REGIONAL HIGH QUALITY FIBER PROPERTIES AS MEASURED BY CONVENTIONAL AND AFIS METHODS

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Abstract

Comparison of fiber samples from the 1994 Regional High Quality Tests (RHQT) were evaluated by conventional breeders' and Advanced Fiber Information Systems (AFIS) measurements. The fiber samples were from 18 current and potential varieties and were grown at seven locations in seven Southeastern states. Samples from two replications at each location were taken. The first objective was to estimate the proportion of the total fiber property variability that was due to genetic causes. The second objective was to compare the association of the AFIS and conventional breeder's fiber properties. All fiber properties showed significant genetic variability. Genetic variability as determined by AFIS for neps, short fiber content, maturity and fineness was readily detectable and offers the breeders a rapid method to determine these traits. Nep numbers were highly correlated with variety maturity, r = -0.75; fiber area, r = -0.70; and short fibers, r = 0.59. Fiber area and short fibers were also highly correlated, r = -0.65; and yarn tenacity from conventional breeders' evaluations was highly correlated with fiber area, r = -0.76. Of greatest concern to breeders was the association of fiber area with neps and short fiber content. Unanswered but important questions that need to be addressed in the future are the genetic association of AFIS fiber properties with spinning efficiency, quality, and agronomic acceptability.

Introduction

As with technology in general, the cotton industry is undergoing many changes. Some of these changes are global trade agreements, farm programs, genetic engineering, electronic communications, and computerization. One of the many changes occurring in the cotton industry is the modernization of textile mill operations and the production of better quality textiles. These changes along with good marketing procedures, a stable USA cotton supply, and technology improvements have resulted in expanded markets and high prices received by growers. A major part of the technology improvements has been through varietal improvement in fiber quality (Sasser, 1995). The conventional fiber properties measured by breeders have been length, bundle strength, micronaire, and yarn tenacity. However, improvements in other fiber properties are needed if continued gains in demand for USA cotton are to be achieved. Fiber properties requiring high priority are reductions in neps (fiber entanglements), short fibers (fibers less than 0.5 inches), trash content, and improvements in maturity and fineness (Deussand, 1992). Until recently, determinations for these fiber properties were cumbersome, costly, and often measured without good precision or close association with the desired results.

The development of the Advanced Fiber Information System® (AFIS) manufactured by Zellweger Uster has produced modules of instrumentation and software which estimates quickly and with a small sample all of the newly emphasized fiber properties. Thibodeaux et al. (1993) reported that AFIS was an excellent tool for measuring fiber quality. Ghorashi et al. (1994) reported that the AFIS module for neps gave a very repeatable estimate of neps. A comparison of length and short fiber content measurement methods with the AFIS length and diameter module determinators was made by Smith and Williams (1995). AFIS mean length and upper quartile length were highly correlated ($R^2 \geq 0.98$) with length determinations from the Suter Webb®, Peyer AL-101®, and the Spinlab HVI® length methods. The short fiber content was correlated, R^2 about 90%, between the various length methods. Tounes et al. (1992) research showed that the AFIS trash module was very useful at the textile mill.

Little research has been reported on how AFIS might interact with improving these new priority fiber properties through breeding. History and previous studies (Meredith, 1990) have shown that varietal improvement is essential in any long term fiber quality improvement program. It's reasonable that the AFIS interaction with cotton breeding be investigated. Probably the most commonly used evaluation method is through organized variety tests. One of the most used variety tests that focuses on fiber quality is the Regional High Quality Test (RHQT) which is conducted annually in about nine states. Using the RHQT as the source of fiber and data we organized a comparative evaluation of AFIS and conventional methods. The first objective was to estimate the proportion of variability of neps, short fiber, trash, maturity, and fineness data from AFIS that was due to locations (L), varieties (V), V x L, and error sources of variation. The second objective was to compare the association of these AFIS fiber properties with one another and with conventional breeders' fiber properties. Finally the potential for AFIS use in breeding for fiber quality will be explored.

Materials and Methods

The comparison of conventional breeders' and AFIS fiber properties was made with the fiber samples obtained from

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the 1994 RHQT (Rayburn, 1995). Fiber samples in the RHQT are generally obtained from hand picked bolls, thus may contain less trash than machine harvested cotton. Also fiber samples were ginned on seven laboratory gins without the benefit of a lint-cleaner and therefore lint may be somewhat different than that from commercial gins. Breeders' conventional fiber properties were determined by Starlab®. AFIS modules for neps, trash, fiber length and diameter, and maturity and fineness were determined by Cotton Incorporated at Raleigh, NC, with remnant fibers from the RHQT. The tests consist of 18 varieties and strains evaluated at seven locations. The locations were Florence, SC; Belle Mina, AL; Stoneville, MS; Bossier City, LA; Keiser, AR; Portageville, MO; and College Station, TX. The experimental design was a randomized complete block with fiber samples obtained from two replications at each location. Variance components and their standard errors were estimated by the maximum likelihood method. Tests of significance were made by the standard error x "t" value.

Results and Discussion

The 18 current and potential varieties used in this test have a broad range of environments (seven states). The varieties originated from nine separate breeding organizations and involve entries from Carolina to California representing every major USA cotton growing region. Acala B-7465 produced the highest yarn tenacity and bundle strength, most neps and trash, finest fiber, and lowest micronaire. The most short fibers were from Deltapine 8732; the most mature fiber, least trash, and highest micronaire were from HX 93-407. Deltapine 50 produced the coarsest lint and weakest fiber. The least short fibers were from HB-133.

Variance Components

The contribution of genetics to fiber property variability over a wide range of environments is a reasonable method to determine the breeding potential of that fiber property. The proportion of the total variance of seven fiber properties routinely determined in the RHQT and nine AFIS fiber properties are given in table 2. The location component was large for all 16 fiber properties and would be considered as being significant if tests were made using the variation among replications within location as an estimate of error. However, using the conservative maximum likelihood location estimate none of the location variance components were considered significant. Significant variety fiber property variation for all 16 traits was detected when the variety component was tested with the variety x location interaction. Of major interest is the estimate for AFIS trash, neps, maturity, and fineness.

Trash variation among varieties was significant but small; 3.8% of the total. Much of this variability was associated with the smoothleaf trait which has previously been identified as having significantly less trash than hirsute varieties. In these studies the 12 hirsute entries averaged 1122 trash particles/gram and the six smoothleaf entries averaged 869 particles or 23% less. Reductions in trash due to smoothleaf have been reported from several studies (Anthony and Meredith, 1989; Williford et al. 1987; and Novick, et al. 1991) The AFIS trash module was capable of separating the smoothleaf from the hirsute varieties.

Neps are fiber entanglements, involving either plant materials or other fibers, and are a major problem in the production of excellent quality textiles. The variety and variety x location components for nep count/gram was significant, P = 0.02 and 0.01, respectively. Miravalle et al. (1986) also detected a significant variety x location component for number of neps. In this study conducted over nine locations, certain varieties tended to have low neps across all locations. For nep size only the variety component, P = 0.01 was significant.

Micronaire's major components are fiber maturity and fineness. Meredith (1991) showed that variation in maturity is mostly environmental and the variation in fineness is controlled almost equally by both environments and genetics. Traditional and AFIS micronaire measurements gave similar results; both having large components due to locations and significant variety and variety x location components. This breakdown of varietal and environmental components is similar to a previous study (Meredith, 1986). Fiber maturity has been estimated in the RHQT by use of the Arealometer. In this study, Arealometer and AFIS maturity estimates are similar. As with micronaire, the components for locations are large and significant variety and variety x location components are evident. AFIS estimates of fineness are diameter and area; smaller values indicate finer lint. AFIS fineness shows some differences from arealometer fineness. The fineness error variance for AFIS is lower than that estimated by the Arealometer. This may be why AFIS fineness variety components were much greater than that for the Arealometer. The Arealometer perimeter estimates contain only 16.1% of the total variance associated with variety and variety x location components. AFIS diameter and area show 72.3 and 49.5% of the total variance and variety x location effects. In addition, AFIS detected significant variety x location effect. The Acala varieties produced the finest lint. However, most entries had greater fineness than two commonly used varieties, Deltapine 50 and Deltapine 90.

Breeders' estimate of short fiber content has been the fiber length mean/upper half mean ratio. This estimate obviously does not directly measure short fiber content. Also, due to instrument methodology, it tends to underestimate the short fiber content of varieties with short fiber relative to long fiber varieties. Partially, for these reasons the results in table 2 for uniformity index shows a very small variety influence of 4.1%; 3.2 + 0.9% for variety, and variety x location components. AFIS offers breeders a valuable tool for developing varieties with lower short fiber content. Short fiber estimates on a numbers or weight basis gave similar variety rankings.

Associations of Fiber Properties

Table 3 shows correlations between breeders' traditional and AFIS fiber properties. Breeders' micronaire was highly correlated, r > 0.59; for all AFIS traits except AFIS 2.5% span length, r = -0.55. It's easy to reason why textile mills value the micronaire as an indication of fiber quality. Micronaire was positively correlated with AFIS micronaire, maturity, diameter, and area; r = 0.89, 0.62, 0.80, and 0.87, respectively. Micronaire was negatively correlated with trash, number of neps, size of neps, short fiber content, and 2.5% span length. The correlation for the same fiber traits when estimated by breeders' traditional methods or AFIS were generally similar. For 2.5% span length the correlation was 0.91, micronaire was 0.89, maturity was 0.62, fiber diameter and perimeter was 0.82. The major exception was the correlation of the uniformity and short fiber, r = -0.08. AFIS fiber diameter and area estimates were highly correlated with yarn tenacity, r = -0.83 and -0.76, respectively, and with bundle strength, r = -0.68 and -0.59, respectively.

Table 4 shows correlations between six AFIS fiber traits. As expected, the correlation between fiber diameter and area was high, r = 0.97. The negative association of diameter with trash, neps, and short fibers, suggest breeders may have to make some major decisions in fiber quality objective.

Breeding Implications

The first inference to be drawn from this study is that the AFIS modules produce data that has high genetic repeatability. Neppiness, short fiber content, and fineness can now be selected for if they become major breeding objectives. However, since there is no economic incentive to place high priorities on these traits breeders will probably not strongly pursue these objectives in the early stages of selection. However, they may evaluate advanced selection for these fiber properties.

The second inference is that the negative association of fineness with other desired fiber properties suggests breeders will have difficulty in producing fine fiber (low diameter and area) without increasing neps and short fibers. Miravalle et al. (1986) reported similar associations between neps and fineness, and Mangialardi and Meredith (1990) reported similar correlations with fiber fineness and other fiber properties. Currently, the only variety types expressing excellent fineness are the Acalas or strains developed by using Acalas as parents.

The extent of genetic variability for fineness in the Gossypium germplasm collection isn't well characterized. Other unanswered breeding questions are how will improvements in AFIS fiber properties reflect in textile efficiency and quality and how will breeders and growers be reinforced for producing the desired fibers. A third very important unanswered question involves what are the genetic associations between agronomic traits, yield, earliness, pest resistance, and the desired AFIS fiber properties.

References

Anthony, W.S., and W.R. Meredith, Jr. 1989. Evaluation of plant hairiness trait for two cotton cultivars. In J.M. Brown (ed.) 1989 Proc. Beltwide Cotton Prod. Res. Conf., Nashville, TN, pp. 77-81. Natl. Cotton Council of Am., Memphis, TN.

Deussand, H. 1992. Improved cotton fiber properties: The textile industry's key to success in global competition. In C.R. Benedict and G.M. Jividen (eds.) 1992 Cotton Fiber Cellulose: Structure, Function and Utilization Conf., Savannah, GA, pp. 43-63. Natl. Cotton Council of Am., Memphis, TN.

Ghorashi, H.M., J.C. Baldwin, and M.A. Khan. 1994. AFIS advancement in neps and linear measurements. In D.J. Herber (ed.) 1994 Proc. Beltwide Cotton Prod. Res. Conf., San Diego, CA, pp. 1433-1436. Natl. Cotton Council of Am., Memphis, TN.

Mangialardi, G.J., Jr., and W.R. Meredith, Jr. 1990. Relationship of fineness, maturity, and strength to neps and seed-coat fragments in ginned lint. Trans. of ASAE 33:1075.

Meredith, W.R., Jr. 1986. Fiber quality variation among USA cotton growing regions. In J.M. Brown (ed.) 1986 Proc. Beltwide Cotton Prod. Res. Conf., Las Vegas, NV, pp. 105-106. Natl. Cotton Council of Am., Memphis, TN.

Meredith, W.R., Jr. 1990. Contributions of introduction to cotton improvement. In H.L. Shands (ed.) Contributions of introduction to Crop Improvement. Am. Soc. of Agr., pp. 127-146.

Meredith, W.R., Jr. 1991. Association of maturity and perimeter with micronaire. In J.M. Brown (ed.) 1991 Proc. of Beltwide Cotton Prod. Res. Conf., San Antonio, TX, p. 569. Natl. Cotton Council of Am., Memphis, TN.

Miravalle, R.J., G.J. Mangialardi, Jr., and W.F. Lalor. 1986. Neps in cotton genotypes grown in six locations across the cotton belt in 1984. In J.M. Brown (ed.) 1986 Proc. Beltwide Cotton Prod. Res. Conf., Atlanta, GA, pp. 426-428. Natl. Cotton Council of Am., Memphis, TN.

Novick, R.G., J.E. Jones, W.S. Anthony, W. Aquillard, and J.I. Dickson. 1991. Genetic trait effects on nonlint trash of cotton. Crop Sci. 31:1029-1034.

Rayburn, S.T. 1995. High Quality Regional Variety Tests. 1994 National Cotton Variety Test, pp. 144-185.

Sasser, P.E. 1995. The 1994 Crop quality. In D.J. Herber (ed.) 1995 Proc. Beltwide Cotton Prod. Res. Conf., San Antonio, TX, pp. 3-4. Natl. Cotton Council of Am., Memphis, TN.

Smith, H.R., and P. Williams. 1995. A comparison of AFIS length measurements with other length test instruments on USDA staple standards. In D.J. Herber (ed.) 1995 Proc. Beltwide Cotton Prod. Res. Conf., San Antonio, TX, pp. 1243-1245. Natl. Cotton Council of Am., Memphis, TN.

Thibodeaux, D.P., O. Hinojosa, and W.R. Meredith, Jr. 1993. Application of AFIS measurement technology to evaluate the quality of cotton treated with Prep™. In D.J. Herber (ed.) 1993 Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, LA, pp.1113-1116. Natl. Cotton Council of Am., Memphis, TN.

Tounes, M.G., J.C. Baldwin, and F.M. Shofner. 1992. A comparison of AFIS T counting and sizing of trash and dust particles with other methods. In D.J. Herber (ed.) 1992 Proc. Beltwide Cotton Prod. Res. Conf., Nashville, TN, pp. 985-988. Natl. Cotton Council of Am., Memphis, TN.

Williford, J.R., W.R. Meredith, Jr., and W.S. Anthony. 1987. Factors influencing yield and quality of Mississippi Delta cotton. Trans. of ASAE 311-316.

Table 1. Range of fiber properties for variety averages over seven locations.

FIBER PROPERTY	TYPE EVALUATION	RANGE MIN.	RANGE MAX.	UNITS
Yarn tenacity	Breeder	124	169	mN/tex
Bundle strength	Breeder	184	257	mN/tex
2.5% SL	Breeder	1.13	1.21	Inches
Uniformity	Breeder	.843	.857	mean/UH mean
Micronaire	Breeder	3.85	5.01	Micronaire
Areal. mat.	Breeder	81	93	%
Areal. perm.	Breeder	43.2	50.1	Microns
Trash	AFIS	607	1449	No./g
Neps, no.	AFIS	89	187	No./g
Neps, size	AFIS	654	718	µm
2.5% SL	AFIS	1.44	1.56	Inches
Short fiber	AFIS	15.8	25.5	% <0.5 inch
Micronaire	AFIS	4.09	5.43	Micronaire
Maturity, %	AFIS	78	83	%
Diameter	AFIS	12.1	14.2	µm
Area	AFIS	102	121	µm^2

Table 2. Fiber property variance components as a percent of total variance for locations (L), varieties (V), L x V, and error.

Source	Yarn Ten.	Str. T_1	AFIS Trash	Neps No,/g	Neps Size	Length Breed 2.5%	Length AFIS 2.5%	Length Breed Unif.	Length Short Fiber
L	30.4	14.7	78.0	46.1	14.5	52.5	53.3	81.2	23.0
V	50.3**	55.5**	3.8*	14.6*	24.1*	23.6**	17.5*	3.2*	30.2**
L x V	7.0**	10.2**	4.1*	9.7	2.1	7.8**	9.7**	0.9	8.0
Error	12.4	19.6	14.1	29.6	59.3	16.1	19.5	14.6	38.9
Source	Breed Mic.	AFIS Mic.	Areal. Mat.	AFIS Mat.	Areal. Perm.	AFIS Diam.	AFIS Area	----	----
L	52.5	65.2	70.7	70.0	57.0	13.3	41.4		
V			23.6**	16.2*	8.5*	10.6*	13.9*	61.2**	40.2**
L x V			7.8**	8.5**	6.6**	7.1**	2.2	11.1**	9.3**
Error	16.1	10.1	14.2	12.2	26.9	14.4	9.1		

Variance component statistical tests were made by the "t" test where standard errors were estimated by the maximum likelihood method. Degrees of freedom for L, V, L x V, and error are 6, 17, 102, and 117 respectively.
*, ** indicates statistical significance at the 0.05 and 0.01 probability levels, respectively.

Table 3. Linear correlation (r) between breeders' conventional and AFIS' fiber properties.

BREEDER	AFIS LENGTH 2.5% SL	AFIS LENGTH SHORT FIBER	AFIS MATURITY AND FINENESS MICRO-NAIRE	MAT. %	DIAM.	AREA	TRASH	NEPS NO./G	NEPS SIZE
Yarn Tenacity	0.54	0.14	-0.41	0.09	-0.83	-0.76	0.58	0.44	0.79
Strength T_1	0.48	-0.02	-0.24	0.20	-0.68	-0.59	0.20	0.49	0.45
2.5% SL	0.91	0.73	-0.52	-0.34	-0.54	-0.58	0.42	0.35	0.69
Uniformity ratio	0.54	-0.08	-0.25	-0.08	-0.37	-0.37	0.20	0.33	0.30
Micronaire	-0.55	-0.59	0.89	0.62	0.80	0.87	-0.80	-0.79	-0.79
Arealometer Perimeter	-0.63	-0.47	0.41	0	0.82	0.75	-0.41	-0.31	-0.51
Arealometer Maturity	-0.06	-0.21	0.57	0.62	0.15	0.27	-0.44	-0.50	-0.39

r ≥ 0.47 and 0.59 significant at the 0.05 and 0.01 probability levels, respectively.

Table 4. Variety mean correlations for AFIS fiber properties.

	Nep No.	Short fiber	Diameter	Area	Mat. %
Trash	0.59	0.29	-0.70	-0.77	-0.53
Nep, No.		0.59	-0.60	-0.70	-0.75
Short Fiber			-0.59	-0.65	-0.58
Diameter				0.97	0.26
Area					0.45

□≥ 0.47 and 0.59 significant at the 0.05 and 0.01 probability levels, respectively.