PHYSICAL PROPERTIES OF COTTON FIBERS MEASURED WITH COTTONSCOPE

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Abstract

This research explores the physical properties of cotton fibers as measured, via image analysis, with Cottonscope in comparison to other standard methods, i.e. air-flow micronaire. Micronaire measurements are a loose indicator of fiber fineness and maturity. Modern methods of precisely determining these fiber traits can be used to understand the complex interaction between fineness and maturity, which results in the micronaire values.

Introduction

Micronaire is an important quality parameter for cotton fibers. However, its use by cotton scientists is limited because it is a function of two fiber physical properties, fineness and maturity, that are important to the textile industry for different reasons. Direct and accurate measurements of these traits would be beneficial for yarn processing. Improved yarn uniformity and efficiency can be achieved with accurate prediction models (Deussen, 1992). Prediction models could be improved by incorporating these important parameters instead of micronaire. This paper will discuss the importance of direct measurement of fiber fineness and maturity in comparison with the indirect estimate micronaire.

Fineness has been defined using several different terms and units because of the significant impact it has on yarn spinning and end-use quality (Peirce and Lord, 1939). Micronaire was originally developed as a rapid technique of measuring fiber fineness through its relationship to air-flow resistance (Lord, 1956a). When a fiber sample of standard weight is compressed and air is passed through the sample, the resulting pressure drop is a function of fiber size. A compressed plug of finer fibers will have smaller pore spaces than a plug of coarser fibers. The smaller the pore space for air to channel through the greater is the resistance to airflow.

As Lord (1956b) further investigated fiber fineness and micronaire, it was noticed that fineness (as fiber thickness) was not the only property impacting micronaire. The maturity of fibers was discovered to also be of influence. Fiber maturity or the degree of cell wall thickening, determines the degree to which a fiber is able to flatten when it collapses. The change in shape from round to flat does not change the perimeter of the external cell wall. Mature fibers with well-developed cell walls do not become as flat as immature fibers. Immature fibers with large perimeters can collapse into shapes that appear, when cross-sectioned, as fibers with very small perimeter. A high fraction of these immature fibers can cause air-flow measurements to be misinterpreted as fine fibers. Therefore, the relationship of micronaire to fiber fineness is impacted significantly by fiber maturity (Lord, E., 1956b; Abbott et al., 2010).

Materials and Methods

Samples were collected from the 2012 Regional Breeder's Testing Network (RBTN) trial in Alexandria, LA. The field was arranged in a Randomized Complete Block Design consisting of thirty-four entries each grown in four replicated plots. Each plot was sampled by hand harvesting twenty-five bolls. Eleven entries were randomly selected for testing with High Volume Instrumentation or HVI (Uster Technologies, Memphis, TN) and Cottonscope (BSC Electronics, Ardross, WAUST). HVI measures airflow resistance to assess micronaire. The Cottonscope takes direct measurements via polarized light microscopy of a fiber's cell wall dimensions and yields the sample's ribbon width, maturity, fineness, and micronaire. The air-flow method of micronaire determination is assessing a mean value for a sample of 10g whereas the Cottonscope requires only 50mg of fiber to collect images for 20,000 fiber segments. These images are used to determine each segment's fineness and maturity before calculating a micronaire value. What we see in comparing the micronaire distributions is the variation resulting from the within sample variation of fineness and maturity. Replicated tests of each sample were taken using both instruments and the resulting data was plotted for comparison.

Results

In comparing the distribution of HVI micronaire (Fig.1) measurements with the micronaire value calculated by the Cottonscope (Fig.2), there are notable difference in the range of values for this trait between the two instruments. While similarities in rank across the entries are present, it is the range of values which are detectable by the Cottonscope that demonstrate the caveat of HVI micronaire.

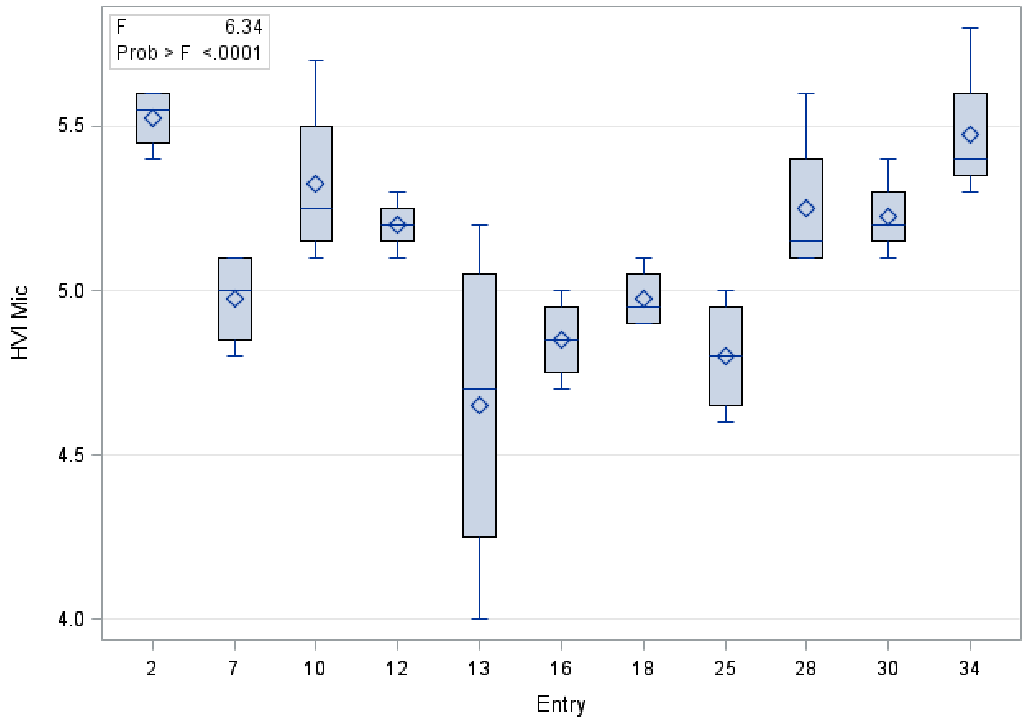

Figure 1 – Distribution of HVI Micronaire plotted by variety's entry number from the 2012 Regional Breeders Testing Network trial in Alexandria, LA

Entry 2 had a narrow range of HVI micronaire values (<0.3 mic units) but a very wide range for Cottonscope micronaire values (0.8 mic units). A similar trend is present in other entries with the exception of entry 10 and 13. Entry 10 had a noticeably wider HVI micronaire range than its Cottonscope values. Entry 13 had a very wide range in both micronaire values. While the Cottonscope can calculate micronaire with good agreement to HVI micronaire and provide better representation of the variability within samples, neither method gives an accurate assessment of fineness and maturity.

The plotted distribution of fineness (Fig. 3) and HVI micronaire (Fig. 1) show similar ranking by entry (Pearson's Correlation Coefficient 0.77). Despite this good agreement between the two values, comparison of the entries shows how small ranges in micronaire values (entry 12 and 25) can equate to large ranges (entry 12) or small ranges in fiber fineness (Fig. 3; entry 25).

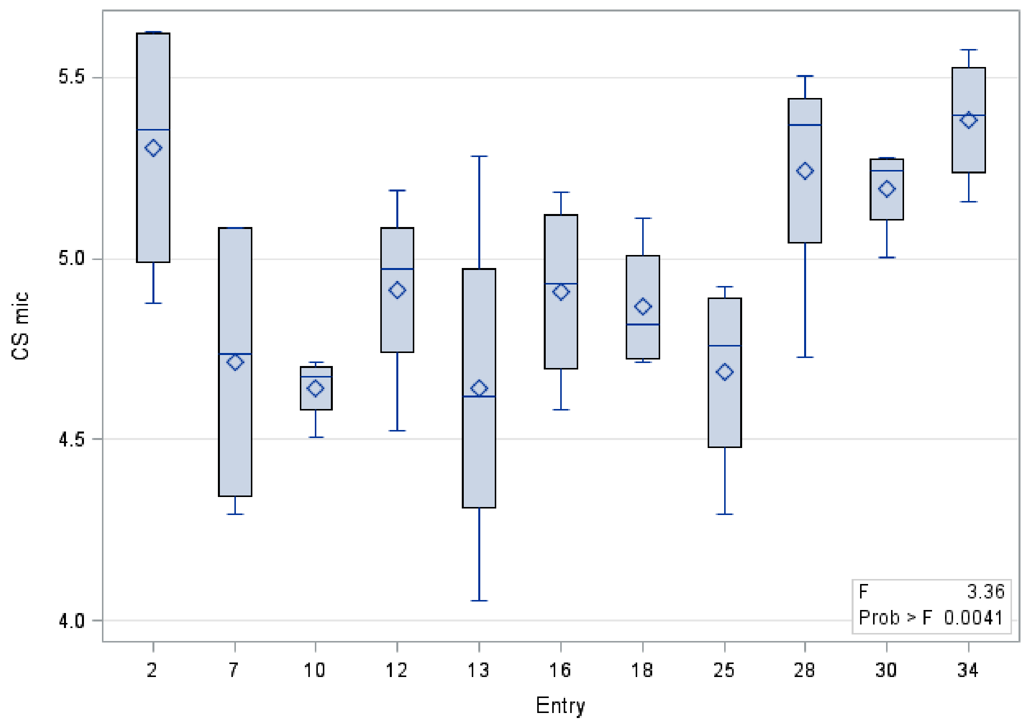

Figure 2 – Distribution of Cottonscope Micronaire plotted by variety's entry number from the 2012 Regional Breeders Testing Network trial in Alexandria, LA

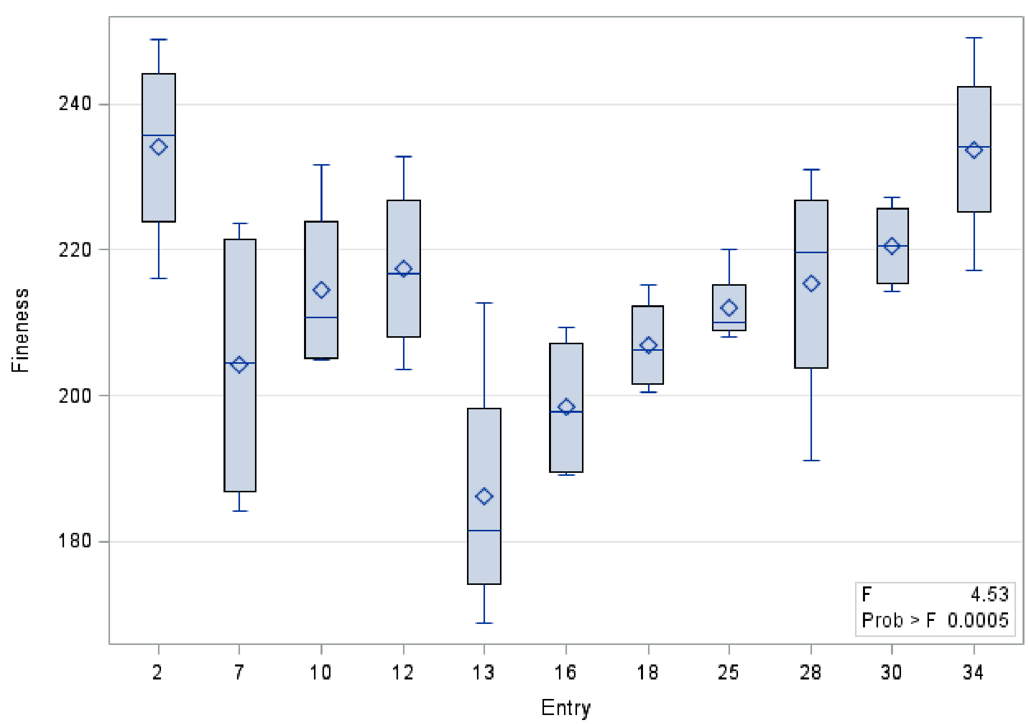

Figure 3 – Distribution of Cottonscope Fineness (mtex) plotted by variety's entry number from the 2012 Regional Breeders Testing Network trial in Alexandria, LA

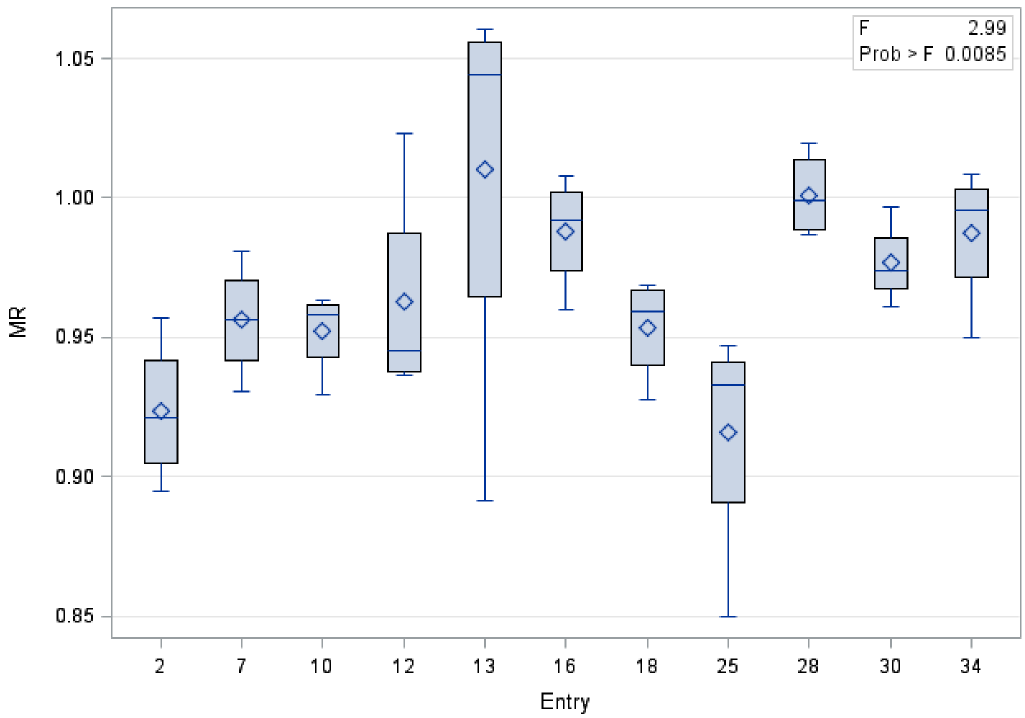

Figure 4 – Distribution of Cottonscope Maturity (MR) plotted by variety's entry number from the 2012 Regional Breeders Testing Network trial in Alexandria, LA

The data (Fig. 3 and 4) shows in some entries that the relationship of micronaire to its component traits is not consistently predictable. Entry 2 is a coarse fiber of low maturity. Entries 28 and 34 were of average (entry 28) or coarse (entry 34) fineness and high maturity samples. Entry 13 had the highest average maturity of all entries but the range of maturity was wide enough to cover the range of values exhibited by the remaining entries. Also entry 13 exhibited the finest fibers of all entries but again a very wide range seen within the samples.

Consistent with reports by Thibodeaux and Rajasekaran (1999), this data shows that micronaire does not give a reliable indication of the values for fineness or maturity. Entries 2, 28, and 34 were not significantly different from each other in their micronaire values despite the fineness and maturity differences. Entry 13 had the lowest HVI and Cottonscope micronaire values but the total range spanned 1.2 mic units (Fig 1, 4.0-5.2; Fig 2, 4.1-5.3).

Conclusion

Direct measurements of fineness and maturity are needed to identify the cause of problems seen by industry in spinning and dyeing. Without these measurements, dependence on micronaire results in erroneous assumptions. Micronaire provides good correlation with fineness but it is the influence of maturity and the within sample distribution of both traits that result in enough unexplained variation for problems with fiber processing to go unnoticed until after processing is completed.

Cotton is a highly variable fiber and sole use of micronaire to estimate fiber dimensions is not able to make use of the variability or fully understand the dynamics of fineness and maturity. The interaction of fiber maturity influences interpretation of micronaire enough so that its use as a fineness indicator is not reliable. Lord (1956b) reports a high rate of prediction error in some of the earliest work on modelling micronaire with its component traits. More precision is needed to discern samples of fine fibers from immature ones, or coarse fibers from mature ones. Breeding and genetics research to improve fineness and maturity using micronaire is limited, and issues with spinning and dyeing are left to assumptions because the variability and interaction of fineness and maturity, which result in micronaire, is unknown.

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