SINGLE FIBER TESTING VIA FAVIMAT

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Abstract

Cotton fiber is usually tested in bulk form utilizing a mass or beard of fibers to be presented to a test instrument for measurement. There are many reasons for this, not the least of which is that handling single cotton fibers is tedious and time consuming. Cotton breeders are being pushed to make decisions on which new lines and germplasm to pursue and which to abandon. Cotton breeders are relying on small samples to make these decisions. Single fiber testing may allow for more data to be provided to cotton breeders than is currently available. Single fiber testing also allows for the distributions of the measured properties to be gathered. The Favimat single fiber tester was utilized to measure cotton fiber fineness, strength, and elongation. The results of the single fiber testing were compared to bulk fiber measurements from instruments such as the HVI and AFIS.

Introduction

Single fiber testing via instruments such as the Favimat may prove of use to breeders and researchers with limited testing material available or in areas where the detailed data which can be obtained is able to justify the investment in time and effort. Single fiber testing with the Favimat allows for automated testing of fineness (linear density), strength, and elongation. As single fiber testing is performed the distribution of properties in a sample may be readily obtained.

Single fiber tensile testing is compared to more traditional bulk testing which uses bundles of fibers, such as HVI and Stelometer. Favimat measured fineness is compared to results via the AFIS and gravimetric analysis.

Materials and Methods

Eight HVI calibration cottons, collectively referred to as 8x8 cottons, were used to represent a wide range of fiber length and strength of domestic upland cottons. These cottons were obtained from the Agricultural Marketing Service (AMS). The range of HVI properties of the 8x8 cottons is shown in Table 1.

Table 1. Range of HVI values for 8x8 cottons

Property	Minimum Value	Maximum Value
Micronaire	3.54	4.55
Strength (cN/tex)	23.7	33.4
UHML (in)	0.961	1.189
Uniformity Index	77.7	84.2

The single fiber testing was carried out utilizing the Favimat instrument (Textechno, Mönchengladbach, Germany). The Favimat measures the fineness of fibers utilizing the vibroscopic technique (Montgomery and Milloway, 1952). Fiber strength and elongation are measured via a constant rate of extension measuring head in a manner similar to many universal tensile testing machines. The gauge length for testing is variable and the data reported was gathered using 13 and 3.2 mm (1/8 in) gauge lengths. Approximately 1000 fibers of each cotton were tested for each gauge length, and the breaking force and elongation as well as the work-to-break were captured for each fiber. The 3.2 mm gauge length is too short to allow vibroscopic testing so the linear density was also measured using the gravimetric method (ASTM D1557). Full testing was performed at 13 mm gauge length instead of the manufacturer's recommendation of 10 mm due to errors in the data as published in a previous report (Delhom et al, 2009).

Results from the Favimat testing were compared to data gathered via HVI (Uster, Knoxville, TN), AFIS (Uster, Charlotte, NC) and Stelometer (SDL Atlas, Stockport, England) testing. The HVI strength and elongation data was gathered by testing five combs of each sample. AFIS data was gathered by testing 5 repetitions of 5000 fibers for each cotton. Stelometer testing was gathered by five bundles per cotton. Gravimetric linear density was determined by cutting five bundles of fibers to a known length and counting 300 fibers from each bundle. The bundles of 300 cut fibers were weighed and averaged to calculate the linear density of each cotton.

Fineness testing on the Favimat is via the vibroscopic method, while the AFIS uses an optic-electronic method, and the gravimetric technique is a direct measurement. Strength and elongation testing on Favimat was performed using various gauge lengths and utilizing a different rate of extension than the Stelometer or HVI.

Results and Discussion

Approximately 1000 fibers of each cotton were tested on the Favimat using a 13 mm gauge length and the vibroscopic method for determining fineness. The fineness results are compared to results from AFIS and gravimetric analysis in Table 2. It is readily apparent that gravimetric and AFIS give similar results however, the Favimat results are in a different range of values.

Table 2. Fineness (mtex) results for various measurement techniques

Cotton	Favimat	Gravimetric	AFIS
38	231.9	163.2	177.6
37	217.0	148.3	160.4
36	230.6	155.8	177.2
35	222.5	151.7	170.2
34	215.9	142.0	155.4
33	248.1	159.3	161.8
32	244.5	141.2	151.4
31	216.3	139.9	165.0

Single fiber strength tests, utilizing both a 13 mm and 3.2 mm gauge length are compared to more common bundle strength tests in Table 3. The relationship of the single fiber 3.2 mm strength to the Stelometer testing, which utilizes the same gauge length, is consistent with previously reported observations (Thibodeaux et al, 1998 and Cui et al, 2003). Single fiber testing resulted in higher mean values than bundle testing. Figure 1 shows the correlation of single fiber strength to Stelometer for both gauge lengths.

Table 3. Strength (cN/tex) results for various measurement techniques

Cotton	Favimat (13 mm)	Favimat (3.2 mm)	HVI	Stelometer
38	24.9	43.9	27.9	22.3
37	22.5	42.0	23.7	21.7
36	19.3	38.9	29.0	19.5
35	20.2	39.4	27.9	18.9
34	22.5	39.8	27.5	20.6
33	22.1	38.8	27.4	20.8
32	18.4	37.8	31.7	16.6
31	23.0	44.5	33.4	21.0

The distribution of fiber strength is obtained naturally as an effect of carrying out single fiber testing. The distribution of single fiber strength, measured with a 13 mm gauge length, is shown for the strongest and weakest cottons in the test set (Figure 2).

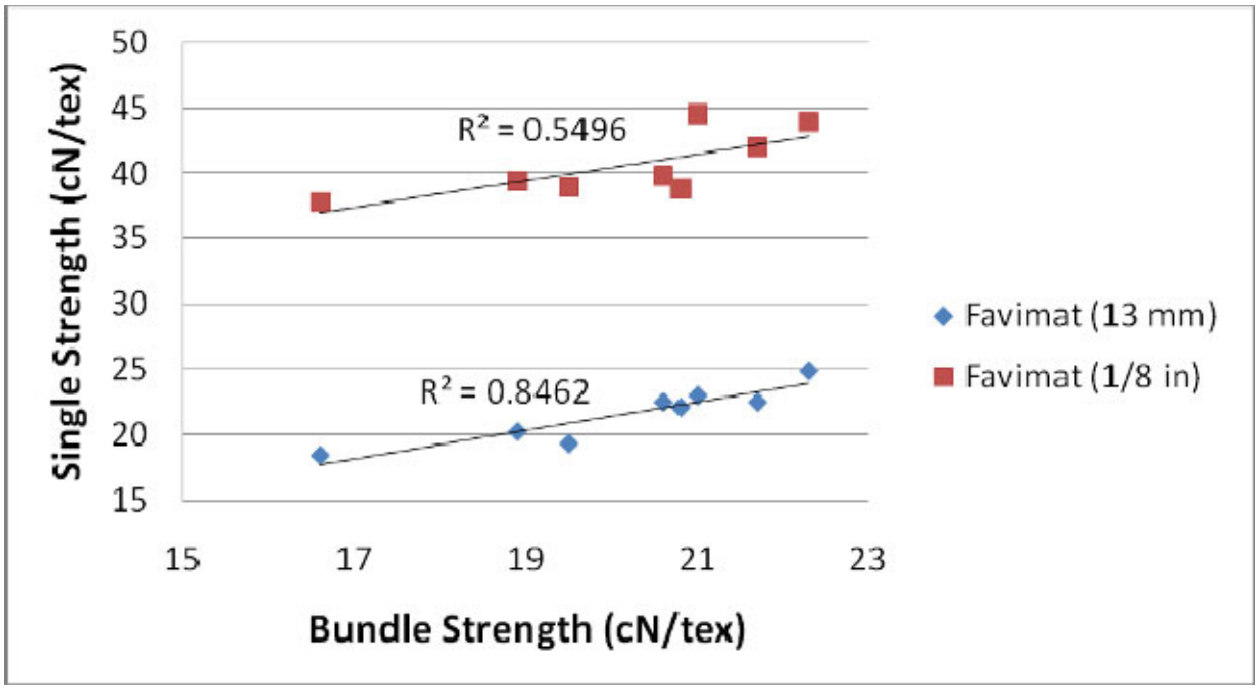

Figure 1. Correlation of single fiber and Stelometer bundle fiber strength tests

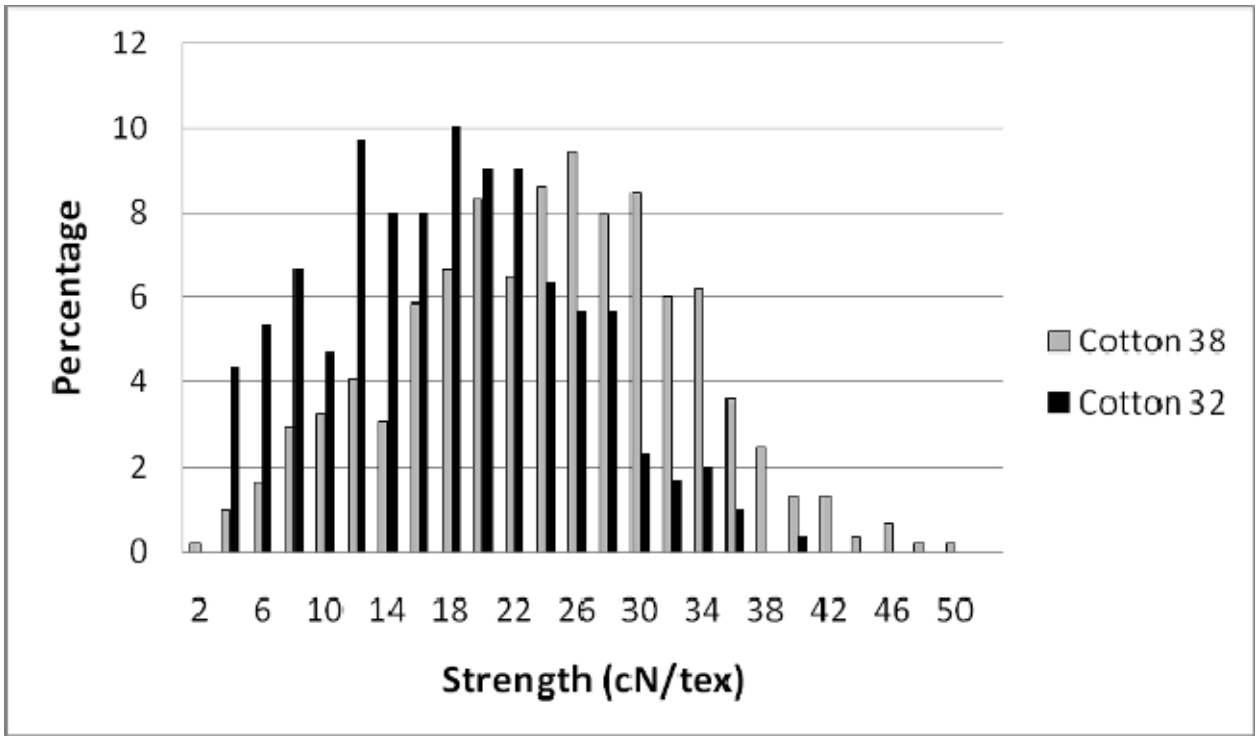

Figure 2. Single fiber strength distribution (13 mm gauge length) for Cotton 38 and Cotton 32

Breaking elongation values from single fiber testing is compared to bundle fiber testing via HVI and Stelometer in Table 4. The 3.2 mm gauge length testing resulted in a high R^2 value when correlating with Stelometer testing, as shown in Figure 3. The 3.2 mm gauge length resulted in much higher values for elongation than the 13 mm gauge length. The distribution of elongation values for Cottons 38 and 32 are shown in Figure 4.

Table 4. Elongation (%) results for various measurement techniques

Cotton	Favimat (13 mm)	Favimat (3.2 mm)	HVI	Stelometer
38	8.29	11.80	4.69	6.2
37	7.71	10.76	3.99	5.7
36	7.86	12.33	5.49	6.6
35	9.17	14.50	5.96	7.3
34	5.50	8.96	3.92	5.4
33	5.99	9.47	4.49	5.6
32	7.50	11.52	6.46	6.5
31	6.25	10.53	4.97	6.2

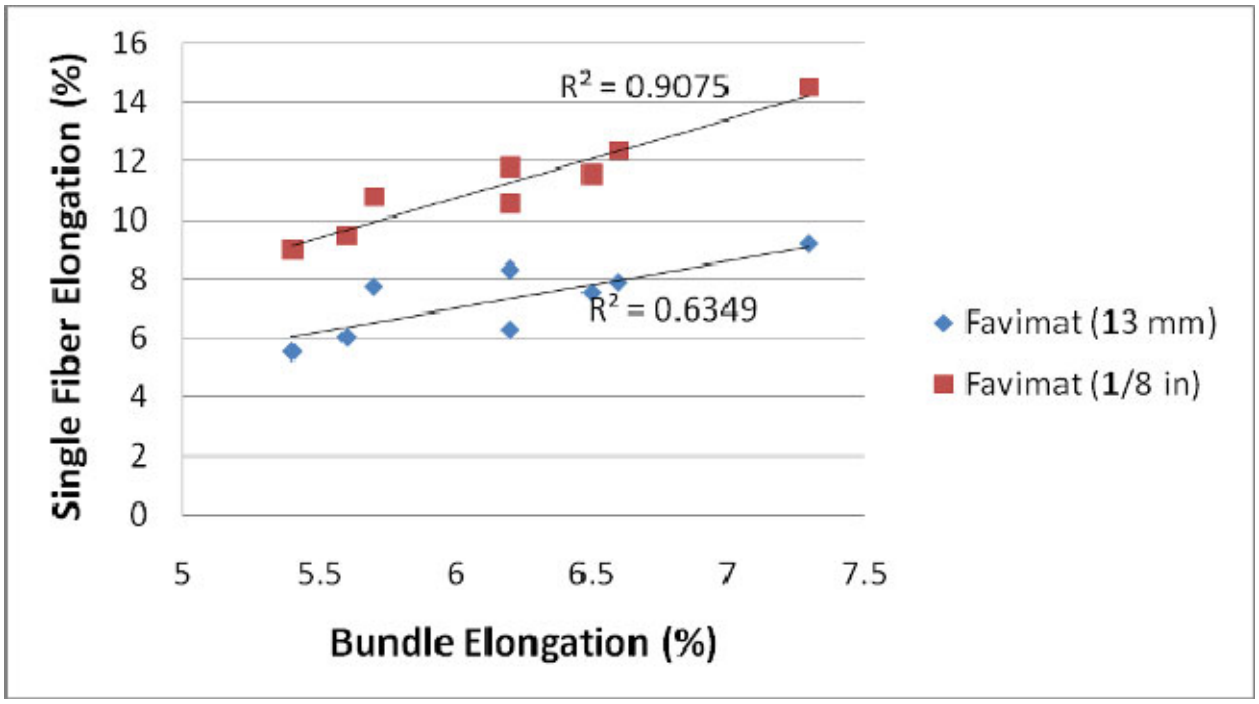

Figure 3. Correlation of single fiber and Stelometer bundle fiber elongation tests

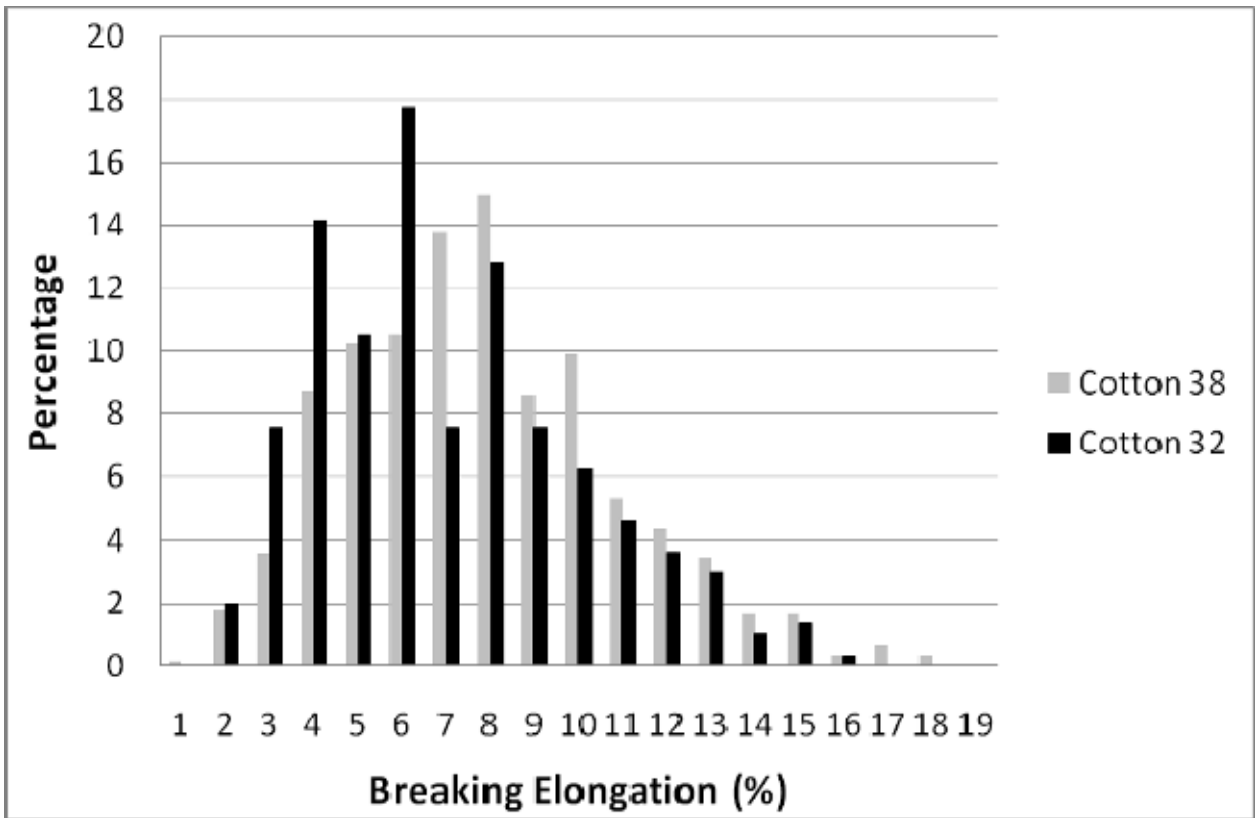

Figure 4. Single fiber elongation distribution (13 mm gauge length) for Cotton 38 and Cotton 32

Breaking strength is reported as tenacity, meaning that the breaking force has been normalized by the fineness (linear density) of the fiber. The raw breaking force data is shown in Table 5 for both gauge lengths. Table 5 also contains the "work to break" for each sample. Work to break is the area under the force-elongation curve and is a measure of the total energy required to break the fiber. The longer gauge length requires more energy (work to break) but less breaking (peak) force.

Table 5. Single fiber breaking data

	Work to Break (cN *cm)		Breaking Force (cN)	
Cotton	13 mm	3.2 mm	13 mm	3.2 mm
38	0.308	0.134	5.64	7.02
37	0.234	0.107	4.50	6.14
36	0.240	0.124	4.22	5.93
35	0.284	0.148	4.29	5.95
34	0.171	0.086	4.47	5.61
33	0.207	0.098	4.92	6.13
32	0.228	0.105	4.07	5.17
31	0.206	0.096	4.56	6.20

Summary

Single fiber testing is tedious and resource intensive, however it allows useful information to be obtained using very limited materials. The single fiber tensile testing correlated well with the Stelometer testing and should aid breeders in making more informed decisions. There are many parameters of single fiber testing which must still be addressed, such as the rate of extension, gauge length, pre-tension value, and an appropriate number of observations needed.

Disclaimer

The use of a company or product name is solely for the purpose of providing specific information and does not imply approval or recommendation by the United States Department of Agriculture to the exclusion of others.

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