produced.

However, as the existing testing methods and equipments may not suit to all cotton producing countries, the potential risk is that complaints and/or litigations may be issued between some cotton companies from Africa and their customers. Conditions of production in the USA are quite different from the ones in Africa. In consequence, we can assume that the levels of heterogeneities of the raw material, of the sampling and of the testing results at least may vary from place to place. It is then required to study the variability of six cotton fiber technological characteristics recommended by the CSITC Task Force [1] which are: Micronaire (Mic), Length (UHML), length Uniformity (UI), Strength (STR), color Reflectance (Rd) and color Yellowness (Xb).

Meanwhile, SITC methods have to fit both the needs of African producers and the agreed worldwide expectations in terms of reliability, of precision and of trueness of the results. Therefore, in the frame of CFC/ICAC/33 Project, we ran experimentations to answer the following question: What is the level of variability of the fiber technological characteristics as measured by SITC within the bales produced in African countries?

MATERIAL AND METHODS

To study the within-bale variability, we assumed the hypothesis that the within-bale variability can be predicted as a function of the production and ginning conditions. If the within-bale distribution is Gaussian, checking this hypothesis requires categorizing the sources of the within-bale variance.

To insure a good measurement of the within-bale variability, the experiments were conducted during the two season crops 2008-2009 (crop season 1) and 2009-2010 (crop season 2).

Taking care of the large number of the ginning mills in Africa, we randomly chose two to three « situations » (ginning plants and of their supply area in seed-cotton) according to their list of equipments (saw or roller gin, presence or absence of lint-

cleaners) among a list of all recorded existing situations in thirteen African countries.
In each situation, a total of 10 bales were sampled in crop season 1 and limited to 5 bales in crop season 2 for technical and financial reasons. Eight samples were taken per bale from 8 different layers. Altogether, over 3200 samples were taken and analyzed in Regional Technical Centers laboratories using their equipments (HVI M1000) [1].

PLANNED MODE OF EXPLORATION OF THE DATA

The model for exploring the acquired results was the following: result = (bale fixed effect) + (layer in the bale random effect) + (replicate or measurement effect random effect) +block effect [3, 4]. This model is written:

$$Y_{i,j,k} = m_i + A_{i,j} + B_{i,k} + E_{i,j,k} \qquad (1)$$

Where:

Y is the response variable
m_i is the mean of the bale i
A is the random effect of the layer j in the bale $i \sim N(0, \sigma_A^2)$

$B_{i,k}$ is the effect of the block k in the bale i
$E_{i,j,k}$ is the measurement error of the replicate k of the layer j of the bale i, $\sim N(0, \sigma_E^2)$, independent from A
i is 1...I bales
j is 1...J layers in the bale
k is 1...K replicates in each layer.
The two retained random effects retained as variability sources (A and E) are supposed independent:

- σ_A^2 is the variance of the random layer effect,
- σ_E^2 is the variance of the residual effect.

This model is a mixed linear model where the classical maximization method of the restricted likelihood ratio allows estimation of the variances of the layer effect and of the measurement error [5].
From the estimation of the standard deviations σ_A and σ_E, the variance of the error of estimation of the bale mean can be deduced for any sample made up of J' layers, each being measured K' times:

$$\sigma_M^2 = \frac{\sigma_A^2}{J'} + \frac{\sigma_E^2}{J'K'}$$

(2)
If one decides to mix cotton fibers from J' layers to analyze them all together with N' replicates, the sampling variance becomes:

$$\sigma_M^2 = \frac{\sigma_A^2}{J'} + \frac{\sigma_E^2}{N'}$$

(3)
Our objective is to avoid exceeding a 10% litigation risk on individual bales and to fulfill the usual commercial tolerances listed in Table I.

Table I. Tolerances used for calculation of the litigation risk [6]

Characteristic	Commercial tolerances
UHML	+/- 0.508 mm
UI	+/- 1 %
Strength	+/- 1.5 cN/tex
Micronaire	+/- 0.1 unit
Rd	+/- 1 %
X.b (Yellowness)	+/- 0.5 unit

Each situation will be represented by one point in the scatter plot 'Standard deviations between layers (SigmaA) vs. within layer (SigmaE)'(see Figure 1). According to the position of each point, we will then be able to deduce which is/are the best sampling and/or best testing procedure(s) required to fit both the agreed litigation risk and the international tolerances for trading.

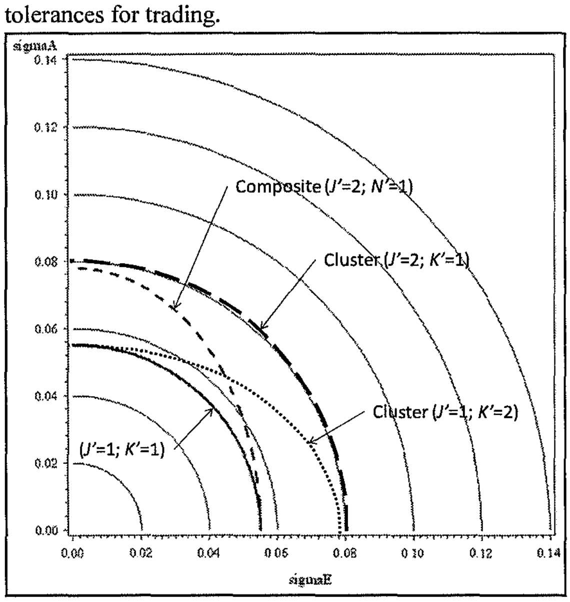

FIGURE 1. Relationship linking the standard deviation between layers (SigmaA) vs within layer standard deviation (SigmaE).

Bales from the gin plants within the bold circle will show less than 10% litigation risk with 1 layer sampled and 1 replicate of measurement. Bales from the ginning plants within the doted circle will show less than 10% litigation risk with *J'* layers sampled and *K'* replicate of measurement.

CONCLUSION

The exploration of the within-bale variance of the cotton technological characteristics as measured by SITC is possible with the help of a mixed-model; it will allow the calculation of the most important variance components which are the random effects of the layer within the bale and the replicate of testing effect. According to their respective importance, it will be possible to issue recommendations in practical terms for every day classification of cotton.
This work is currently presented to Textile Research Journal for Peer Review before a probable edition in a coming issue.

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DISCLAIMER

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