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ENGINEERING AND GINNING

Evaluating Newly Designed Lint Cleaner Grid Bars to Remove Seed Coat Fragments

Carlos B. Armijo*, Christopher D. Delhom, Derek P. Whitelock,
Sidney E. Hughs, and Marvis N. Gillum

ABSTRACT

An experiment was conducted to remove seed coat fragments (SCF) with a saw-type lint cleaner using newly designed grid bars. The test consisted of one control and five experimental grid bar designs, and a treatment that contained no lint cleaning (No LC). Two types of cotton were used, a common upland cultivar and a cultivar known to have a fragile seed coat that breaks easily and contaminates lint with SCF. Results showed that fiber from the Acala cultivar was longer, more uniform, contained less short fiber, had fewer neps, and fewer seed coat neps (SCN) than the fragile cultivar. There were differences in fiber properties among lint cleaning treatments, but those differences were between the treatment that contained No LC and the grid bar treatments collectively. Visible foreign matter in ginned lint was not different among lint cleaning treatments. Both AFIS seed coat nep count and a manual count of SCF, which were used as indicators for SCF, were not different among lint cleaning treatments. As expected, fiber in the lint cleaner waste was shorter, and contained more short fiber and more neps than fiber in the bale, but SCN count in the lint cleaner waste also was not different among grid bar designs. High-speed videography showed that SCF were not removed by colliding with the grid bars, but were actually drawn back into the lint stream by attached fiber. Other means to separate SCF from ginned fiber are being investigated.

Seed coat fragments (SCF) in ginned lint cause quality problems during textile mill processing (Hebert et al., 1986; Hughs et al., 1988; Jacobsen et al., 2001; Krifa and Gourlot, 2001). SCF are defined as bits of seed coat tissue with attached lint (Brown and Ware, 1958). They are formed during the harvesting and ginning operations and can originate from undamaged mature cottonseed, damaged cottonseed, or immature cottonseed (Bargeron and Garner, 1991). Pearson (1955) reported that SCF affect not only the quality of the finished product but are a factor while processing yarn, and are often responsible for ends down or yarn breakage in spinning. These fiber “tufts” appear in dyed yarn or cloth as undesirable specks, and might lead to a hole or weakened spot in the yarn or fabric (Pearson, 1955). Whether the fragments are caused by production or ginning practices, weather events, or some inherent trait, they must be avoided as much as possible.

Past research at the USDA-ARS Southwestern Cotton Ginning Research Laboratory has attempted to alleviate SCF at the harvester, saw gin stand, roller gin stand, and seed cotton cleaning process, but these efforts were only somewhat effective (Armijo et al. 2006a, b; Armijo et al., 2009a). More recent research at the laboratory has focused on alleviating SCF at the saw-type lint cleaner with newly designed grid bars.

Past studies by Mangialardi and Shepherd (1968) and Mangialardi (1987) showed that SCF were not reduced with different levels of saw-type lint cleaning, but both of these studies used conventional grid bars in the lint cleaners. Leonard et al. (1982) tested notched grid bars on a saw-type lint cleaner, and found that even though the notched grid bars reduced lint cleaner waste and lint loss, fiber quality was not improved and the grid bars were not recommended over conventional grid bars. Baker and Brashears (1989) tested grid bar spacing, grid sharpness, and grid-to-saw clearance, and found that grid bar spacing and sharpness affected lint loss, but did not improve fiber quality. The studies by Leonard et al. (1982) and Baker and Brashears (1989) did not focus on removing SCF. More recently, there has been related research on grid bar designs by Whitelock and Anthony (2003), Ray (2006), and Wanjura et al. (2009), but these studies evaluated grid bars on

C.B. Armijo, D.P. Whitelock, S.E. Hughs, and M.N. Gillum, USDA-ARS Southwestern Cotton Ginning Research Laboratory, PO Box 578, Mesilla Park, NM 88047; and C.D. Delhom, USDA-ARS Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, LA 70124.
*Corresponding author: cararmij@nmsu.edu

machines used mainly to clean seed cotton, and not lint, and they did not focus on removing SCF.

Armijo et al. (2009b) tested 10 model-sized newly designed grid bars mounted on a lint cleaner simulator. A fiber bundle with an attached SCF was subjected to the grid bars, and a high-speed video camera recorded the action that took place as the SCF collided with the grid bar. Results showed that four out of the 10 model-size grid bars performed best in removing SCF from the fiber bundle (particularly the 105° and 60° grid bars that had a second edge), and warranted full-size testing on a commercial saw-type lint cleaner. These four grid bar designs were subsequently made full size and tested in a 2010 study.

Results from the 2010 study showed that AFIS seed coat nep (SCN) count, which was used as an indicator for the presence of SCF, was not different among grid bar designs in either the lint sample after lint cleaning or the lint portion of the lint cleaner trash (Armijo et al., 2011). There was variability in SCN count. There were differences among grid bar designs in trash content in the lint and lint loss in the lint cleaner trash. The 105°, 60°, and 45° grid bars (those with one or more active edges) had less lint loss as the angle of the sharp toe of the grid bar decreased. However, the test used a larger clearance between the grid bar and lint cleaner saw than that used on the study with the lint cleaner simulator (Armijo et al., 2009b), and the control treatment was run on a different (but similar make and model) lint cleaner that was not operating at optimum. The 2010 study was repeated in 2012 with a smaller clearance between the grid bar and lint cleaner saw, a control treatment that used grid bars mounted on the same lint cleaner, and one additional newly designed grid bar. Results of the 2012 study are presented here.

The objective of the study was to determine if SCF could be removed from ginned lint with experimental lint cleaner grid bars. Both AFIS SCN count and a manual count of seed coat fragments were used to indicate levels of fragments in the lint. The study included a cultivar known to have elevated levels of SCF.

MATERIALS AND METHODS

Figure 1 shows a cross section of the five experimental grid bars tested: 105°, 60°, 45°, 0°R, and 90°R. The grid bars were labeled to identify the included angle from the sharp toe (or the angle from vertical) of the grid bar. The 105° and 60° grid bars had a small surface approximately 1.7 mm (0.069 in) from the toe of the bar, giving these bars a second edge to help remove the SCF. The 45° grid bar did not have a second edge and the surface length from the toe of the grid bar was approximately 14 mm (0.563 in). The 0°R grid bar did not have a definite angle but instead had a 0.79-mm (0.031-in) radius. The 90°R grid bar was similar to the 0°R grid bar, but included one edge and a radius of 90°. The grid bars were 1.64-m (64.375-in) long and made out of aluminum.

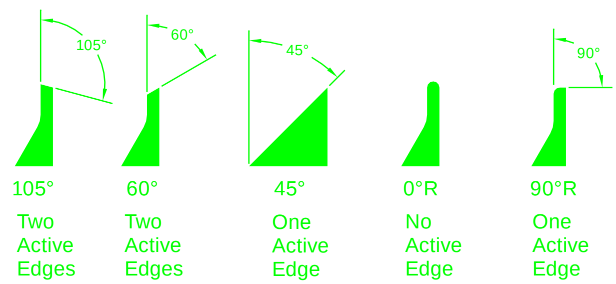

Figure 1. Detailed cross section of the five experimental grid bars used in the study.

Figure 2 shows a side view of the 45° grid bars as an example of how the experimental grid bars were placed in relation to the lint cleaner saw. A commercial Continental Lodestar (Bajaj ConEagle LLC, Millbrook, AL) saw-type lint cleaner was used in the test. The Lodestar was 1.7-m (66-in) wide, had a 406-mm (16-in) diameter saw cylinder that ran at 1033 rpm, and contained five grid bars. The distance from the feed plate to the lint cleaner saw was 1.6 mm (0.063 in), from the feed roller to the feed plate was 0.25 mm (0.010 in) (floating-spring loaded), and from the grid bar to the saw was approximately 1 mm (0.038 in). The distance from the grid bar to the saw in the 2010 study (Armijo et al., 2011) was 1.6 mm (0.063 in), but it was decided that this gap was too wide and that a narrower gap might give the grid bar a better opportunity to remove the SCF. Also, the manufacturer (Continental) recommended a distance of 0.8 mm (0.031 in) from the saw to the grid bar (USDA, 1977). Because flexing of the aluminum experimental grid bars caused interference with the saw at 0.8-mm (0.031-in) clearance, the distance from the grid bar to the saw was set to approximately 1 mm (0.038 in). The Lodestar had a 457-mm (18-in) diameter doffing brush. Saw-type lint cleaners typically use a combing ratio (the ratio between the rim speed of the saw and the rim speed of the feed roller) between 16 and 28 (USDA, 1994); the combing ratio averaged 25 during the test.

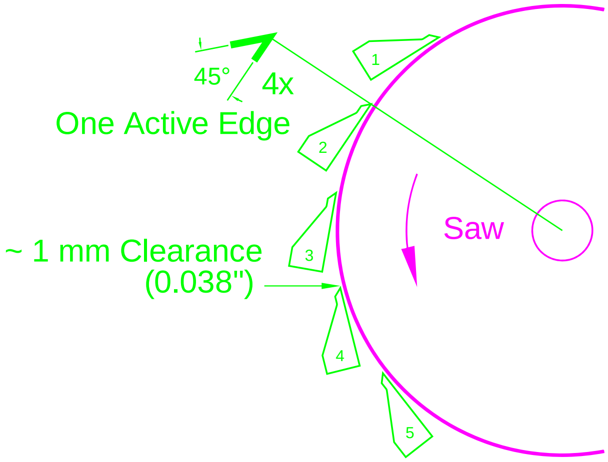

Figure 2. Side view of experimental 45° grid bars in relation to the lint cleaner saw.

The test included conventional (control) grid bars to compare with the experimental grid bars. The control treatment was run on the same lint cleaner as the experimental grid bars. The control grid bars had an included angle from the sharp toe of 32° on the first grid bar, and 55° on the remaining four bars of the set. The control grid bars also were made out of aluminum. Figure 3 shows the control grid bars in relation the lint cleaner saw.

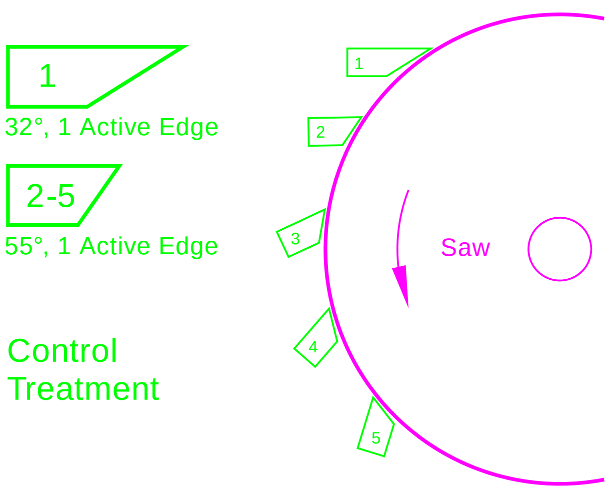

Figure 3. Side view of control grid bars in relation to the lint cleaner saw.

The study was conducted at the USDA-ARS Southwestern Cotton Ginning Research Laboratory in Mesilla Park, NM. The test consisted of the six grid bar designs (five experimental and one control), two types of cotton, and three replications for a total of 36 lots. Each lot consisted of 102 kg (225 lb) of seed cotton. The cottons included an upland cultivar (Acala 1517-08), and a cultivar (not disclosed) known to have a fragile seed coat that might be more sensitive to differences in grid bar design. Both cottons were grown and picker harvested in the Mesilla Valley of southern New Mexico. To prevent contaminating the samples taken between ginning lots of different cultivars, the two cultivars were precleaned separately prior to running the lint cleaner treatments. The precleaning sequence was a six-cylinder incline, stick machine, and six-cylinder incline. A 46-saw Continental/Murray Double Eagle saw gin stand and Continental/Moss-Gordin Galaxy stick-machine-type feeder were used. The experimental design was a split-plot, randomized, complete block with replications serving as blocks. Cultivar was randomized within grid bar design, and grid bar design was randomized within replication. Analysis of variance was performed with the GLIMMIX (Generalized Linear Mixed Models) procedure of SAS (version 9.2; SAS Institute, Inc., Cary, NC) with rep and grid-bar-treatment*rep assigned as random effects. Differences between main effect least square means were tested with Tukey's studentized range test.

Sampling included seed cotton at the wagon and feeder, cottonseed at the seed belt, lint samples before and after lint cleaning, and trash samples at the lint cleaner. Fiber properties of the lint samples taken before lint cleaning were included in the statistical design to compare a no lint cleaning treatment (No LC) with the grid bar treatments. There were two subsamples taken during each ginning lot of which the quality measurements were averaged together. The trash content of the seed cotton samples were determined using the pneumatic fractionation method, and the moisture content of lint samples was determined using the oven drying method (Shepherd, 1972). The USTER (Uster Technologies, Inc., Charlotte, NC) Advanced Fiber Information System (AFIS), High Volume Instrument (HVI), and Shirley Analyzer at both the USDA-ARS Southern Regional Research Center (New Orleans, LA) and Cotton Incorporated (Cary, NC) were used to determine the fiber and lint cleaner waste properties. Cottonseed analysis was performed at Mid-Continent Laboratories (Memphis, TN) according to the Trading Rules of the National Cottonseed Products Association (National Cottonseed Products Association, 1997). A manual count of SCF was determined using the Standard Test Method for Seed Coat Fragments and Funiculi in Cotton Fiber Samples (ASTM, 1979). Loan rate was based on HVI fiber quality measurements using 2009 to 2010 Commodity Credit Corporation (CCC) prices. Bale value was calculated using loan rate and turnout, and was based on 682 kg (1500 lb) of seed cotton. Color grades were coded to facilitate statistical analysis. For example, code 100 = color grade 31, code 104 = color grade 21, and code 105 = color grade 11. Lint loss was determined from the fiber portion of lint cleaner waste, and lint cleaner efficiency was determined from visible foreign matter content in the lint samples.

RESULTS AND DISCUSSION

Foreign matter content at the wagon was 10.2 and 9.6% (dirty basis) for the fragile and Acala cultivar, respectively, and moisture content at the wagon was 4.3 and 5.5% (dry basis) for the fragile and Acala cultivar, respectively.

Table 1 shows initial foreign matter and moisture content of the ginning lots, ginning rate, turnout, and bale value. Foreign matter content (dirty basis) of the seed cotton at the feeder was not different among lint cleaner treatments, but was different between cultivars; the fragile cultivar was 1.2% and the Acala cultivar was 1.9%. Moisture content (dry basis) at the lint cleaner also was not different among lint cleaner treatments and was different between cultivars, but only ranged from 4.2 to 4.5%. Temperature and relative humidity in the ginning plant were not different among lint cleaner treatments or between cultivars and averaged 26.1 °C (79 °F) and 21.2%, respectively. Ginning rate was not different among lint cleaner treatments, but was different between cultivars; the fragile cultivar was 958 kg/m/hr and the Acala cultivar was 914 kg/m/hr. Lint cleaner processing rate was not different among lint cleaner treatments, but was different between cultivars; 446 kg/m/hr for the fragile cultivar and 426 kg/m/hr for the Acala cultivar. Turnout was different among lint cleaning treatments. The best turnout occurred with the No LC treatment (42.8%) due to no waste being removed. The 45° grid bar treatment had the next highest turnout at 41.7%. Although loan rate was significantly different among lint cleaning treatments (Observed Significance Level = 0.0076), Tukey's studentized range test ($p \leq 0.05$) did not separate the means and loan rate averaged 53.79¢. Bale value was not different among lint cleaning treatments and averaged $328.22. Although the No LC treatment had 1.8% higher turnout, the additional weight in the bale was not enough to overcome the discount for lower color and leaf grades, and bale value was statistically the same as the treatments that contained lint cleaning. The fragile cultivar had a 9.3 percentage point higher turnout and a 10.6% higher bale value than the Acala cultivar. High turnout is one of the fragile cultivar's strong qualities.

Table 1. Least square means and statistical analysis of foreign matter and moisture contents, gin plant conditions, gin and lint cleaner process rate, turnout, loan rate, and bale value, by lint cleaner treatment and cultivar

Treatment	Trash Content Feeder	Moisture Content Feeder	Moisture Content LC	Room Temp.	Room R.H.	Gin Process Rate	LC[z] Process Rate	Turnout	Loan Rate	Bale Value
	%	%	%	°C	%	kg/m/hr	kg/m/hr	%	¢	$
					Lint Cleaner Treatment[y]					
No LC	1.58	5.08	4.31	26.1	21.1	936	436	42.8 a	53.17 a	324.93
105° Grid Bar	1.56	4.95	4.17	25.1	16.7	900	419	40.8 b	53.85 a	327.07
60° Grid Bar	1.55	5.31	4.82	26.4	33.5	959	447	40.4 b	54.04 a	324.90
45° Grid Bar	1.63	5.04	4.16	26.3	17.0	944	440	41.7 ab	53.70 a	333.03
0°R Grid Bar	1.63	5.07	4.35	25.4	20.8	914	426	40.7 b	53.78 a	325.37
90°R	1.62	5.05	4.26	26.5	20.7	956	445	41.0 b	53.88 a	329.05
Control LC	1.48	5.06	4.08	26.7	18.2	943	440	41.3 b	54.12 a	333.19
					Cultivar[y]					
Fragile	1.22 b	4.97 b	4.17 b	26.0	21.2	958 a	446 a	45.9 a	50.41 b	344.73 a
Acala	1.94 a	5.19 a	4.45 a	26.1	21.1	914 b	426 b	36.6 b	57.17 a	311.71 b
					Observed Significance Level[x]					
LC	NS	NS	NS	NS	NS	NS	NS	0.0001	0.0076	NS
Cultivar	< 0.0001	0.0014	0.0118	NS	NS	0.0002	0.0002	< 0.0001	< 0.0001	< 0.0001
LC*Cultivar	NS	NS	NS	NS	NS	NS	NS	NS	0.0007	NS

[z] LC = lint cleaner.

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] NS = not statistically significant at ($p > 0.05$).

Table 2 shows the cottonseed properties. None of the cottonseed properties were different among lint cleaning treatments (this was expected); linters content and total foreign matter averaged 12.0 and 0.37%, respectively. Some cottonseed properties were different between cultivars. The fragile cultivar was 1.7 and 1.4 percentage points higher than the Acala cultivar in linters and oil content, respectively. Cottonseed grade was different between cultivars and averaged 114 and 115 for the fragile and Acala cultivar, respectively.

Tables 3 and 4 show the AFIS fiber properties. Saw-type lint cleaning usually decreases fiber length and increases the amount of fiber neps. Surprisingly, none of the treatments that used lint cleaning appeared to harm fiber length. The No LC treatment and the two gird bars with double edges (105° and 60°) on average had longer fiber than the other experimental grid bars and the control. However, fiber length, upper-quartile length, and short fiber content were not statistically different among lint cleaner treatments and averaged 23.2 mm, 28.8 mm, and 12.2%, respectively. Results from this test confirm that saw-type lint cleaning increases the amount of fiber neps, as AFIS nep count and nep size were different among lint cleaner treatments. The No LC treatment had fewer neps (265 per gram) than all the grid bar treatments, except the 105° grid bar (300 neps per gram). The 45° grid bar had the highest average nep count, which was approximately 30% more neps than the No LC treatment. No LC had the largest average nep size (773 µm), and nep size appeared to decrease slightly with the use of lint cleaning. Only the control and 0°R grid bar (746 and 747 µm, respectively) had significantly smaller neps than No LC. Fiber length, short fiber content, and nep count were different between cultivars. The Acala cultivar was about 16% longer, had 3.5 percentage points less short fiber, and 7.6% fewer neps than the fragile cultivar.

Table 4 shows that the grid bar treatments did remove foreign matter from the fiber. All of the AFIS foreign matter measurements, except SCN count, were different among lint cleaning treatments with the No LC treatment being separate from the grid bar treatments. For example, total trash count was 885 particles per gram with No LC, and averaged 290 particles per gram for the grid bar treatments. Similarly, visible foreign

Table 2. Least square means and statistical analysis of cottonseed properties, by lint cleaner treatment and cultivar

Treatment	Linters	Total Foreign Matter	Moisture	Free Fatty Acids	Oil	Ammonia	Net Quality Index	Quantity Index	Grade
	%	%	%	%	%	%	Index	Index	Index
				Lint Cleaner Treatment					
No LC[z]	12.0	0.36	4.17	0.63	21.1	4.21	100	114	114
105°	11.8	0.35	4.20	0.64	20.9	4.25	100	114	114
60°	12.0	0.35	4.21	0.63	21.4	4.21	100	116	116
45°	12.3	0.38	4.15	0.62	20.9	4.23	100	114	114
0°R	11.8	0.36	4.18	0.60	20.9	4.14	100	113	113
90°R	12.0	0.36	4.09	0.60	21.4	4.20	101	116	116
Control LC	12.4	0.38	4.21	0.72	20.9	4.21	100	114	114
				Cultivar[y]					
Fragile	12.9 a	0.37	4.17	0.60 b	20.4 b	4.49 a	100	114 b	114 b
Acala	11.2 b	0.36	4.17	0.67 a	21.7 a	3.93 b	100	115 a	115 a
				Observed Significance Level[x]					
LC	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cultivar	< 0.0001	NS	NS	0.0038	< 0.0001	< 0.0001	NS	0.0027	0.0030
LC*Cultivar	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z] LC = lint cleaner.

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] NS = not statistically significant at ($p > 0.05$).

matter was 3.3% with No LC, and averaged 1.4% for the grid bar treatments. The fragile cultivar had about 64% more visible foreign matter than the Acala cultivar. AFIS SCN count was the fiber property used as an indicator for the level of SCF. Table 4 shows that SCN count was different between cultivars; the fragile cultivar had 53 SCN per gram and the Acala cultivar had 32 SCN per gram. This was expected as the fragile cultivar was chosen due to its larger amount of seed coat neps. However, SCN was not different among lint cleaning treatments. In addition, a manual count and combined mass of SCF showed no difference among grid bar treatments (the No LC treatment was not evaluated), but did show differences between cultivars. Manual count of SCF was 58 and 35 fragments per 5 g of fiber for the fragile and Acala cultivar, respectively. Combined mass of SCF was 77.1 and 35.0 mg per 5 g of fiber for the fragile and Acala cultivar, respectively.

Table 5 shows the HVI fiber properties. Micronaire, fiber length, uniformity, color grade, and leaf grade were different among lint cleaning treatments. Differences in micronaire were probably due to the higher leaf grade found in the No LC treatment, which affected the measurement. As expected, the No LC treatment tended to have the longest fiber (28.7 mm or 36.2 staple length) and best uniformity (81.8%), but the No LC treatment also had a significantly reduced color grade of 21 (which is still acceptable) and higher leaf grade of almost 4. Length was reduced almost one staple length overall due to lint cleaning, but the 105°, 0°R, and control grid bars performed the best and averaged 28.2 mm (35.5 staple length). Uniformity was approximately 1 percentage point less due to lint cleaning with the 90°R grid bar performing the best among grid bar treatments. Color grade and leaf grade improved significantly with lint cleaning; the grid bar treatments were not different and averaged 11 and 2.1, respectively. With the exception of color grade, all HVI fiber properties were different between cultivar with the Acala cultivar being longer by approximately six staple lengths, more uniform by approximately 2 percentage points, stronger by 6 g/tex, and having a slightly more favorable leaf grade (2.3 versus 2.4) than the fragile cultivar. Color grade was not different between cultivars and averaged 105 (11 new code).

Table 3. Least square means and statistical analysis of AFIS fiber properties, by lint cleaner treatment and cultivar

Treatment	Length[z]	Upper Quartile Length[z]	Short Fiber Content[z]	Fineness	Immature Fiber Content	Maturity Ratio	Nep Count	Nep Size
	mm	mm	%	m-tex	%	-	per g	µm
				Lint Cleaner Treatment[y]				
No LC[x]	23.6	29.2	11.5	164	6.39 a	0.90 a	265 b	773 a
105°	23.4	29.0	11.5	162	6.35 a	0.90 ab	300 ab	751 ab
60°	23.3	29.0	11.8	161	6.73 a	0.89 b	318 a	755 ab
45°	23.0	28.7	12.5	162	6.92 a	0.89 b	344 a	751 ab
0°R	22.8	28.4	12.7	164	6.61 a	0.89 ab	315 a	747 b
90°R	22.9	28.8	12.4	164	6.73 a	0.89 ab	319 a	756 ab
Control LC	23.2	28.6	12.7	163	6.90 a	0.88 ab	334 a	746 b
				Cultivar[y]				
Fragile	21.4 b	26.5 b	13.9 a	164 a	7.07 a	0.88 b	326 a	776 a
Acala	24.9 a	31.1 a	10.4 b	162 b	6.25 b	0.91 a	301 b	733 b
				Observed Significance Level[w]				
LC	NS	NS	NS	NS	0.0110	0.0034	0.0014	0.0030
Cultivar	< 0.0001	< 0.0001	< 0.0001	0.0253	< 0.0001	< 0.0001	< 0.0001	< 0.0001
LC*Cultivar	NS	NS	NS	NS	NS	NS	NS	NS

[z] By the weight method.

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] LC = lint cleaner

[w] NS = not statistically significant at ($p > 0.05$).

Table 4. Least square means and statistical analysis of AFIS fiber properties and manual count of seed coat fragments, by lint cleaner treatment and cultivar

Treatment	Seed Coat Nep Count	Seed Coat Nep Size	Dust Count	Trash Count	Total Trash Count	Trash Size	Visible Foreign Matter	Seed Coat Fragment Count	Seed Coat Fragment Weight
	per g	mm	per g	per g	per g	µm	%	per 5 g	mg/5 g
				Lint Cleaner Treatment[z]					
No LC[y]	44.2	1281	753 a	131 a	885 a	329 b	3.33 a	-----	-----
105°	41.2	1294	225 b	53.5 b	279 b	369 a	1.30 b	45.5	57.0
60°	42.8	1269	256 b	57.7 b	314 b	374 a	1.54 b	47.4	57.7
45°	45.3	1257	225 b	49.8 b	275 b	366 a	1.44 b	47.2	58.1
0°R	41.0	1258	246 b	54.3 b	300 b	373 a	1.50 b	43.6	51.0
90°R	43.3	1286	237 b	50.5 b	287 b	369 a	1.48 b	54.2	61.4
Control LC	41.9	1262	233 b	47.8 b	282 b	364 a	1.33 b	42.1	51.2
				Cultivar Treatment[z]					
Fragile	53.3 a	1302 a	290 b	65.6	355	393 a	2.12 a	58.3 a	77.1 a
Acala	32.3 b	1243 b	332 a	61.4	393	334 b	1.29 b	35.0 b	35.0 b
				Observed Significance Level[x]					
LC	NS	NS	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	NS	NS
Cultivar	< 0.0001	0.0003	0.0302	NS	NS	< 0.0001	< 0.0001	< 0.0001	< 0.0001
LC*Cultivar	NS	NS	0.0001	0.0325	0.0001	NS	NS	NS	NS

[z] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] LC = lint cleaner.

[x] NS = not statistically significant at ($p > 0.05$).

Table 5. Least square means and statistical analysis of HVI fiber properties, by lint cleaner treatment and cultivar

Treatment	Micron-aire	UpperHalf Mean Length	Staple Length	Unifor-mity	Strength	Reflec-tance	Yellow-ness	Color Grade[z]	Leaf grade
	Reading	mm	1/32 in	%	g/tex	Rd	+b	Index	index
				Lint Cleaner Treatment[y]					
No LC[x]	4.57 a	28.7 a	36.2 a	81.8 a	29.8	78.1 b	9.33 b	21 b	3.90 a
105°	4.44 b	28.2 ab	35.3 b	80.8 b	30.6	80.9 a	9.80 a	11 a	2.08 b
60°	4.39 b	28.1 b	35.4 b	80.8 b	30.7	81.3 a	9.94 a	11 a	2.08 b
45°	4.43 b	28.0 b	35.3 b	80.6 b	30.8	81.2 a	9.75 a	11 a	2.08 b
0°R	4.43 b	28.3 ab	35.6 ab	80.8 b	30.9	81.3 a	9.78 a	11 a	2.17 b
90°R	4.44 b	28.1 b	35.3 b	81.0 ab	30.5	81.5 a	9.82 a	11 a	2.25 b
Control LC	4.40 b	28.2 ab	35.5 ab	80.7 b	30.3	81.2 a	9.83 a	11 a	2.00 b
				Cultivar[w]					
Fragile	4.59 a	25.8 b	32.4 b	79.9 b	27.5 b	80.4 b	10.2 a	11	2.44 a
Acala	4.30 b	30.7 a	38.6 a	82.0 a	33.5 a	81.1 a	9.32 b	11	2.29 b
				Observed Significance Level[x]					
LC	0.0005	0.0032	0.0017	0.0011	NS	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Cultivar	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	NS	0.0139
LC*Cultivar	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z] Statistical analysis conducted using coded values (see text for explanation).

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[x] LC = lint cleaner

[w]NS = not statistically significant at ($p > 0.05$).

Table 6 shows foreign matter in the ginned lint and lint cleaner waste determined by the Shirley Analyzer, and lint cleaner efficiencies. When discussing results from the Shirley Analyzer, it should be noted that the makeup of ginned lint is approximately 97% fiber and 2% foreign matter, whereas the makeup of the lint cleaner waste is approximately 38% fiber and 54% foreign matter. Visible trash content in the lint was approximately 6% with No LC, and was reduced to approximately 2% due to lint cleaning, but there were no differences among the grid bar treatments. However, there were differences among grid bar treatments in the makeup of the lint cleaner waste. The 0°R grid bar had significantly less visible trash content (47.1%) in the lint cleaner waste than the 45° grid bar (56.3%), with the other grid bar treatments in between. These results are corroborated with lint cleaner lint loss (Table 6) where the 0°R grid bar (the least aggressive grid bar) had the highest average lint loss at 2.76% and the 45° grid bar had the lowest lint loss at 1.36%, although lint loss was not significantly different among grid bars. Lint cleaning efficiency also was not different among grid bar treatments; it follows a similar trend as lint loss, and averaged 65.1%. Visible trash content in the lint was different between cultivars and averaged 3.1 and 2.2% for the fragile and Acala cultivar, respectively.

Table 7 shows AFIS fiber properties on the lint portion of the lint cleaner waste separated by the Shirley Analyzer. Fiber properties of lint obtained from processing lint cleaner waste with the Shirley Analyzer might not represent exactly the fiber found in the waste but are generally useful in indicating relative influences of lint cleaner treatments. With the exception of fineness, all fiber properties shown were not different among lint cleaning treatments (fineness ranged from 150 to 155 m-tex). Fiber in the lint cleaner waste was 19% shorter, had 133% more short fiber, and 34% more neps when compared to ginned fiber. SCN count in the lint cleaner waste (per gram average) was noticeably lower than SCN in the fiber (per gram average) across all treatments. It is unclear if the Shirley Analyzer altered SCN count. This and that fiber SCN count did not improve with lint cleaning (Table 4) suggests that SCN (and possibly SCF) remained in the lint and were not removed by the lint cleaner grid bars and thrown into the trash. As seen with ginned fiber, most fiber properties on the lint portion of lint cleaner waste were different between cultivars.

Table 6. Least square means and statistical analysis of foreign matter in lint, foreign matter in the lint cleaner waste, and lint cleaner efficiencies, by lint cleaner type and cultivar

Treatment	Lint Cleaner Fiber			Lint Cleaner Waste			Lint Cleaner Eff.	Lint Cleaner Lint Loss
	Lint Content	Trash Content Visible	Trash Content Invisible	Lint Content	Trash Content Visible	Trash Content Invisible		
	%	%	%	%	%	%	%	%
				Lint Cleaner Treatment[z]				
No LC[y]	92.5 b	5.98 a	1.52 a	--------	--------	--------	--------	--------
105°	96.9 a	2.11 b	0.94 ab	39.0 ab	53.5 ab	7.48	66.6	1.81
60°	96.7 a	2.22 b	1.08 ab	43.7 ab	48.3 b	8.00	62.0	2.20
45°	96.9 a	2.17 b	0.97 ab	35.6 b	56.3 a	8.10	63.7	1.36
0°R	97.1 a	1.95 b	0.90 b	45.5 a	47.1 b	7.35	68.3	2.76
90°R	97.1 a	2.02 b	0.88 b	41.9 ab	50.2 ab	7.86	65.7	2.39
Control LC	97.0 a	2.10 b	0.86 b	37.9 ab	53.7 ab	8.43	64.2	2.41
				Cultivar[z]				
Fragile	95.9 b	3.10 a	1.03	39.9	53.1 a	7.02 b	62.9 b	2.65 a
Acala	96.8 a	2.20 b	1.02	41.3	50.0 b	8.73 a	67.3 a	1.66 b
				Observed Significance Level[x]				
LC	< 0.0001	< 0.0001	0.0061	0.0169	0.0154	NS	NS	NS
Cultivar	< 0.0001	< 0.0001	NS	NS	0.0080	0.0009	0.0110	0.0006
LC*Cultivar	0.0092	0.0018	NS	NS	NS	NS	NS	NS

[z] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] LC = lint cleaner.

[x] NS = not statistically significant at ($p > 0.05$).

Table 7. Least square means and statistical analysis of selected AFIS fiber properties on the lint portion of lint cleaner waste, by lint cleaner treatment and cultivar

Treatment	Length	Upper Quartile Length	Short Fiber Content	Fineness	Immature Fiber Content	Maturity Ratio	Nep Count	Seed Coat Neps	Dust Count	Trash Count	Visible Foreign Matter
	mm	mm	%	m-tex	%	-	per g	Per g	per g	per g	%
Lint Cleaner[z] Treatment[z]											
No LC[y]	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
105°	18.6	24.6	28.5	153 ab	10.1	0.82	479	14.0	213	9.25	0.16
60°	19.0	25.1	27.1	152 abc	9.89	0.82	379	12.4	216	8.42	0.15
45°	18.5	24.6	28.9	150 c	10.6	0.81	412	10.8	205	9.08	0.16
0°R	18.5	24.4	28.8	155 a	9.61	0.83	431	13.8	226	10.1	0.20
90°R	18.7	24.7	27.7	152 bc	9.98	0.82	380	12.4	163	8.25	0.14
Control LC	18.5	24.5	29.1	153 ab	9.95	0.83	453	14.5	264	9.67	0.19
Cultivar[z]											
Fragile	17.2 b	22.6 b	31.9 a	153 a	10.8 a	0.81 b	346 b	13.8	188	8.22	0.15 b
Acala	20.1 a	26.7 a	24.8 b	152 b	9.25 b	0.84 a	498 a	12.2	241	10.0	0.19 a
Observed Significance Level[x]											
LC	NS	NS	NS	0.0032	NS	NS	NS	NS	NS	NS	NS
Cultivar	< 0.0001	< 0.0001	< 0.0001	0.0034	< 0.0001	< 0.0001	< 0.0001	NS	NS	NS	0.0222
LC*Cultivar	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z] Means followed by the same letter in each column are not different based on Tukey's studentized range test ($p \leq 0.05$).

[y] LC = lint cleaner.

[x] NS = not statistically significant at ($p > 0.05$).

Although results from a lint cleaner simulator showed that grid bars with a second cleaning edge had the potential to remove SCF (Armijo et al., 2009b), these findings were not confirmed on this study which used a full-sized commercial lint cleaner. Subsequent to this study, high-speed videography of a peripheral view of the lint cleaner was used to learn more about what was occurring in real-time as fiber/SCF collides with a grid bar on a commercial lint cleaner. (Previous videography used a lateral (end) view of the edge of a grid bar on a lint cleaner simulator.) A Phantom V7.1 camera (Vision Research, Wayne, NJ) recorded video at 5000 frames per second and an exposure time of 2 µsec. Figure 4 shows six sequential frames of video of ginned lint laden with SCF colliding with a 105° grid bar. As seen in this video, it was apparent that the grid bars were removing some SCF, but the vast majority of fragments were being drawn back into the lint stream after striking the grid bar. The striking force of the SCF hitting the grid bar was not enough to overcome the attachment force of the fiber/SCF to the lint cleaner saw and, hence, the SCF was not removed. Other means to separate SCF from ginned fiber are being investigated.

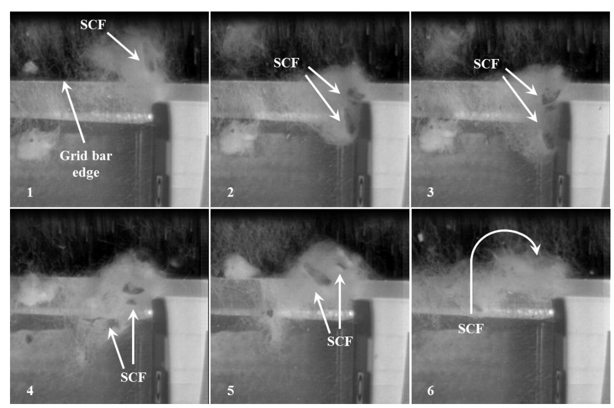

Figure 4. Sequential high-speed video frames showing SCF attached to saw (1), the same SCF impacting the edge of the grid bar (2, 3, and 4), and the same SCF being pulled back into the lint stream on the saw (5 and 6).

SUMMARY AND CONCLUSIONS

As expected, there were noticeable differences in fiber properties between the fragile seed coat and Acala cultivars. There were also differences in fiber properties and foreign matter content among lint cleaning treatments, but most of those differences were between the treatment that contained No LC and the other grid bar treatments collectively. Thus, there were essentially no differences in fiber properties among grid bar treatments. Both AFIS SCN count and a manual count of SCF, which were used as an indicator for the presence of SCF, were not different among lint cleaning treatments (including No LC). It should be noted that there was variability in the seed coat measurements. The least aggressive grid bar design had the lowest amount of foreign matter in the lint cleaner waste. As expected, fiber in the lint cleaner waste was shorter, and contained more short fiber and neps than fiber in the bale, but SCN count in the lint cleaner waste was also not different among grid bar designs. High-speed videography showed that SCF impacting the grid bars were being pulled back into the lint stream by attached fiber, and an auxiliary air knife mounted on the first grid bar could help to remove SCF.

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DISCLAIMER

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