RELATIONSHIP BETWEEN FIBER AND YARN PROPERTIES

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Abstract

A fundamental understanding of the relationship between cotton fiber and yarn properties is important, as fiber properties are determined through a number of well-defined protocols. In this study, yarn linear density was assessed by a gravimetric method, and then was compared with fiber HVI™ micronaire and AFIS fineness as well as yarn count and yarn tenacity. In general, fiber micronaire / fineness property and yarn count / tenacity increase with yarn linear density. Interestingly, linking yarn tenacity to linear density indicates different patterns among three individual varieties.

Introduction

The relationship between cotton fiber and yarn properties is of great interest, because this knowledge is of extreme important to cotton breeders for cotton enhancement and to fiber processors for improved yarn processing. Over the years, significant research have been taken to unravel yarn processing and product qualities by relating them with fiber qualities in raw cottons that were measured primarily by high volume instrumentation (HVI™) and advanced fiber information system (AFIS) (Abbot et al., 2009; Faulkner et al., 2012; Thibodeaux et al., 2008).

The main objective of this study was to determine yarn linear density by a gravimetric protocol and then to correlate it with fiber HVI™ micronaire and AFIS fineness as well as yarn count and yarn tenacity.

Materials and Methods

Cotton Fiber and Yarn Quality Measurements

Origins of cotton fibers and their fiber / yarn quality measurements were reported in detail previously (Liu et al., 2015). In brief, a total of 20 entries (16 breeding and 4 commercial cultivars) were grown in replicated field tests at three locations during the 2011 and 2012 crop years. These samples were well conditioned at a constant relative humidity of 65 ± 2% and temperature of 21 ± 2°C for at least 48 hours prior to any measurement and processing.

Gravimetric Yarn Linear Density Determination

All skein tested yarns were retained, and gravimetric yarn linear densities were estimated according to an earlier protocol (ASTM 2010). A 0.5 yd (or 0.457 m) length yarn was cut and then weighed, and the average of 5 tests was taken for each sample. Because of limited resource, only 16 samples representing 3 varieties (FM-958, DP-393, UA-48) and 2 crop years from one growing location were available in this preliminary study.

Results and Discussion

Fiber HVI™ Micronaire / AFIS Fineness vs. Yarn Linear Density

Fiber micronaire is an important fiber physical property in raw cottons. It is influenced by both maturity (degree of secondary cell wall development) and fineness (weight per unit length) of the fibers (Lord, 1956). To determine the micronaire value, fiber samples (~ 10g) were measured by passing air through the fibers and measuring the drop in pressure. Yarn gravimetric linear density in the unit of tex (1 tex = 1 g/ km) was simply calculated from the weight of a 0.5 yd yarn. Despite a much scattered pattern in Figure 1, it shows an overall increase in yarn linear density with fiber micronaire increasing. As the yarns having similar linear density might contain differing (fine and coarse) fibers in cross-sections, they could be divided into at least two categories; one represents the yarns processed from

fibers with smaller micronaire and another represents those with greater micronaire.

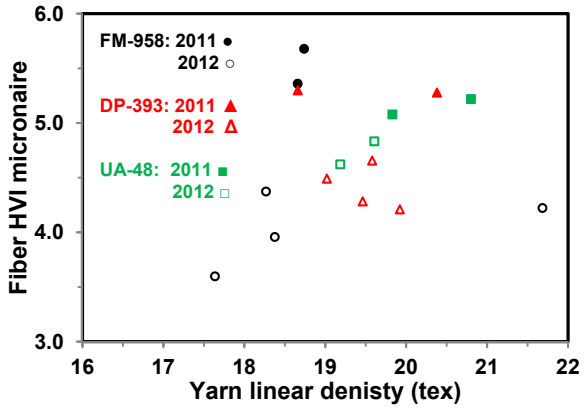

Figure 1. Relationship between fiber micronaire and yarn linear density among 3 fiber varieties.

AFIS fineness exhibits similar pattern of correlation with yarn linear density to fiber micronaire (Figure 2). It is expected, as AFIS fiber fineness increase linearly with HVI™ micronaire generally.

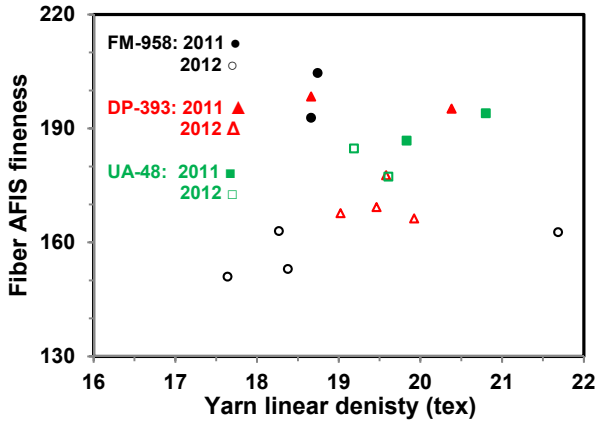

Figure 2. Relationship between fiber fineness and yarn linear density among 3 fiber varieties.

Relationship between Yarn Count and Linear Density

Yarn count reflects average yarn number, tex, in a skein yarn with a given weight and length (ASTM, 2012). The plot linking yarn count with yarn linear density is given in Figure 3. It is reasonable to observe a general increase in yarn count with linear density, but surprisingly with insignificant linear correlation between the two readings.

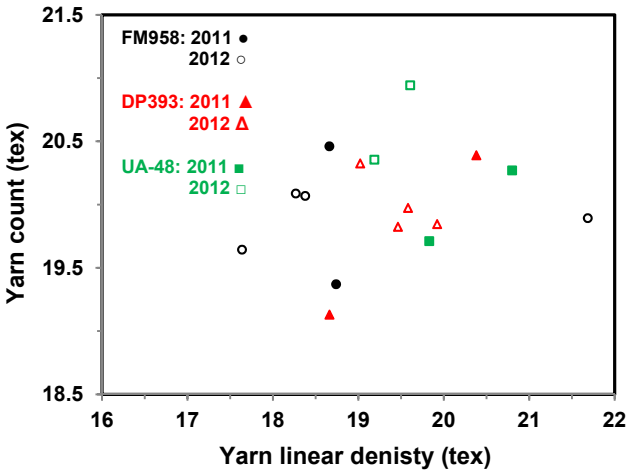

Figure 3. Relationship between yarn count and gravimetric yarn linear density among 3 fiber varieties.

Yarn Tenacity and Linear Density

Yarn skein breaking tenacity (mN/tex) was determined from yarn breaking strength (mN), the number of wraps in skein and yarn count. Anticipated, yarn breaking strength increases with yarn count apparently (Figure 4).

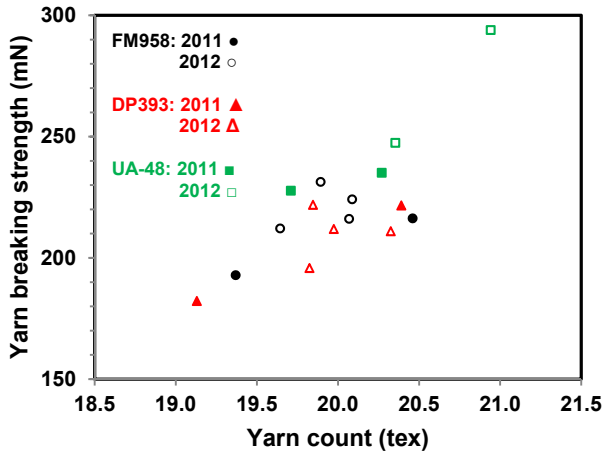

Figure 4. Relationship between yarn breaking strength and yarn count among 3 fiber varieties.

Figure 5 shows the plot of yarn breaking strength against linear density, and the disparity between Figure 4 and 5 might address the aspect of better understanding the yarn linear density. Figure 5 alike, Figure 6 indicates unclear trend in yarn tenacity with linear density for all fibers, but different patterns when comparing 3 varieties.

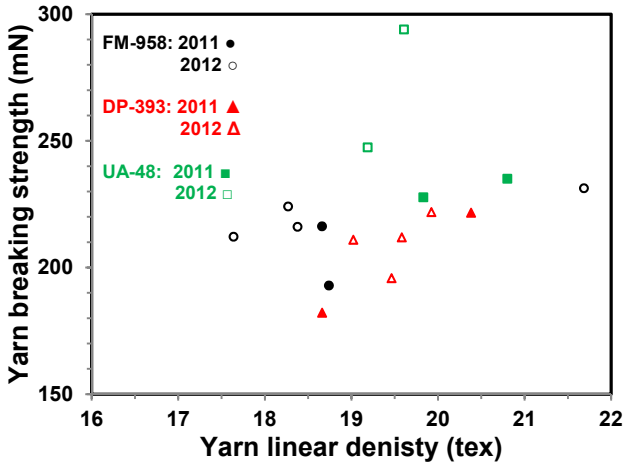

Figure 5. Yarn breaking strength vs. yarn linear density among 3 fiber varieties.

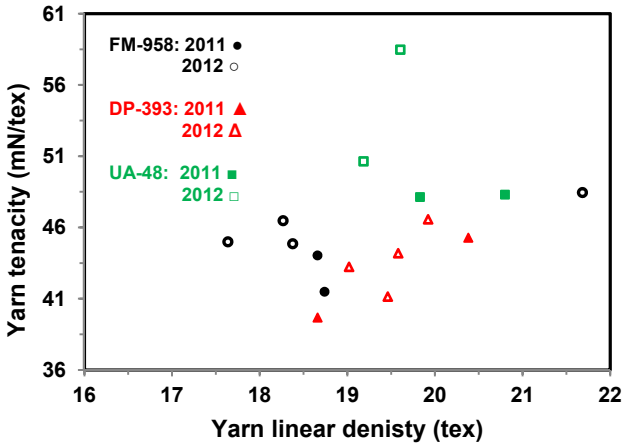

Figure 6. Yarn breaking tenacity vs. yarn linear density among 3 fiber varieties.

Fiber HVI™ Micronaire and Yarn Tenacity

Due to limited samples for each variety, result in Table 1 might provide some hints. From the 2011-year to 2012-year cottons, micronaire decreased, yarn tenacity increased whereas yarn linear density was nearly unchanged.

Table 1. Averages of Fiber HVI micronaire as well as yarn tenacity and linear density

	FM-958			DP-393			UA-48		
	Micronaire	Tenacity	Density	Micronaire	Tenacity	Density	Micronaire	Tenacity	Density
2011	5.52	42.8	18.7	5.29	42.5	19.5	5.15	48.2	20.3
2012	4.04	46.2	19.0	4.41	43.8	19.5	4.73	54.5	19.4

Summary

Gravimetric yarn linear density increases generally with fiber micronaire and fineness property. Notably, it has a low correlation with yarn count, one of three parameters used to determine yarn tenacity. Comparison of yarn tenacity against linear density indicates a different pattern when closely looking into individual varieties.

Acknowledgements

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Mention of a product or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

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