2005 Beltwide Cotton Conferences, New Orleans, Louisiana - January 4 - 7, 2005

NEW LINT CLEANER FOR REDUCED FIBER LOSS

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Abstract

This study compared the standard controlled-batt, saw-type lint cleaner with a recently patented lint cleaner that combines features of a cylinder cleaner used for seed cotton with elements of a standard lint cleaner. Standard lint cleaners improve the appearance and market value per pound but reduce bale weight and degrade some desirable mill qualities. The new lint cleaner mitigates those adverse features. Two varieties of cotton were used in the evaluation. Turnout and waste percent were significant at the 5% level of probability for machine treatments. The High Volume Instrument (HVI) factors of micronaire, reflectance, plus b, leaf, percent area and length were statistically significant for machine treatments. Advanced Fiber Information System (AFIS) factors of nep size, neps per gram, seed coat neps per gram, total dust and dust per gram were significant for machine treatments; most AFIS factors were significant for cottons. The interaction for machine treatment and cotton was significant for nep size, neps per gram, and seed coat neps per gram. The waste per 500-lb bale averaged across varieties was 15.2 and 7.0 pounds for the standard lint cleaner and the new lint cleaner, respectively, for an increased bale weight of 8.2 pounds. For both cottons 1 and 2, the new lint cleaner yielded the highest monetary return with an increase of $5.36 and $16.34 per bale, respectively.

Introduction

The controlled-batt, saw-type lint cleaner has been used for many years in the ginning industry to comb and blend cotton fiber (lint), and to remove motes (aborted ovules), cottonseed, undesirable fiber, and plant parts. The lint from a gin stand or another lint cleaner is formed into a batt on a condenser screen drum and then fed into one or more sets of compression rollers, passed between very closely fitted feed rollers and a feed plate or bar, and then fed onto a saw cylinder. Some lint cleaners do not control the batt in this manner but use a different feed mechanism. The United States Cotton Ginning Laboratory, USDA, Stoneville, MS, developed the flow-through saw-type lint-cleaning machine for use in cotton gins in 1950 (Stedronsky and Shaw, 1950). Lummus Corporation recently introduced a lint cleaner (Sentinel) that also operates without the feed mechanism (Rutherford, et al., 2002).

In both types of saw lint cleaners, the teeth of the saw cylinder convey the fibers past several (5 to 9) cleaning points commonly called grid bars that are spaced 0.03 in. to 0.06 in. away from the saw teeth. Good fiber as well as undesirable material is ejected at each of these grid bars or cleaning points, with the amount of good fiber increasing proportionately as the number of cleaning points increase (Anthony, 1999; 2000). The amount of material removed by lint cleaning depends on the amount of foreign matter in the cotton as well as the percentage of motes and the fiber length characteristics. Typically, one stage of saw-type lint cleaning removes about 20 lbs of material that includes at least 50% good fiber (Mangialardi and Anthony, 1998). In addition to removing trash, lint cleaners comb and blend the cotton to produce a smooth appearance. They also degrade some desirable mill qualities, especially at low moistures.

The material ejected by lint cleaners is commonly, but erroneously, called “motes” by much of the cotton industry and “lint cleaner waste” by some (Anthony, 1999). It is not unusual for the foreign matter in the lint cleaner waste to represent less than 50% of the total by weight. Much of the fiber in the lint cleaner waste is equal in quality to the fiber in the bale, and should remain in the bale. In order to reduce the amount of wasted fiber, a new machine was developed and patented by Anthony (2003a). The new lint cleaner consisted of a standard lint cleaner modified to include a secondary saw to prevent loss of the longer fiber that is ejected by the primary cleaning saw and grid bar arrangement. The new lint cleaner included either a steel brush or splined roller to guide the cotton onto the secondary saw. Material from the standard grid bar/saw cylinder falls on the second saw cylinder and is metered and compressed by a powered splined roller or brush. The roller or brush is positioned and operated such that only the longer fiber ejected by the primary saw cylinder is retained by the secondary saw. Laboratory and field tests with the new lint cleaner were very successful (Anthony, 2004).

Whitelock and Anthony (2003) evaluated the cleaning efficiency of modified seed cotton cleaners used to clean lint after ginning. Tests were performed with different types of grid bars and cylinder speeds. Results showed that more aggressive, square grid bars performed better than conventional round grid bars in cleaning. Increasing cylinder speeds from 480 to 1100 rpm also increased the cleaning performance of the cylinder cleaners. Of the five types of grid bars evaluated in this study, the sharp (with corner pointing toward spikes so that it appeared diamond-shaped), square grid bars with the spiked cylinders operated at 1100-rpm cleaned lint better than the other treatments and was 80% as effective as a conventional saw-type lint cleaner. However, the diamond-shaped grid bars lost too much fiber. The flat, square grid bars (Figure 1) with the spiked cylinders operated 1100 rpm ejected only 67% as much material as the diamond-shaped grid bars but very little fiber was lost. Thus, the flat, square grid bars with the spiked cylinders operated at 1100 rpm appeared to be the best solution to balancing cleaning and fiber wastage.

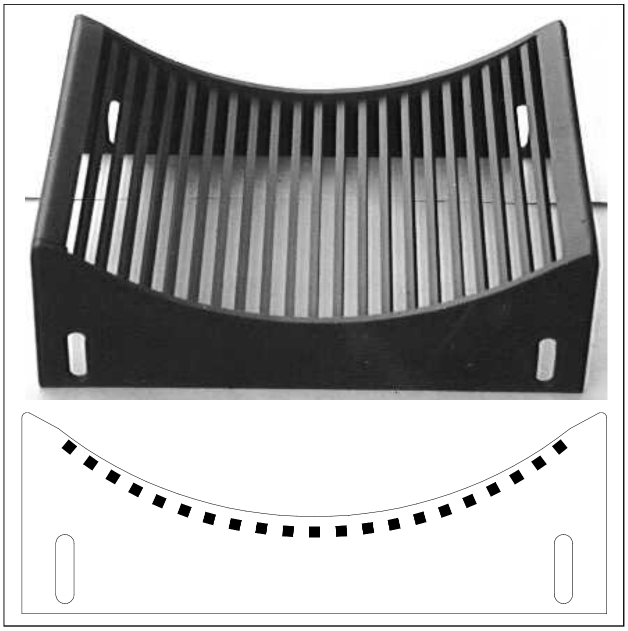

Figure 1. Flat, square (3/8-in.) grid bars spaced ¼-in. apart appeared to balance cleaning and fiber loss.

As described in Patent Number 6,539,585 (Anthony, 2003b), the preferred cylinder cleaner features described by Whitelock and Anthony (2003) were incorporated with the saw and brush components of a lint cleaner to create one machine (Figure 2). In this new machine, lint is introduced into the cylinder cleaner above one of the rotating, spiked cylinders. As the fibers are engaged by the spikes on the cylinders, the lint is both agitated and transported across the grid bars below the cylinders. The movement of the material across and against the grid bars effectively scrubs the lint, dislodging foreign matter within the lint which then falls by gravity through the openings between the grid bars. In contrast, the fibers engaged by the spikes are released by the centrifugal force generated by the rotating cylinders, thereby conveying the material to successive downstream cylinders and repeatedly subjecting the lint to the cleaning action. Once the fiber containing material is engaged by the last separator cylinder, this partially cleaned material is propelled off of the revolving cylinder toward and through the outlet of the cylinder cleaner, and directly into the lint cleaner saw.

Fibers in the material partially cleaned by the cylinder cleaner are propelled to the lint cleaner saw and seized by the saw teeth projecting from the saw cylinder. As the cylinder rotates, the lint is transported past the cleaning bars. The fibers retained on the rotating cylinder are subjected to further cleaning to remove any remaining foreign matter by a combination of centrifugal force, the scrubbing action between the cylinder and cleaning bars, and gravity. After the fibers on the cylinder have passed the cleaning bars, the cleaned fibers are removed from the cylinder by the doffing brush. Material removed from the primary saw cylinder/grid bar arrangement falls on the second saw cylinder and is metered and compressed by a powered splined roller or brush. The roller or brush is positioned and operated such that only the longer fiber ejected by the primary saw cylinder is retained by the secondary saw. Preliminary tests indicated reduced fiber loses and improved cleaning from the new lint cleaner. Operational features were also consistent with operation in a commercial gin.

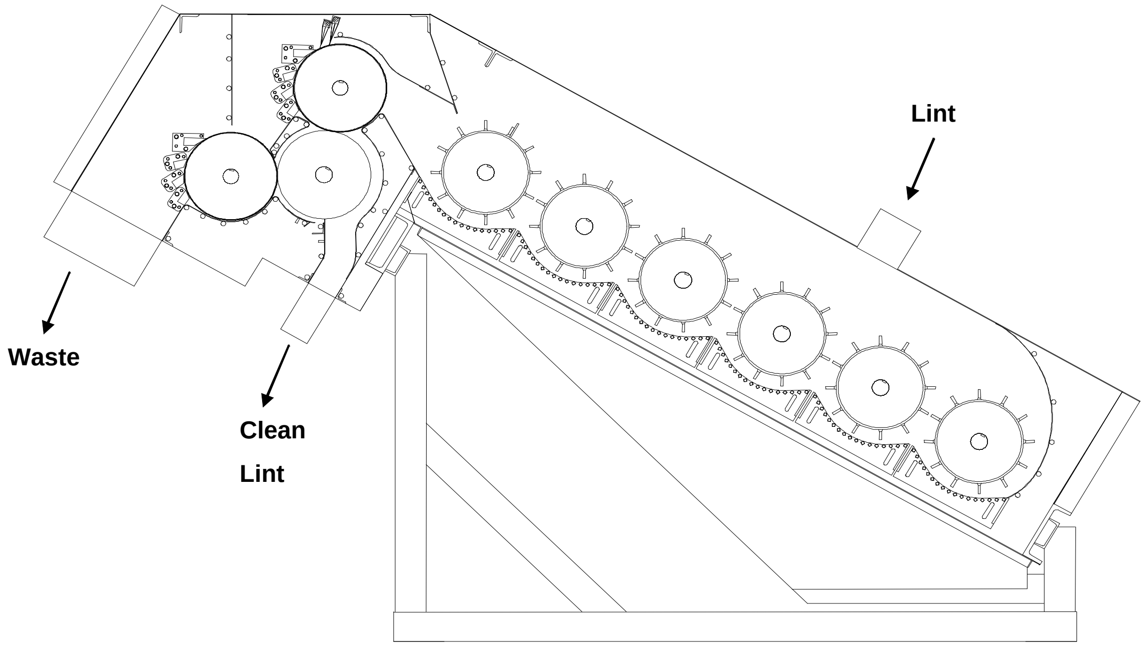

Figure 2. Cross-sectional view of the combined cylinder cleaner and lint cleaner with retaining saw. The splined roller used to apply the longer fiber to the saw is not shown.

Purpose

The purpose of this study was to evaluate the 18-in. wide cylinder cleaner/lint cleaner combination and determine its effectiveness in comparison to a standard saw-type lint cleaner.

Methodology

The experimental lint cleaner is essentially an 18-in. wide six-cylinder cleaner combined with a saw-type lint cleaner saw as well as a secondary saw to prevent fiber loss as described by Anthony (2003a) and referred to as "CCLCLC". The material ejected by the first saw is placed on the second saw by either a steel brush or splined roller to guide the longer fiber onto the saw. A cross-sectional drawing is at Figure 2.

This study was conducted in two parts: 1) The CCLCLC was compared to one stage of saw-type lint cleaning with two varieties of cotton, and 2) part 1 was repeated after small changes were made to the CCLCLC.

For Part 1, Stoneville 4892BR (cotton 1) and SureGrow 747 (cotton 2) varieties were used. Machine treatments were the CCLCLC at 1100 rpm and one lint cleaner at 950 rpm. About 80 pounds of cotton were used for each of 18 treatment combinations. Three samples each were taken for feeder moisture, lint moisture, feeder fractionation, AFIS, and HVI. Final lint weight adjusted for sampling was divided by the initial seed cotton weight adjusted for sampling to calculate lint turnout. The material rejected by the cylinder cleaner section of the CCLCLC as well as the saw section were collected and weighed separately. The fiber in each waste material was also weighed to estimate the true fiber wastage by each machine section.

For Part 2, Stoneville 4892BR and SureGrow 747 varieties were again used. Machine treatments were the CCLCLC and one lint cleaner. Operational adjustments that included the speed of the splined cylinder as well as the spacing above the saw were made to the lint cleaner and the CCLCLC to improve their performance before Study 2 was conducted. About 80 pounds were used for each of 18 treatment combinations. Three samples were taken for feeder moisture, lint moisture, feeder fractionation, AFIS, and HVI. Final lint weight adjusted for sampling was divided by the initial seed cotton weight adjusted for sampling to calculate lint turnout. The material rejected by the cylinder section of the CCLCLC as well as the saw sections were collected and weighed separately.

Results

Means for the gin data and HVI data are at Table 1. Means for the AFIS data are at Table 2. Analyses of variance are at Tables 3 and 4 (SAS 1996). Turnout, waste percent, and feeder moisture (but not lint moisture) was significant at the 5% level of probability for machine treatments. All variables in Table 1 were significant for variety and the interaction between machine treatment and cotton were significant for waste percent. All HVI factors were significant for machine treatments except uniformity and color. All HVI factors were significant for cottons. Nep size, neps per gram, seed coat neps per gram, total dust and dust per gram were significant for machine treatments. Most AFIS factors were significant for cottons.

Significant Interactions

The interaction for machine treatment and cotton was significant for HVI color, percent area and length. The interaction for machine treatment and cotton was significant for AFIS nep size, neps per gram, and seed coat neps per gram. Means for the significant interactions are at Table 5. The waste per 500-pound bale averaged across varieties was 15.2 and 7.0 pounds for one stage of saw-type lint cleaning and the CCLCLC, respectively, for an increased bale weight of 8.2 pounds. Fiber length (in.) was the same for both machines (1.10 and 1.11 for cotton 1 and 1.09 and 1.09 for cotton 2 for the one lint cleaner and CCLCLC, respectively,). Color was the same for both machine treatments for cotton 1 but the color was better for the CCLCLC (52 versus 51) for cotton 2. Neps per gram and seedcoat neps per gram were higher for the CCLCLC for both cottons but at differing amounts, likely creating the interaction.

Market Value

The parameters related to market value of the bales adjusted to a 500-lb bale are given in Table 6. For both cottons 1 and 2, the CCLCLC yielded the highest monetary return. The increased income for cottons 1 and 2 was $5.36 and $16.34, respectively.

Summary and Conclusions

The objective of this study was to evaluate a new-type lint cleaner to determine its effectiveness compared to a standard saw-type lint cleaner. The experimental lint cleaner (six cylinder cleaner combined with a saw-type lint cleaner cylinder as well as a secondary saw cylinder to prevent fiber loss) was compared to a standard saw-type lint cleaner. Two varieties of cotton were also used. Turnout and waste percent were significant for machine treatments. The HVI factors of micronaire, reflectance, plus b, leaf, percent area and length were statistically significant for machine treatments. Nep size, neps per gram, seed coat neps per gram, total dust and dust per gram were significant for machine treatments; most AFIS factors were significant for cottons, and the interaction for machine treatment and cotton was significant for nep size, neps per gram, and seed coat neps per gram.

The waste per 500-pound bale averaged across varieties was 15.2 and 7.0 pounds for one stage of saw-type lint cleaning and the CCLCLC, respectively, for an increased bale weight of 8.2 pounds. Fiber length was the same for both machines. Color was the same for both machine treatments for cotton 1 but the color was better for the CCLCLC (52 versus 51) for cotton 2. Neps per gram and seedcoat neps per gram were higher for the CCLCLC for both cottons but at differing amounts, likely creating the interaction. For both cottons 1 and 2, the CCLCLC yielded the highest monetary return. The increased income for cottons 1 and 2 was $5.36 and $16.34, respectively.
Further research to determine the optimum operating speeds for the spiked cylinders as well as the two saw cylinders in terms of cleaning and nepping potential is needed.

Disclaimer

Mention of a trade name, propriety product or specific equipment does not constitute a guarantee or warranty by the United States Department of Agriculture and does not imply approval of a product to the exclusion of others that may be suitable.

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Table 1. Means for gin data and HVI data for cotton and machine treatments.

Variable	Cotton 1		Cotton 2	
	1 LC	CCLCLC	1 LC	CCLCLC
	Gin data			
Moisture, %				
Lint	5.61	5.81	5.32	5.38
Feeder	8.65	9.12	7.65	8.06
Fractionation[1], %	4.08	3.94	3.18	3.29
Turnout, %	36.7	37.4	36.0	36.7
Waste, %				
Cylinder cleaner	0.00	1.06	0.00	0.63
Lint cleaner	3.65	0.66	2.42	0.46
Total	3.65	1.72	2.42	1.09
	HVI data			
Micronaire	5.11	5.16	4.95	4.96
Strength, g/tex	28.81	29.05	25.55	25.81
Rd	71.17	70.23	69.33	68.50
Plus b	9.22	9.04	8.40	8.35
Leaf	3.92	4.27	2.88	3.07
% area	0.06	0.09	0.03	0.04
Length, in.	1.100	1.111	1.087	1.090
Uniformity	83.88	83.87	83.21	83.27
Color	42	42	52	51

[1]Total foreign matter at the extractor-feeder apron.

Table 2. Means for AFIS variable for cotton and machine treatments (see Appendix A for abbreviations)

Variable	Cotton 1		Cotton 2	
	1 LC	CCLCLC	1 LC	CCLCLC
	AFIS data			
Lw, in.	1.01	1.01	0.97	0.97
Lwcv, %	28.7	28.6	30.0	30.0
UQLw, in.	1.17	1.17	1.15	1.15
SFCw, %	5.15	5.20	6.43	6.47
Ln, in.	0.86	0.86	0.82	0.82
Lncv, %	40.5	40.9	43.2	43.5
SFCn, %	16.8	17.2	20.0	20.3
lpt5, in.	1.32	1.32	1.29	1.29
l2pt5, in.	1.39	1.39	1.36	1.36
Fineness	190.9	191.0	182.9	183.6
IFC, %	2.72	2.74	3.15	3.19
Maturity Ratio	0.92	0.92	0.89	0.89
Nep size	690	719	684	690
Nep/gm	135	156	155	163
SCNsize	1182	1219	1245	1232
SCNgm	11.9	16.0	10.0	10.2
Total dust	363	519	238	315
Meansize, micron	489.7	465.5	412.8	421.5
Dust, gm	244.5	362.0	180.8	241.2
Trash, gm	118.2	156.7	57.3	73.4
VFM	2.05	2.83	1.02	1.48

Table 3. Analyses of variance for foreign matter, moisture, waste, and turnout.

Variable	Error	Cotton	Machine	Cotton *machine	R-Square	CV	MSE	Mean
Waste, %	0.11	7.74**	23.65**	0.82**	0.90	15.44	0.33	2.13
Turnout	0.15×10^{-4}	47.37×10^{-5}	48.35×10^{-5}**	0.04×10^{-5}	0.67	1.05	0.00	0.37
Feeder fractionation, total	0.07	5.31**	0.01	0.15	0.70	7.35	0.27	3.62
Feeder moisture	0.35	9.52**	1.70*	0.01	0.51	7.04	0.59	8.39
Lint moisture	0.06	1.14*	0.15	0.04	0.43	4.36	0.24	5.54
Mike	15.78×10^{-4}	2933.58×10^{-4}**	75.62×10^{-4}*	20.00×10^{-4}	0.86	0.79	0.04	5.05
Strength	0.16	93.86**	0.54	0	0.95	1.47	0.40	27.32
Rd	0.11	28.27**	6.94**	0.02	0.91	0.48	0.34	69.76
Plus b	0.01	5.07**	0.13**	0.03	0.94	1.12	0.10	8.75
Leaf	0.05	12.19**	0.91**	0.15	0.90	6.14	0.22	3.57
% Area	0.66	120.05×10^{-4}**	30.70×10^{-4}**	5.11×10^{-4}**	0.89	14.36	0.01	0.06
Length	0.35×10^{-4}	26.07×10^{-4}**	4.10×10^{-4}**	1.57×10^{-4}*	0.75	0.54	0.01	1.10
Uniformity	0.08	3.57×10^{-4}*	0.01	0.01	0.58	0.34	0.29	83.56
Color	0.13	789.11×10^{-4}**	0.1	0.1	1.00	0.76	0.36	46.66

* Indicates significance at the 5% level of probability.

** Indicates significance at the 1% level of probability.

Table 4. Analyses of variance for AFIS data.

	Error	Cotton	Machine	Cotton *machine	R-Square	CV	MSE	Mean
Lw	0.46×10^{-4}	109.15×10^{-4}**	0.34×10^{-4}	0.01×10^{-4}	0.88	0.69	0.01	0.99
Lwcv	0.18	16.26**	0.01	0.03	0.74	1.46	0.43	29.31
UQLw	0.36×10^{-4}	52.63×10^{-4}**	0.39×10^{-4}	0.04×10^{-4}	0.82	0.52	0.01	1.6
SFCw	0.09	14.39**	0.02	0.01	0.83	5.2	0.3	5.8
Ln	0.82×10^{-4}	165.95×10^{-4}**	0.47×10^{-4}	0.03×10^{-4}	0.86	1.08	0.01	0.84
Lncv	0.55	63.27**	1.15	0.03	0.79	1.76	0.74	42.03
SFCn	0.63	90.17**	0.8	0.06	0.82	4.29	0.79	18.6
1pt5	0.37×10^{-4}	77.79×10^{-4}**	0.01×10^{-4}	0.02×10^{-4}	0.87	0.47	0.01	1.3
12pt5	0.68×10^{-4}	81.11×10^{-4}**	0.57×10^{-4}	0.31×10^{-4}	0.79	0.6	0.01	1.38
Fine	2.2	529.31*	1.2	0.71	0.88	0.79	1.48	187.1
IFC	0.03	1.75**	0.01	0.01	0.67	5.67	0.17	2.95
Matrat	0.31×10^{-4}	122.79×10^{-4}**	0.14×10^{-4}	0.12×10^{-4}	0.93	0.62	0.01	0.91
Nepsize	140.3	2889.34**	2651.39**	1224.61**	0.62	1.7	11.84	697
Nepgm	85.63	1528.33**	1859.23**	416.58*	0.57	6.05	9.3	153
SCNsize	7133.75	12985.17	1373.19	5330.11	0.07	6.92	84.46	1220
SCNgm	6.84	128.64**	39.98*	33.08*	0.5	21.51	2.61	12.2
Total	8095.45	239890.17**	120081.95**	13860.11	0.6	24.66	89.97	365
Meansize	1953.38	32445.99**	529.31	2395.62	0.35	9.89	44.2	447
Dust/gm	6218.24	75686.01**	70369.34**	7232.67	0.45	30.09	78.86	262.1

* Indicates significance at the 5% level of probability.

** Indicates significance at the 1% level of probability.

Table 5. Means for the significant interactions.

Variables		Means for significant interactions					
Cotton[1]	Machine[2]	Waste, %[3]	Nep/gm	SCN/gm	Color	% Area	Length, in.
1	1 LC	3.65	135	11.9	42	0.061	1.10
	CCLCLC	1.72	156.3	16	42	0.087	1.11
2	1 LC	2.42	154.9	10	52	0.032	1.09
	CCLCLC	1.09	165.5	10.2	51	0.043	1.09

[1] Cotton 1=STV4892BR and Cotton 2=SG747.

[2] LC=one saw-type lint cleaner. CCLCLC=18-inch wide cylinder cleaner operated at 1100 rpm with square grid bars and a saw cylinder with retaining saw. All machine treatments include dryer (125 °F), one cylinder cleaner, stick machine, Trashmaster, and Continental extractor-feeder and 20-saw gin stand.

[3] Waste, %, is multiplied by 5 to obtain waste per 500-pound bale, i.e. 18.25, 8.6, 12.1, and 5.4.

Table 6. Machine performance adjusted to 500-lb bale.

Variables		Marketing means per bale						
Cotton[1]	Machine[2]	Bale weight, lbs.	Waste, lbs.	Color	Leaf	Length, in.	Value, $ per lb[3]	Value, $ per bale
1	1 LC	481.75	18.25	42	4	1.10	0.504	242.80
	CCLCLC	491.4	8.6	42	4	1.11	0.505	248.16
2	1 LC	487.9	12.1	52	3	1.09	0.483	235.66
	CCLCLC	500	5.4	51	3	1.09	0.504	252.00

[1] Cotton 1=STV4892BR and Cotton 2=SG747.

[2] LC=one saw-type lint cleaner. CCLCLC=18-inch wide cylinder cleaner operated at 1100 rpm and equipped with square grid bars and a saw cylinder with retaining saw. All machine treatments include dryer (125 °F), one cylinder cleaner, stick machine, Trashmaster, and Continental extractor-feeder and 20-saw gin stand.

[3] Based on the 2003 Commodity Credit Corporation prices per pound at Greenwood, MS.

Appendix A. Description of Advanced Fiber Information System and High Volume Instrument variables.

Variable	Description
	Advanced Fiber Information System variables
Nep Size [μM]	The mean size of all neps (AFIS includes both fiber and seed coat neps) in the sample.
Neps per gram	The total nep count normalized per gram. This includes both fiber and seed coat neps.
L(w) [in.]	The average length of all the fibers in the sample computed on a weight basis.
L(w) CV [%]	The percentage of the coefficient of variation of the length by weight.
UQL(w) [in.]	Upper quartile length by weight. This is the length which is exceeded by 25% of the fibers by weight.
SFC(w) [%]	The short fiber content of the sample (calculated by weight).
L(n) [in.]	The average length of all the fibers in the sample computed on a number basis.
L(n) CV [%]	The percentage of the coefficient of variation of the length by number.
SFC(n) [%]	The short fiber content of the sample (actual fibers counted by number).
L5%(n) [in.]	The length, calculated by number, that is exceeded by five percent of the fibers.
L2.5%(n) [in.]	The length, calculated by number, that is exceeded by 2.5 percent of the fibers.
Total trash	Total trash consists of trash and dust; this is the total of the trash [count/gram] and dust count per gram of the sample.
Trash size [μM]	The mean size of all the trash in the sample.
Dust [count/gram]	The particles measured by the trash module that are below the size defined as dust on the trash report type setup screen.
Trash [count/gram]	All foreign matter in cotton that is above the size defined as dust is considered trash. This is the amount of trash per gram of the sample.
VFM [%]	The percentage of visible foreign matter (dust and trash) in the sample.
SCN size [μM]	The mean size of all seed coat neps in the sample.
SCN per gram	The seed coat nep count normalized per gram.

FINE [mTex]	Fineness - mean fiber fineness (weight per unit length) in millitex. One Thousand meters of fibers with a mass of 1 milligram equals 1 millitex.
IFC [%]	immature fiber content is the percentage of fibers with less than 0.25 maturity. The lower the ifc%, the more suitable the fiber is for dyeing.
Mat Ratio	Maturity ratio - the ratio of fibers with a 0.5 (or more) circularity ratio divided by the amount of fibers with a 0.25 (or less) circularity. The higher the maturity ratio, the more mature the fibers are and the better the fibers are for dyeing.
	High Volume Instrument Variables
Micronaire	Micronaire is a measure of fineness and maturity variable.
Strength	Strength measurements are reported in terms of grams per tex. A tex unit is equal to the weight in grams of 1,000 meters of fiber.
Rd and Plusb	The color of cotton is determined by the degree of reflectance (rd) and yellowness (+b). Reflectance indicates how bright or dull a sample is, and yellowness indicates the degree of color pigmentation.
Percent area	Trash is a measure of the amount of non-lint materials in the cotton, such as leaf and bark from the cotton plant. The surface of the cotton sample is scanned by a video camera and the percentage of the surface area occupied by trash particles is calculated.
Length	Fiber length is the average length of the longer one-half of the fibers (upper half mean length).
Uniform	Length uniformity is the ratio between the mean length and the upper half mean length of the fibers and is expressed as a percentage.