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EVALUATION OF LABORATORY-SCALE SPINNING AS A PROSPECTIVE TOOL FOR COTTON BREEDERS AND BIOTECHNOLOGISTS

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Abstract

The feasibility of using micro-spinning methodology to predict the industrial potential of cotton samples is examined. Correlations between micro-spun and industrial yarn tensile properties are highly significant which indicates that the micro-spinning methodology, as is, may offer an adequate performance-ranking for tensile properties.

This was not the case when considering other critical yarn quality parameters, i.e., evenness characteristics. In particular, due to the cleaning deficiencies of the mini-card (resulting in a higher amount and size of seed coat fragments and trash particles), the relationship between micro-spun and industrial yarn neps shows a substantial dispersion, with higher count differences for higher mass variation thresholds. A pre-cleaning protocol appears necessary to compensate for these deficiencies, in order to allow proper ranking of samples originating from breeding programs.

Introduction

Micro-spinning methodology allows production of yarn from limited quantities of ginned cotton. Typically, samples of approximately 50 g of fiber are processed through a mini-card and a miniature draw frame to produce a sliver of approximately 2.5 ktex (35 grains/yard). The sliver is then spun on a high-draft spinning frame to produce the desired yarn (Frydrych and Dréan, 2000; Krifa and Ethridge, 2003).

The use of micro-spinning and small-scale spinning for cotton breeding and process optimization has been a common practice for many decades (Frydrych and Dréan, 2000; Price and Meredith, 2004). Resort to such spinning tests and to measurement of yarn characteristics offers the advantage of expressing the interactions between all fiber properties, thus characterizing a cotton sample by its end-product quality potential.

Previous work conducted on the micro-spinning system showed highly significant correlations between micro-spun and industrial-scale yarn quality when considering yarn strength, elongation and hairiness (Krifa and Ethridge, 2003). Significant, but lower correlations with more dispersed regressions were obtained for evenness parameters, particularly yarn defects (neps, thick places). Globally, the micro-spinning system appeared to offer an adequate performance-ranking tool on strength parameters but not on yarn evenness properties. This was mainly due to the elevated number of defects, and therefore the high variability in evenness parameters, observed on the micro-spun yarns.

These results raised questions about the micro-spinning representativeness and predictiveness of the industrial potential of samples originating from breeding programs. A major issue in this regard is that the limited quantities of seed cotton produced from breeders' plots are ginned on small laboratory gins; therefore, there is little-to-no cleaning done either on the seed cotton or the ginned lint. The resulting high trash content of the cotton samples may further deteriorate the performance-ranking capability of the methodology and complicate the evaluation of spinning results. Therefore, specific fiber preparation protocols may be necessary to compensate for the absence of lint cleaning and ensure a reliable ranking of the spinning performance of alternative cotton samples.

In order to address this issue, we examined the effect of diverse contaminants (seed coat fragments and trash particles) on the relationship between micro-spun and industrial-scale yarn quality. A summary of the results is reported here.

Relationship between micro-spun and industrial yarn

As stated above, micro-spun yarn tensile properties are highly correlated to those of the industrial scale yarn. Results supporting this statement were reported in a previous publication (Krifa and Ethridge, 2003) and are corroborated in the literature (Price and Meredith, 2004). This document is therefore focused on treating the yarn evenness defects issue.

Relationships between micro-spun and industrial yarn neps detected with three mass threshold intervals (+140% to +200, +200% to +280% and >+280%) are shown in Figure 1. Although all three correlations are significant, the scatter plots shown on the figure exhibit high dispersion with different patterns depending on the detection threshold considered.

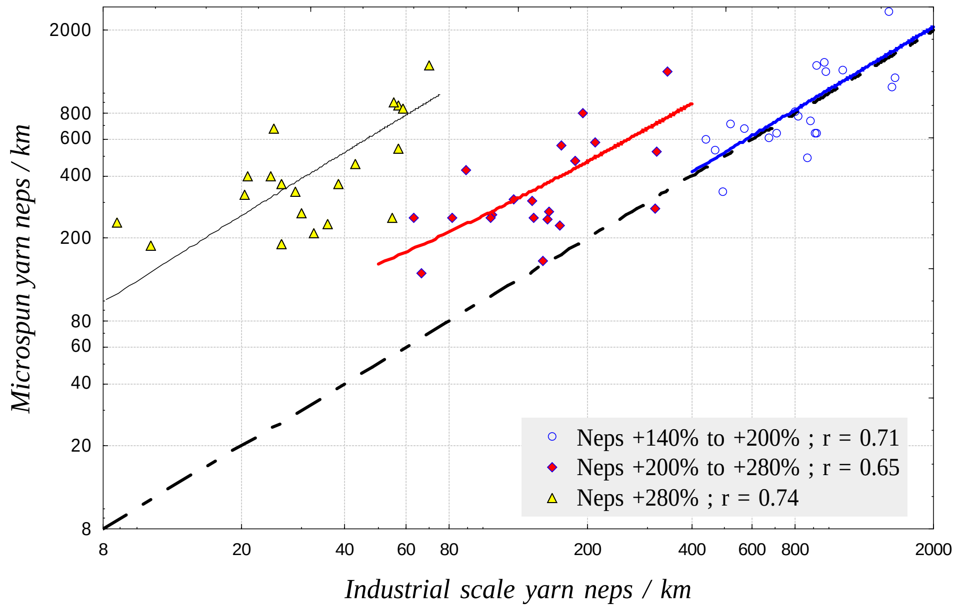

Figure 1: Relationship between micro-spun and industrial scale yarn neps.

For yarn neps detected in the +140% to +200% mass variation interval, the data points lay in the close vicinity of the equality line showing similar count levels for micro-spun and industrial-scale yarns. For higher mass variation thresholds (+200% to +280% and > +280%) the data points stray from the equality line and the micro-spun yarns show higher neps counts than the industrial-scale ones.

The difference between micro-spun and industrial yarn neps counts is therefore relatively higher as the nep detection threshold is higher. Similar trends were previously observed and were explained by the difference in seed coat fragments and trash particles count and size between micro-spun and industrial scale yarns (Krifa and Ethridge, 2003). Figure 2 and 3 illustrate this difference in particle number and size, respectively. These results were obtained using Trashcam analysis on yarn boards, an image analysis system developed by Cirad (Gourlot et al., 1995; Krifa et al., 1998; Frydrych et al., 1999).

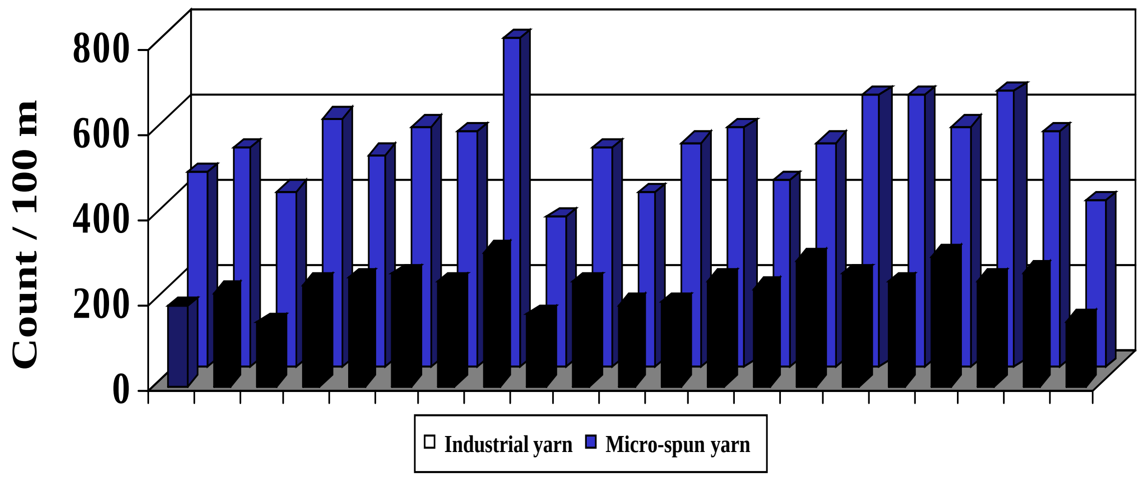

Figure 2: Seed coat fragments + trash particles count, micro-spun vs. industrial yarn.

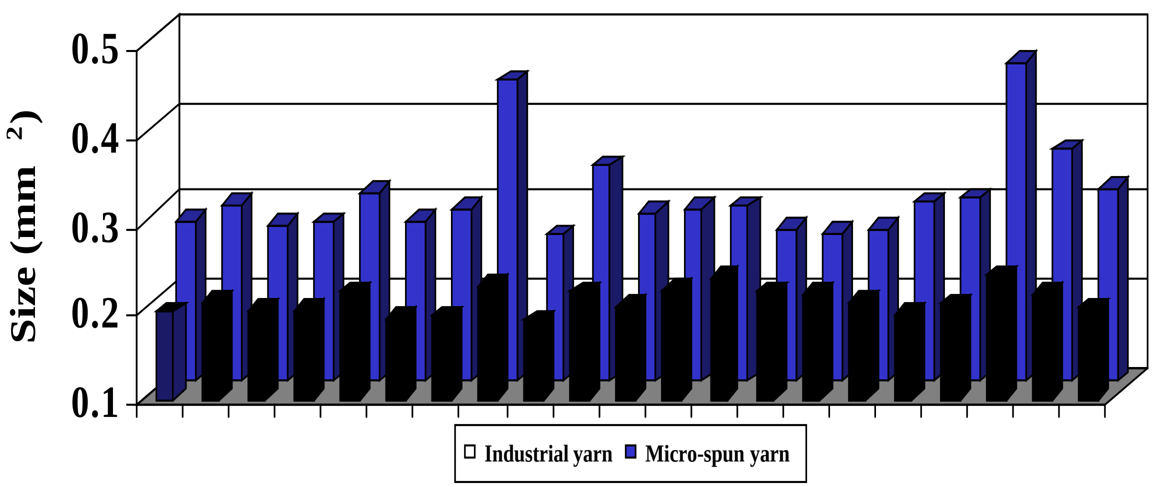

Figure 3: Seed coat fragments + trash particles mean size, micro-spun vs. industrial yarn.

The particles detected on micro-spun yarn are both more numerous and larger in size than those detected on the industrial scale yarn, which explains the observed differences in yarn evenness parameters with respect to the mass variation thresholds. Indeed, the larger particles present in micro-spun yarns are likely to be detected at higher mass thresholds than are those present in the industrial yarns.

In view of these results, it appears clear that in order to improve the correlations between micro-spun and industrial scale yarns with regard to evenness parameters, it is necessary to compensate for the cleaning deficiencies of the micro-spinning methodology. In fact, the main issue remains that the cleaning efficiency of the mini-card is way below the standards of industrial scale cards (and opening-cleaning systems).

Moreover, as previously stated, the cleaning issue will become even more critical when applying the methodology to geneticists' samples which are not processed through lint-cleaning due to the limited quantities of seed cotton produced. Therefore, specific fiber preparation protocols (pre-cleaning prior to micro-spinning) must be developed to compensate for the absence of lint cleaning and ensure a reliable ranking of the spinning performance of breeders and biotechnologists cotton samples.

Preliminary trials were conducted to test the effect of pre-cleaning on seed coat fragment and trash particles size distribution. As a first approach, a Platt Shirley Analyzer was used to clean the fiber samples prior to micro-spinning. Figure 4 reports an example of the results obtained, where the pre-cleaning shifted the size distribution of the particles detected on the micro-spun yarn towards the distribution observed on the industrial yarn.

These preliminary trials, conducted using the Shirley Analyzer, are currently being complemented by testing diverse combinations of laboratory openers/cleaners in conjunction with the mini-card. The preparation protocol proving optimum for breeders' samples will be selected not only based on particle number and size, but also on its effect on the other fiber attributes being monitored (length properties, for instance). Naturally, the ultimate selection criterion will be the performance of the combination pre-cleaning/micro-spinning in ranking genotypes and growing locations (i.e., the capability to produce a ranking that is representative of the industrial process).

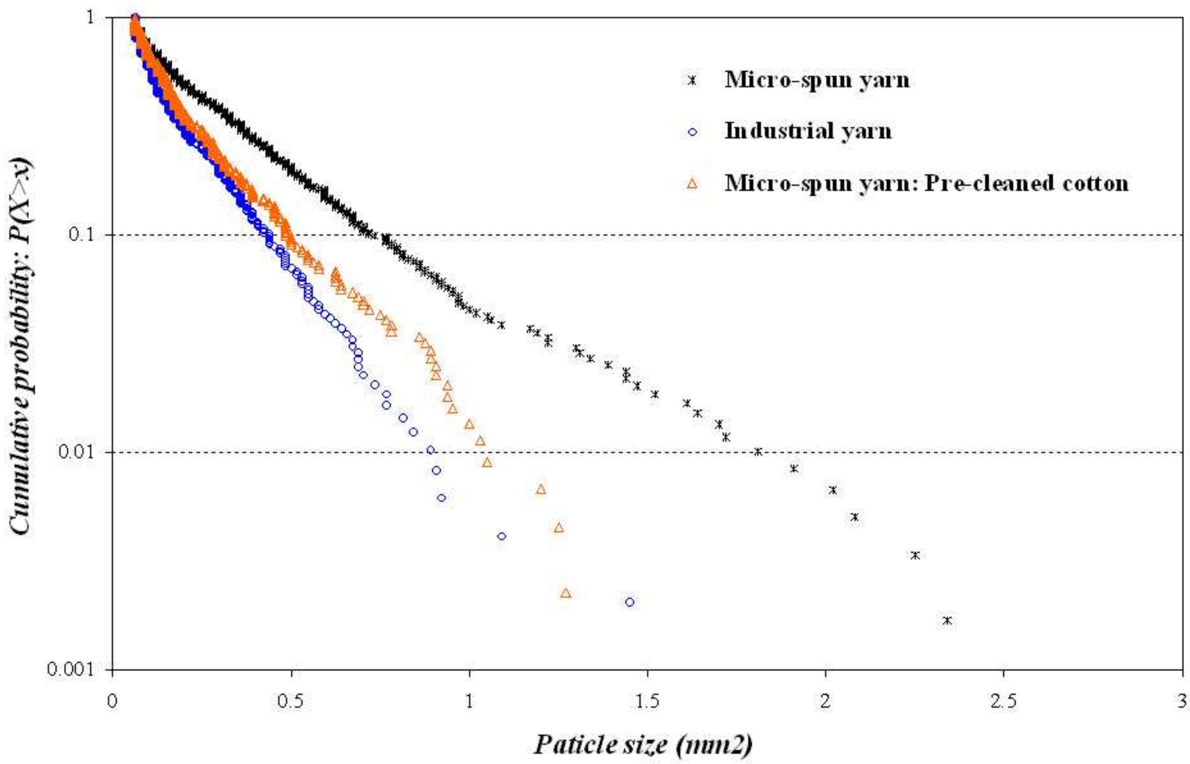

Figure 4: Trashcam particle size distribution on micro-spun yarn, micro-spun yarn from pre-cleaned lint and industrial yarn.

Conclusion

The potential of the micro-spinning system as a tool for ranking cotton samples based on some critical yarn quality parameters (tensile properties) has been shown using commercial cotton samples. Achieving comparable results for yarn evenness parameters requires the development of a pre-cleaning protocol to compensate for the deficiencies of the mini-card (when used as the only opening-cleaning process) and simulate the industrial-scale fiber cleaning operations. This pre-cleaning issue is particularly critical when dealing with breeders and biotechnologists samples due to the common lack of lint cleaning when small quantities of seed cotton are ginned using laboratory gins.

Acknowledgement

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