RELATIONSHIPS BETWEEN FIBER AND YARN TENSILE PROPERTIES

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Abstract

Cotton breeding programs must strive to deliver fibers that perform better in textile manufacturing (May and Jividen, 1999 – Meredith et al., 1991, Meredith, 2005). This is critical for effective competition with the various man-made fibers and with international growths of cotton. Yet, several fiber properties not measured in the cotton breeding programs have a large impact on processing performance. Among these are the elongation characteristics associated with fiber tenacity. Backe (1996) showed the importance of cotton fiber bundle elongation on yarn quality and weaving performances. The author concluded that cotton fiber bundle elongation should be measured and seriously considered when developing cotton lay-downs. He reported that the higher the cotton fiber bundle elongation, all other fiber properties remaining constant, the better the yarn's quality and resistance to the stresses and strains of weaving. Inheritance of cotton fiber tenacity has been studied extensively. May et al. (1999) reported that "heritability of fiber tenacity is generally high for selection units ranging from single plants to population bulks". He reported that among eighteen studies undertaken between 1954 and 1994, the narrow sense heritability for fiber tenacity ranged from 0.10 to 0.86. The same author reported that for fiber elongation the narrow sense heritability ranged from 0.36 to 0.90. May et al. (1998) also reported negative correlations between fiber elongation and fiber tenacity.

In general, most of the breeders simply ignore fiber elongation because the lack of calibration procedures for HVI elongation makes it impossible to rely on such data in an open market. In addition, the literature produced by cotton breeders shows that even when elongation measurements are available (Stelometer tests) there is a lack of understanding of its meaning. Indeed, because of the negative correlation between elongation and tenacity, they often conclude that there is no need to work on elongation because it could result in lower tenacity. We demonstrated in a previous paper (Benzina and al., 2007) that this negative correlation indeed exists but it is a weak correlation that does not preclude the simultaneous improvement of tenacity and elongation.

In the same study Benzina et al. (2007) measured cotton fiber bundle elongation and tenacity using a modified tensile testing instrument to which Pressley clamps (1/8" gage length) were adapted. The work of rupture was calculated from the curves Load versus Elongation for each cotton, and then correlated to the product Tenacity*Elongation as determined by HVI. The coefficient of determination obtained was good (R-squared = 0.897). From this work the chart shown in Figure 1 was derived.

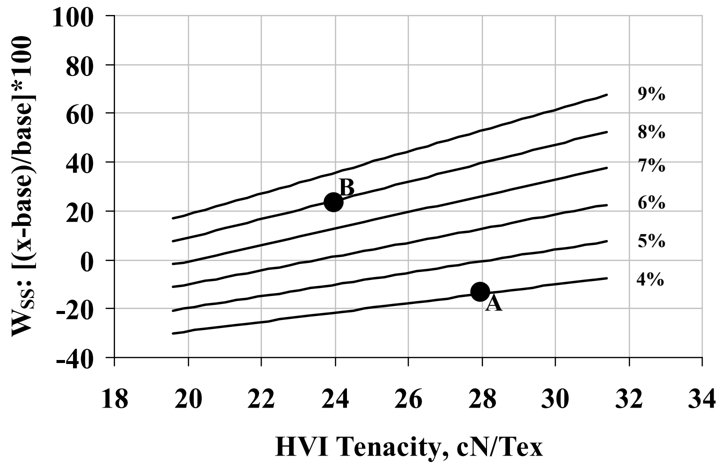

Figure 1. Percentage change of work of rupture (Wss) vs. HVI tenacity calculated for a HVI base set at 24 cN/tex and 6% elongation

In this chart, the change in work of rupture reported in the Y-axis was calculated using an HVI elongation of 6% and HVI tenacity of 24 cN/Tex as bases. This graph illustrates the impact of elongation on work of rupture. Indeed, improving the tenacity while decreasing the elongation could lead to a decrease in work of rupture. For example, a variety A having a HVI tenacity of 28 cN/Tex and 4% elongation would have a work of rupture 15% lower than the base. In contrast, no improvement in fiber tenacity and an increase in elongation could result in a higher work of rupture value. As an example, a variety B with tenacity of 24 cN/Tex and an improved elongation of 8% would have work of rupture 23% higher than the base. Therefore, variety B would perform better in spinning and weaving than variety A. Nevertheless, variety A would receive a monetary premium because the current marketing system does not take elongation or work of rupture into account. It is, therefore, necessary to document the benefit for the cotton industry of cotton varieties having improved elongation and better work of rupture.

These results demonstrate the importance of fiber bundle elongation in the work of rupture of fiber bundles, which is critically important to processing performance. Therefore, there is need to breed new cultivars with improved work of rupture. This should result in lower fiber breakage when the cotton fibers are submitted to different mechanical stresses (ginning, carding, spinning, and weaving).

In this study, we demonstrate that a combination of fiber properties could provide good estimates of yarn elongation and yarn strength, using ring spun yarns over a large range of counts. Yarn elongation (Figure 2) could be estimated from HVI elongation and HVI UHML (R-squared = 0.844) while yarn strength (Figure 3) could be estimated from AFIS Mean Length by weight, AFIS Standard Fineness, and AFIS Maturity Ratio (R-squared = 0.938). Therefore, even though the HVI elongation measurement needs to be perfected, the use of HVI tensile properties in breeding programs could lead to improved yarn quality and processing performance (from the gin to the shirt).

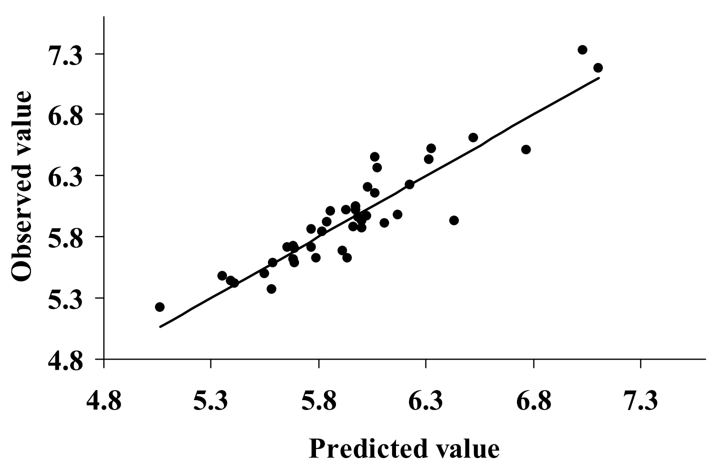

Figure 2: Yarn elongation – Predicted vs. Observed values (Yarn Elongation = -1.277 + 0.466 Elongation + 4.094 UHML, Adjusted R-squared = 0.844)

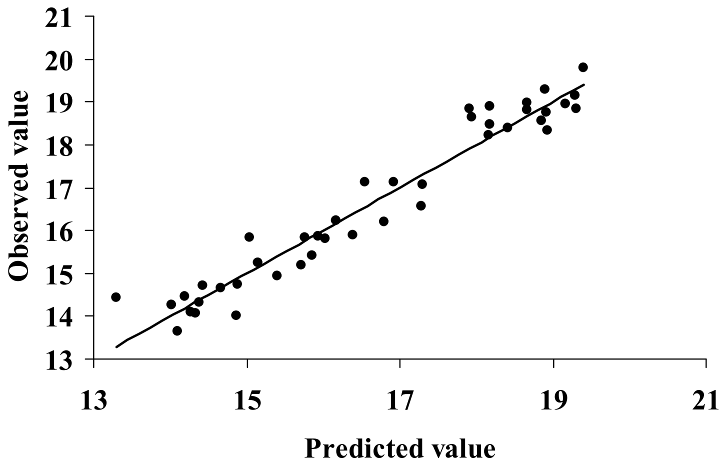

Figure 3: Yarn strength – Predicted vs. Observed values (Yarn Strength = 11.67 + 12.296 L(w) - 0.1147 Hs + 15.409 MR, Adjusted R-squared = 0.938).

A complete manuscript will be published in Textile Research Journal

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