AN INTRODUCTION TO AFIS FOR COTTON BREEDERS

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Abstract

The objectives of this paper were to describe the advanced fiber information system (AFIS) in terms familiar to cotton breeders and to present AFIS and HVI data from familiar cotton cultivars. The AFIS utilizes very small samples and provides a wide range information including complete length and diameter distribution, trash and nep content, and fineness and maturity measurements. This information is currently used primarily for process control in textile mills. It is unlikely that AFIS will be used in the foreseeable future as a decision aid in the purchase of cotton because the analysis is too time consuming. However, breeders could use AFIS information in late stages of cultivar development to select among genotypes for traits that are important to the textile industry, but not measured by traditional methods. Examples of AFIS data from current cultivars are presented.

Introduction

When cotton breeders make crosses this summer, they know that the final product from those crosses will not be available for at least 8 to 10 years. It is therefore imperative that we try to look down the road at what will be required in a variety 8 to 10 years in the future. Ten years ago, the high volume instrument (HVI) was still in developmental stages and was used to class cottons only on a limited basis. Now every bale of cotton in the US, as well as much of the rest of the world, is evaluated using HVI prior to entering commerce. The benefit of this technological advance for cotton farmers, our immediate clientele, is debatable, but the industry as a whole is much stronger because of the ability to quantify cotton fiber characteristics rapidly, objectively and with reasonable accuracy. Successful cotton breeding programs have adapted their breeding objectives to meet the market demands presented by universal HVI testing.

At present there are many new techniques and instruments being developed to do an even better job of describing the physical properties of the cottons we breed. If you can predict which ones will be in wide use 10 years from now, Zellweger Uster has a job for you. As an applied breeder, an agronomist, I am sometimes overwhelmed by number, complexity, and diversity of fiber properties that affect the different stages of textile production and the means to measure those properties.

The Advanced Fiber Information System (AFIS) is one of the measurement systems that may be important when breeding populations you are starting today reach fruition. Most cotton breeders today have at least heard of AFIS and many are somewhat familiar with what it does and the type of information it provides. Others still think AFIS has something to do with the federal agency that inspects animal and plant health. This paper is addressed primarily to the latter group of which the senior author was until recently a member.

The objective of this paper is to outline, in terms familiar to breeder/agronomists, what AFIS is all about. We will first describe briefly what AFIS does and what it actually measures. We will then describe some of the fiber quality parameters reported by AFIS analysis and how the data are currently used. Finally we will give some examples of AFIS fiber data using cultivars with which most breeders are familiar and give some comparisons with HVI data from corresponding fiber samples. Our purpose is not to provide a rigorous assessment of the accuracy of AFIS relative to more traditional systems as has been done elsewhere (e.g. Fiber length: Smith and Williams, 1995; Ghorashi et al., 1994; Fineness and maturity: Pellow et al., 1994; Williams and Yankey, 1996; Short Fiber: Bragg and Shofner, 1993), but rather to familiarize cotton breeders with data from AFIS.

How AFIS Works

A simple schematic diagram of an AFIS instrument is given by Ghorashi et al. (1994). A description of how the AFIS instrument works is given by Hinohosa and Thibodeaux (1994). Basically, a small sliver is prepared manually and fed into the instrument. The AFIS cleans and individualizes the fibers using an internal mini-card. Fibers, neps and trash are presented to electo-optical sensors via high velocity air flow. Material passing through the sensor tube interrupts light impinging on the sensors and algorithms, based on the degree and time of light interruption, provide direct measurements of the dimensions of fiber and other particles passing the sensors. Light scattered by the fiber at a 40 degree angle from the beam direction provide information used to quantify fineness and maturity.

Typical sample size for AFIS analysis is approximately 0.5 g, from which 3000 (or fewer) to 10,000 fibers are measured. More reliable results are generally obtained by measuring more fibers. Typically, 3 replicates of 10,000 fibers per sample are analyzed in approximately 30 min.

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In its development, AFIS was organized in separate modules for measurements related to neps (Module N), length and diameter (Module L&D), trash (Module T), and fineness and maturity (Module F&M). Parameters reported from each module will be discussed below. Modules N, L&D, and T have recently been integrated into a Multidata unit. An additional module (or modification of Module N) capable of measuring seed coat fragments is in development (Ghorashi et al., 1994; Baldwin et al., 1995; Jones and Baldwin, 1996).

Data Reported by AFIS.

Nep Module. Information on neps is rather straight forward. AFIS reports the number of neps per gram of sample (Nep Cnt/g) and the average size of neps in microns (Nep[µm]) (Table 1). A graphic output showing the size distribution of neps is also available. Current AFIS models do not distinguish between fiber entanglements and neps arising from seed coat fragments.

Length and Diameter Module. A complete fiber length distribution is available on a weight (w) or number (n) basis in English or metric units. Since AFIS is a count-based system, values given on a number basis are actual measurements whereas values given on a weight basis are calculated. Standard output includes mean length (L), coefficient of variation of fiber length LCV, short fiber content (SFC), upper quartile length (UQL), 50% span length (L50%), 2.5% span length (L2.5%), and 1% span length (L1%) (Table 1). Graphic output of fiber length distribution is also available.

An estimate of biological fineness is give by fiber diameter measurement. Standard output for diameter includes mean fiber diameter [D(n)], and coefficient of variation of fiber diameter [D(n)CV]. Graphic output of fiber length distribution is also available.

Trash Module. Trash measurements include the mean size of all trash in the sample, total number of trash particles per gram of sample, number of dust-sized particles (<500 µm) per gram of sample, number of trash-sized particles (>500 µm) per gram of sample, and percentage of visible foreign matter in the sample (Table 1). Trash values from AFIS are more repeatable than those provided by HVI and the cost is approximately the same as that for Shirley Analyzer.

Fineness and Maturity Module. Fineness and maturity measurements are given in Table 1. An excellent description of these properties, with illustrations is given by Williams and Yankey (1996). Fineness measurements by AFIS (in addition to biological fineness expressed as diameter) include average cross sectional area (Area) of fibers, average gravimetric fiber finessess (Fin) which is a function of Area, fine fiber fraction (FFF) [A(n) < 60 µm], and Micronafis (AFIS equivalent of micronaire).

Maturity is loosely defined as the degree of cell wall thickening. The basis of maturity measurement by AFIS is a parameter termed Theta. Theta is defined as the average circularity of the measured fibers. Circularity is calculated by the cross sectional area of the fiber wall divided by the area of a circle of the same perimeter and is thus a function of the degree of cell wall thickening or "maturity". In addition to the mean value of Theta, distributions of Theta are also determined and summarized by the parameters: Theta CV, immature fiber fraction (Theta < 0.25) (IFF), mature fiber fraction (Theta > 0.5) (MFF), maturity ratio (a function of MFF and IFF) (MR), and percent mature fibers (a function of MR and roughly equivalent to the more familiar "percent maturity") (PM).

How AFIS Data Is Used

Since AFIS can utilize extremely small samples, the instruments are used extensively in research at the boll, loc, or even seed level (e.g. Bradow et al., 1996). Commercially, AFIS is being used for process control and maintenance scheduling in spinning mills (Oxenham et al., 1995; Williams and Yankey, 1996; Jones and Baldwin, 1996). Increasingly, mills are using AFIS data to supplement HVI data in order to refine lay downs and identify problem bales, particularly in regard to fineness, maturity, and neps (ASTM; Williams and Yankey, 1996). AFIS data may become more important as more mills move increasingly to high speed rotor spinning. Meredith and Price (1996) compared AFIS and traditional fiber property correlations with ring and rotor spun yarn strength. The highest correlation (r = -0.93) for rotor spun yarn strength was with AFIS diameter.

Some Examples of AFIS Data

Fiber samples were obtained from the 1995 Mississippi state cultivar trials (Calhoun et al., 1996) at Stoneville and Tribbett, MS. Large seed cotton samples (20 to 40 lb) were ginned on the micro-gin at the USDA-ARS Ginning Laboratory, Stoneville, MS. Fiber samples were collected after 2 lint cleaners from 2 replications per location. Duplicate samples were analyzed on the commercial HVI line at the USDA-AMS classing office in Dumas, AR, on the Zellweger Uster AFIS instrument at Cotton Incorporated in Raleigh, NC, and on the Peyer FL/AL 101 at the USDA-ARS Ginning Laboratory in Stoneville, MS. Data were subjected to analysis of variance using the location x cultivar interaction to test significance of the main effect of cultivar and to calculate least significant differences (LSD) for means separation. For selected fiber properties, simple correlation coefficients were calculated between HVI measurements and measurements of other instruments. The cultivar trials used in this study included 2 maturity groups. Results were similar for both groups and only data from the early maturing group will be presented.

Summary statistics from analysis of variance are given in Table 2. The main effect of cultivars was significant for all dependent variables except short fiber content (SFC) and fiber length CV when measured by Peyer.

Fiber length. The range in values among cultivars was similar for most fiber length measurements of 95% or more of fibers (0.07 to 0.08 in.). The range in 2.5% and 1% span length was $\geq$ 0.10 in. when measured by AFIS. Precision of measurement as judged by R^2, CV, and LSD was as good from HVI as from AFIS in these data. In this data set, correlations with HVI UHM were fairly high ($r \geq 0.80$) for UQL, L50% and L2.5%, but lower for other fiber length measurements by AFIS (Table 3). It should be noted again that this test was not designed to be a rigorous comparison of measurement methods, but rather to give a general idea of how AFIS data relate to the more familiar HVI data.

Selected AFIS and HVI fiber length measurements, averaged across locations, for cultivars in this test are given in Table 4. 'Paymaster H1244' had the highest HVI UHM value as well as the highest L(w), UQL, L50%, L2.5%, and L1% values from AFIS.

Fiber length uniformity. Fiber length uniformity has in recent years received renewed interest in the textile industry and many problems in spinning mills are attributed to excessive short fiber content (SFC). Uniformity was one of two variables cited by textile mill technicians as being a severe problem in processing (Ferreira, 1995). Uniformity index (UI), fiber length CV, and SFC are considered together here under the generally category of length uniformity. The formula given by Zeidmen and Sasser (1991) was used to calculate HVI SFC from UHM and UI. Cultivars differed significantly for all AFIS and HVI fiber uniformity measurements. However, HVI UI and HVI SFC were not highly correlated with AFIS uniformity or SFC values (Table 3). There were high correlations ($r \geq 0.87$) among AFIS fiber length CV and SFC values, whether on a weight or number basis (data not shown). HVI SFC is a rough approximation at best. AFIS SFC by number has the advantage of being a direct measurement, but values can be affected by varying degrees of trash in samples, some particles of which can be counted as short fiber. Fiber individualization in the AFIS feeding mechanism can also break fibers and be an additional source of short fibers. However, in large scale studies, researchers have found a close relationship between AFIS SFC and Sutter-Webb Array (Jones et al., 1994).

Selected HVI and AFIS fiber length uniformity measurements are presented in Table 5. 'Suregrow 501 had the highest HVI UI value and lowest HVI SFC value. It also had the lowest SFC and among the lowest LCV values from AFIS.

Maturity and Fineness. Micronaire is a simple, fast and widely accepted means of roughly estimating fiber fineness. However, micronaire tells little directly about fiber maturity. 'Deltapine 20' and 'Deltapine 51' had the highest HVI micronaire readings in this test; however, Deltapine 20 had a maturity ratio near the test mean, whereas maturity ratio of Deltapine 51 was significantly above the test mean (Table 6). 'Seedsource 9303' had the lowest HVI micronaire reading, the finest average fiber (i.e. lowest AFIS Fin value), and average maturity (i.e. AFIS Theta value). Correlation of HVI micronaire with AFIS Fineness and Area were fairly high ($r \geq 0.80$), but lower ($r = 0.58$) with Theta (Table 3).

Trash. Both AFIS and HVI distinguished among cultivars in terms of trash content. However, the correlation between HVI Leaf and AFIS VFM was not particularly high ($r = 0.64$). Other studies (Calhoun, unpublished) have indicated that AFIS VFM can detect smaller differences between cultivars than can HVI Leaf. HVI Leaf and AFIS VFM values for cultivars in this test are given in Table 7. These values were obtained after processing fiber through two lint cleaners and the conventional wisdom that hairy leaf cottons contain more trash than smooth-leaf cottons is not borne out in all cases.

Neps. Problems associated with neps, particularly in regard to dying irregularities, have received considerable attention in recent years. HVI provides no estimate of a cultivar's propensity to produce neps during typical processing. Estimates of nep number by AFIS were effective in distinguishing among cultivars. Recent innovations in this AFIS module may provide the ability to distinguish between seed coat-related neps and fiber entanglements. Nep number in cultivars in this test after 2 lint cleaners is provided in Table 7. 'Stoneville 132' had the lowest nep content and Seedsource 9303 had the highest.

Prognostication

AFIS will probably not replace HVI within the next 5 to 10 years, if for no other reason than the time (and therefore expense) required to process samples. HVI requires approximately 30 sec. per sample for the two determinations of properties, whereas AFIS requires approximately 10 min. per replicate of a sample. AFIS now provides useful information to mill operators. Applications at this time are primarily in process and quality control (i.e. to guide setting and maintenance of equipment). AFIS is used to a limited extent to supplement HVI data for bale selection within a mill's inventory. If processing time can be shortened, it is likely that the use of AFIS data in bale selection will expand, but probably not to the selection of bales for purchase in the short term. If cultivars are developed that possess particularly attractive attributes measured by AFIS, there is the potential of achieving a market advantage for those cultivars. Meredith et al. (1996) found a high level of genetic variability for AFIS fiber properties and predicted that traits such as neppiness, short fiber content and fineness could be improved, if they became major breeding objectives. It behooves breeders to be aware of the vast amount of information available in "one-stop shopping" through AFIS and to consider how that information might be of use in their breeding programs.

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Table 1. Fiber properties included in standard report by various AFIS modules.

Module N	
Nep Cnt/g	Number of neps per gram of sample
Nep [µm]	Mean size of neps in grams
Module L&D	
Number basis	
L(n)	Mean fiber length in mm or inch
L(n)CV	Coefficient of variation of fiber length in %
SFC(n)	Short (<0.5 in.) fiber content in %
L50%	5% span length
L2.5%	2.5% span length
L1%	1% span length
D(n)	Mean fiber diameter in microns
D(n)CV	Coefficient of variation of fiber diameter in %
Fiber Cnt	Number of fibers measured
Weight basis	
L(w)	Mean fiber length in mm or inch
L(w)CV	Coefficient of variation of fiber length in %
SFC(w)	Short (<0.5 in.) fiber content in %
UQL(w)	Upper quartile length (fiber length exceeded by only 25% of all fibers)
Module T	
Total Cnt/g	Total number of non-lint particles per gram of sample
Size	Mean size of non-lint particles
Dust Cnt/g	Number of dust-size particles per gram of sample
Trash Cnt/g	Number of trash-size particles per gram of sample
VFM	Visible foreign matter as percent by weight
Module F&M	
Theta	Average circularity
Theta(n)CV	Coefficient of variation of Theta
IFF	Immature fiber fraction (percentage of fibers with Theta less than 0.25)
A(n)	Average cross-sectional area of measured fibers (μm^2)
FFF	Fine fiber fraction (percentage of fibers with Area less than 60 μm^2)
Micronafis	Micronaire equivalent
MFF	Mature fiber fraction (percentage of fibers with Theta greater than 0.5)
MR	Maturity ratio [MR = (MFF-IFF)/200+0.7]
PM	Percent mature fibers [PM = $(2.44-(MR-1.76)^2)/0.0212$]
FIN	Average of fiber fineness in millitex

Table 2. Summary statistics for fiber traits in the 1995 Early Maturing Cotton Variety Test at Stoneville and Tribbett, MS, as measured by HVI, AFIS and Peyer instruments.

Fiber trait	Min.	Max.	Mean	R^2(%)	CV(%)	LSD (0.05)
Fiber length measurements (inches)						
HVI-UHM	1.05	1.12	1.08	89.3	0.91	0.014
AFIS L(w)	0.93	1.00	0.97	79.3	1.61	0.027
AFIS UQL	1.12	1.20	1.15	78.1	1.55	0.028
AFIS L(n)	0.79	0.86	0.82	78.2	2.47	0.031
AFIS L50%	1.27	1.35	1.30	80.8	1.51	0.030
AFIS L2.5%	1.34	1.44	1.39	79.0	1.61	0.032
AFIS L1%	1.54	1.68	1.60	69.2	2.74	0.056
Peyer L(n)	0.78	0.83	0.80	75.2	2.49	0.030
Peyer L1%	1.21	1.29	1.25	81.5	1.57	0.030
Peyer L(w)	0.83	0.90	0.87	75.3	2.27	0.027
?Peyer L2.5%	0.98	1.05	1.01	83.1	1.63	0.027
Fiber uniformity measurements (%)						
HVI-UI	81.58	83.17	82.43	90.0	0.33	0.49
AFIS L(w)CV	28.19	34.31	31.77	81.1	3.18	1.39
AFIS SFC(w)	4.73	8.53	7.11	78.7	11.62	1.21
AFIS L(n)CV	37.39	46.31	42.71	77.7	4.00	2.20
AFIS SFC(n)	14.30	23.68	19.97	77.3	9.87	2.66
Peyer CV(n)	26.13	30.38	27.81	70.3	6.80	2.27ns[1]
Peyer SFC(n)	9.15	15.65	11.90	70.3	22.56	3.51ns
Peyer CV(w)	22.80	25.50	23.88	67.7	5.28	1.44ns
Peyer SFC(w)	4.68	8.00	6.14	70.0	22.31	1.83ns
Fineness and Maturity Measurements						
HVI-Mic	3.88	4.92	4.46	93.6	2.50	0.20
AFIS Dia.	12.65	13.98	13.53	90.0	1.23	0.28
AFIS Mic	3.61	5.11	4.22	91.0	4.03	0.20
AFIS MR	0.85	0.95	0.90	91.6	1.36	0.01
AFIS PM	76.0	84.2	79.7	92.8	1.17	1.1
AFIS Fin	160	180	169	89.3	1.55	3
AFIS Theta	0.46	0.52	0.48	93.0	1.48	0.01
AFIS Area	105	118	111	89.2	1.56	2
Trash-related Measurements						
HVI-Leaf	1.75	3.59	2.31	88.6	12.54	0.40
AFIS Total Cnt	187	469	280	86.6	16.99	65
AFIS Dust Cnt	149	383	224	84.9	18.04	52
AFIS Trash Cnt	32	87	55	89.0	17.22	15
AFIS T Size	323	408	355	62.9	6.86	23
AFIS VFM	0.65	1.78	1.07	82.9	18.35	0.28
Nep Measurements						
AFIS Nep Size	760	796	779	71.4	1.49	17ns
AFIS Nep No.	205	315	260	82.7	9.85	36

[1] ns indicates that F test for cultivar effect was not significant at P=0.05.

Table 3. Simple correlation coefficients between selected HVI and AFIS fiber properties.

Fiber length		Fiber uniformity			Fineness & Mat.	
	HVI		HVI	HVI		HVI
AFIS	UHM	AFIS	UI	SFCW	AFIS	Micron.
L(w)	0.60	L(w)CV	-0.40	0.20	D(n)	0.59
UQL	0.80	SFC(w)	-0.43	0.33	Micron	0.79
L(n)	0.22	L(n)CV	-0.35	0.14	MR	0.63
L50%	0.84	SFC(n)	-0.39	0.26	PM	0.63
L2.5%	0.80				Fin	0.85
L1%	0.48				Theta	0.58
					Area	0.85

Table 4. HVI and AFIS fiber length measurements of cotton cultivars grown at Stoneville and Tribbett, MS in 1995.

	HVI	AFIS					
Cultivar	UHM	L(w)	UQL	L(n)	L50%	L2.5%	L1%
		----------------inches------------------					
H1244	1.12	1.00	1.20	0.84	1.36	1.45	1.68
DP50	1.11	0.99	1.18	0.83	1.34	1.43	1.66
DP5409	1.11	0.97	1.17	0.82	1.34	1.44	1.68
H1215	1.11	1.00	1.18	0.84	1.35	1.44	1.64
STLA887	1.11	0.98	1.17	0.82	1.33	1.43	1.64
H1220	1.10	0.98	1.17	0.83	1.33	1.42	1.63
ST495	1.10	0.96	1.16	0.79	1.33	1.41	1.59
SG501	1.10	0.99	1.16	0.86	1.32	1.42	1.67
CB232	1.09	0.95	1.14	0.80	1.30	1.40	1.61
DP20	1.09	0.97	1.16	0.82	1.31	1.40	1.58
DP51	1.09	0.97	1.16	0.83	1.32	1.41	1.59
DP0227	1.09	0.97	1.16	0.81	1.32	1.42	1.62
H1277	1.09	0.98	1.16	0.83	1.32	1.41	1.59
OA44	1.09	0.98	1.17	0.83	1.32	1.40	1.55
SG125	1.09	0.98	1.16	0.83	1.31	1.40	1.60
DES119	1.09	1.00	1.17	0.86	1.32	1.41	1.65
SS9303	1.09	0.97	1.16	0.82	1.33	1.44	1.66
CB333	1.08	0.96	1.14	0.82	1.30	1.41	1.63
H1330	1.08	0.96	1.14	0.81	1.29	1.38	1.55
HS23	1.08	0.96	1.15	0.80	1.30	1.39	1.55
OA13	1.08	0.95	1.14	0.80	1.29	1.38	1.56
ST474	1.08	0.96	1.14	0.82	1.31	1.41	1.63
T207	1.08	0.96	1.15	0.81	1.31	1.40	1.59
ST132	1.07	0.96	1.13	0.81	1.29	1.39	1.60
SG404	1.06	0.98	1.14	0.84	1.29	1.39	1.63
SS9412	1.06	0.95	1.12	0.81	1.27	1.37	1.61
MEAN	1.09	0.97	1.16	0.82	1.31	1.41	1.61
CV	0.76	1.05	1.19	1.42	1.07	1.15	1.83
LSD	0.01	0.02	0.02	0.02	0.02	0.02	0.04
R^2	0.90	0.85	0.86	0.79	0.86	0.84	0.84

Table 5. HVI and AFIS fiber length uniformity measurements of cotton cultivars grown at Stoneville and Tribbett, MS in 1995.

	HVI	HVI	AFIS			
Cultivar	UI	SFCW	L(w)CV	SFC(w)	L(n)CV	SFC(n)
		------------------%--------------				
SG501	83.2	6.6	30.39	5.38	39.95	16.05
DES119	83.2	6.7	29.97	5.63	40.27	16.83
H1244	83.2	6.4	32.67	6.95	44.54	20.53
DP50	83.0	6.6	32.23	6.88	44.20	20.38
H1215	82.8	6.7	31.44	6.30	42.84	18.90
STLA887	82.8	6.8	32.79	7.58	44.58	21.45
OA44	82.8	7.3	30.57	6.63	42.46	19.53
SG404	82.7	7.8	30.13	5.80	40.18	17.08
DP20	82.6	7.4	31.39	6.95	42.63	19.85
H1277	82.6	7.4	31.23	6.78	42.78	19.70
ST132	82.5	7.9	31.76	6.93	42.09	19.30
SG125	82.5	7.6	31.39	6.88	42.24	19.48
SS9412	82.5	8.0	31.23	6.58	41.48	18.75
CB333	82.4	7.8	31.82	6.53	42.04	18.73
DP51	82.3	7.8	31.27	6.30	41.68	18.25
DP5409	82.3	7.5	33.19	7.33	44.07	20.58
H1220	82.3	7.6	32.07	7.00	43.78	20.40
ST474	82.3	7.8	32.24	6.83	42.40	19.18
DP0227	82.2	7.9	33.28	7.63	44.92	21.60
T207	82.2	8.1	32.29	7.33	43.55	20.73
OA13	82.1	8.2	32.05	7.65	43.68	21.28
CB232	82.0	8.2	32.69	7.50	43.86	21.03
H1330	82.0	8.3	31.53	7.13	42.59	20.05
SS9303	81.8	8.3	33.18	7.43	43.76	20.53
HS23	81.8	8.5	31.99	7.68	44.43	21.88
ST495	81.6	8.6	33.48	8.48	46.31	23.68
MEAN	82.4	7.6	31.97	7.00	43.23	20.07
CV	0.40	5.75	1.84	6.24	2.13	5.26
LSD	0.6	0.7	0.93	0.78	1.47	1.82
R^2	0.81	0.83	0.85	0.81	0.85	0.82

Table 6. HVI and AFIS fineness and maturity measurements of cotton cultivars grown at Stoneville and Tribbett, MS in 1995

	HVI	AFIS						
Cultivar	Mic	D(n)	Mic	MR	PM	Fin	Theta	Area
DP20	5.01	14.03	4.53	0.91	80.7	177	0.492	116.20
DP51	5.00	13.90	5.00	0.95	83.7	179	0.517	117.70
OA44	4.84	14.08	4.36	0.90	79.8	175	0.483	115.25
SG404	4.84	13.75	4.68	0.93	82.3	175	0.504	115.00
HS23	4.83	14.00	4.60	0.91	81.0	177	0.494	116.53
ST132	4.83	13.28	4.93	0.95	84.0	173	0.525	113.45
H1277	4.79	13.98	4.34	0.90	79.9	174	0.484	114.70
H1330	4.75	13.83	4.45	0.91	80.8	174	0.492	114.15
CB333	4.73	13.33	4.47	0.92	81.7	168	0.503	110.83
OA13	4.73	13.83	4.23	0.89	79.1	173	0.479	113.65
ST495	4.70	13.53	4.74	0.94	83.1	173	0.511	114.03
SG501	4.69	13.45	4.50	0.92	81.8	170	0.501	111.75
H1215	4.63	13.53	4.30	0.91	80.6	169	0.491	110.98
SG125	4.62	13.78	4.13	0.88	78.7	171	0.476	112.30
DES119	4.57	13.78	4.23	0.89	79.5	171	0.481	112.73
DP50	4.55	13.43	4.55	0.92	81.9	171	0.503	112.28
H1244	4.53	13.23	4.49	0.92	82.0	168	0.505	110.33
ST474	4.53	13.18	4.52	0.92	82.1	168	0.507	110.30
SS9412	4.51	13.70	3.91	0.87	77.3	169	0.466	110.90
CB232	4.47	13.05	4.20	0.90	80.4	164	0.492	107.98
STLA887	4.46	13.18	4.37	0.92	81.5	166	0.501	109.10
H1220	4.43	13.53	4.03	0.88	78.6	168	0.475	110.43
T207	4.42	13.70	4.24	0.89	79.4	170	0.483	112.13
DP0227	4.41	12.93	4.33	0.92	81.3	165	0.499	108.60
DP5409	4.40	12.98	4.46	0.93	82.1	165	0.508	108.85
SS9303	4.31	12.88	4.33	0.92	81.6	163	0.503	107.45
MEAN	4.67	13.53	4.46	0.91	81.2	171	0.497	112.48
CV	1.66	0.74	2.79	0.99	0.81	0.95	1.148	0.94
LSD	0.20	0.24	0.20	0.01	1.10	2.78	0.009	1.85
R^2	0.95	0.97	0.91	0.92	0.93	0.95	0.935	0.95

Table 7. HVI and AFIS trash, and AFIS nep measurements of cotton cultivars grown at Stoneville and Tribbett, MS in 1995.

Cultivar	HVI Leaf	Nep(n)	Trash (Cnt/g)	AFIS VFM
DP51	1.58	216.25	250.75	0.92
DP20	1.59	243.50	239.50	0.75
H1215	1.75	250.50	257.50	1.00
OA44	1.75	246.50	241.25	0.98
SS9412	1.75	248.75	229.50	0.73
H1277	1.83	254.25	271.50	1.17
ST495	1.84	258.25	208.75	0.92
OA13	1.92	245.00	266.50	0.93
SG125	1.92	233.00	217.25	0.84
SG404	1.92	204.75	212.50	0.87
H1330	2.00	262.50	293.00	1.72
DP0227	2.08	254.75	301.00	1.12
ST474	2.08	226.25	255.00	0.90
CB333	2.25	219.75	290.00	1.01
HS23	2.25	247.25	345.25	1.25
ST132	2.33	208.50	244.50	0.79
T207	2.33	252.25	255.25	0.99
SG501	2.50	218.25	324.00	1.28
STLA887	2.50	274.50	323.50	1.16
DP5409	2.58	276.75	334.00	1.04
SS9303	2.83	286.75	299.25	1.03
CB232	2.92	252.75	398.00	1.46
H1244	2.92	258.75	423.00	1.43
DP50	3.00	278.25	408.50	1.40
H1220	3.50	262.00	377.75	1.28
DES119	3.59	236.00	443.00	1.78
MEAN	2.25	247.26	305.71	1.13
CV	13.17	10.07	16.27	22.52
LSD	0.41	30.85	77.31	0.31
R^2	0.91	0.65	0.86	0.76