USING NEWLY-DESIGNED LINT CLEANER GRID BARS TO REMOVE SEED COAT FRAGEMENTS

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Abstract

An experiment was conducted to remove seed coat fragments at the saw-type lint cleaner using newly-designed grid bars. The test consisted of five experimental grid bar designs and one control. The experimental grid bars had angles from the sharp toe of the grid bar (or the angle from vertical) of 105°, 60°, and 45°; a grid bar design that had a rounded tip with a 0.79-mm (0.031-in) radius; and a grid bar that had one edge and a radius of 90°. The 105° and 60° grid bars were unique in that they had a second edge a short distance from the toe of the grid bar. 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 seed coat fragments. Results showed noticeable differences in fiber properties between the cultivars. Fiber from the fragile cultivar was shorter, less uniform, and contained more short fibers, neps, and seed coat neps. However, there were very few differences in fiber properties among grid bar treatments, particularly AFIS seed coat nep count which was used as an indicator for seed coat fragments. Tests not yet completed include a manual count of seed coat fragments in the lint, and determining trash content in the lint and lint content in the trash.

Introduction

Seed coat fragments (SCFs) in ginned lint continue to be a problem at the textile mill. The most recent research at the USDA-ARS Southwestern Cotton Ginning Research Laboratory focuses on trying to alleviate SCFs at the saw-type lint cleaner with newly-designed grid bars. Past studies by Mangialardi and Shepherd (1968) and Mangialardi (1987) showed that SCFs were not reduced with different levels of saw-type lint cleaning, but both of these studies used conventional grid bars in the lint cleaners.

Past research showed that newly-designed lint cleaner grid bars may be effective in removing a SCF (Armijo et al., 2009). This research used 10 model-size grid bars (Figure 1) mounted on a lint cleaner simulator (Figure 2). 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 ten model-size grid bars performed best in removing a 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.

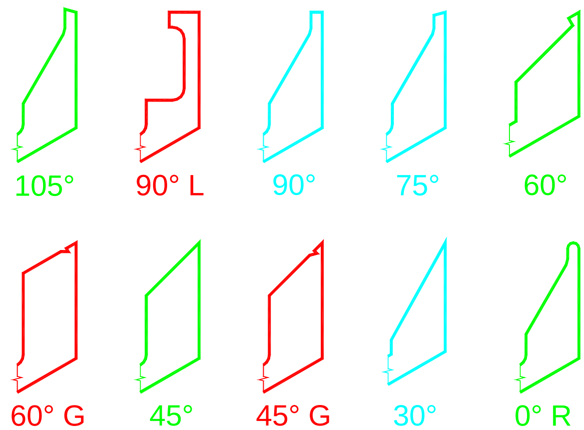

Figure 1. Cross section of the 10 experimental grid bars previously tested. The 105°, 60°, 45°, and 0°R grid bars (shown in green) performed the best.

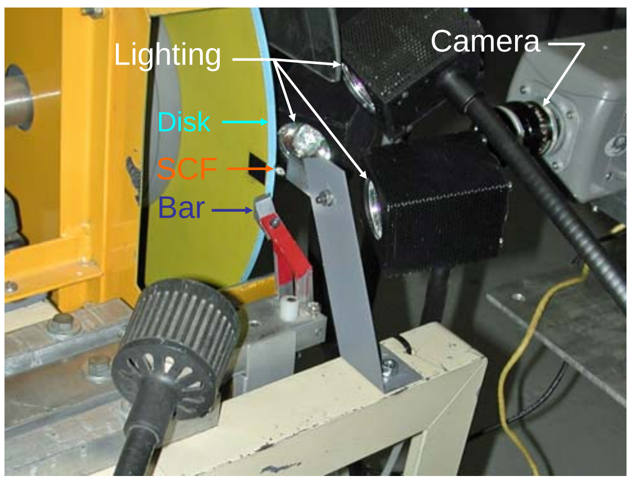

Figure 2. Lint cleaner simulator and high-speed video camera used to test 10 newly-designed, model-sized grid bars.

A test was run in 2010, using the four grid bars shown in green in Figure 1 (Armijo et al., 2011). The grid bars were full-size and mounted on a commercial saw-type lint cleaner. Results showed that AFIS seed coat nep count, which was used as an indicator for the presence of SCFs, was not different among grid bar designs in either the lint sample after lint cleaning or the lint portion of the lint cleaner trash. There was quite a bit of variability in seed coat nep count. There were differences in trash content in the lint, and lint loss in the lint cleaner trash, among grid bar designs. It appeared that 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 what was used on the study with the lint cleaner simulator (Armijo et al., 2009), and the control treatment was run on a different (but similar make and model) lint cleaner that was not operating at optimum. It was determined that it would be best to re-run the test.

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. Partial results of the 2012 study are reported here. As before, the objective of the study was to determine the performance of experimental lint cleaner grid bars in removing SCFs from ginned lint. The study was performed at the USDA-ARS Southwestern Cotton Ginning Research Laboratory in Mesilla Park, NM.

Materials and Methods

Figure 3 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 105º and 60º grid bars had a small surface of about 1.7 mm (0.069 in) from the toe of the bar, giving these bars a second edge to help remove the SCF. The 45º grid bar did not have a second edge and the surface length from the toe of the grid bar was about 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.

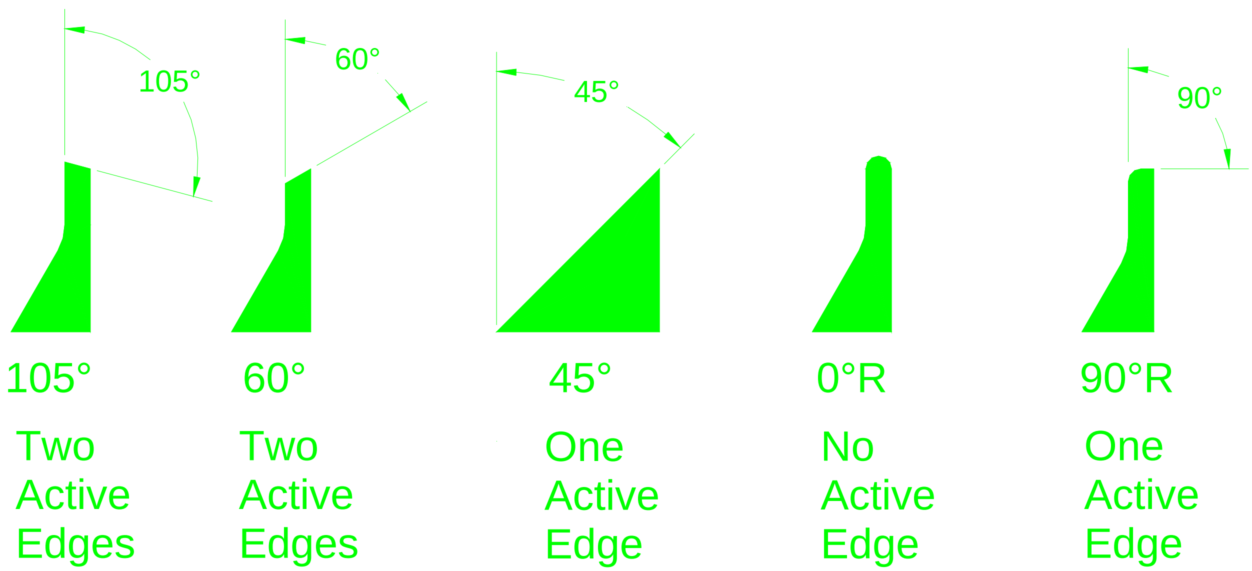

Figure 3. Detailed cross section of the six experimental grid bar used in the study.

Figure 4 shows a side view of the 45° grid bars as an example of how the experimental grid bars were placed in relation the lint cleaner saw. A commercial Continental Lodestar 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 about 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 felt that this was too much of a gap and a narrower gap may give the grid bar a better opportunity to remove the seed coat fragment. Also, the manufacturer (Continental) recommends a distance of 0.8 mm (0.031 in) from the saw to the grid bar (USDA, 1977). Hence, the distance from the grid bar to the saw was reduced to about 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.

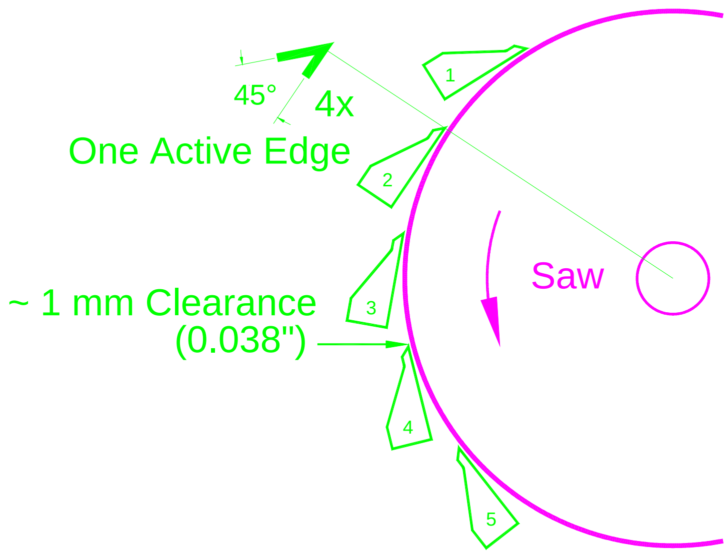

Figure 4. Side view of 45° grid bars in relation to the lint cleaner saw.

The test included conventional (control) grid bars to compare against 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 32º on the first grid bar, and 55º on the remaining four bars of the set. The control grid bars were made out of aluminum. Figure 5 shows the control grid bars in relation the lint cleaner saw.

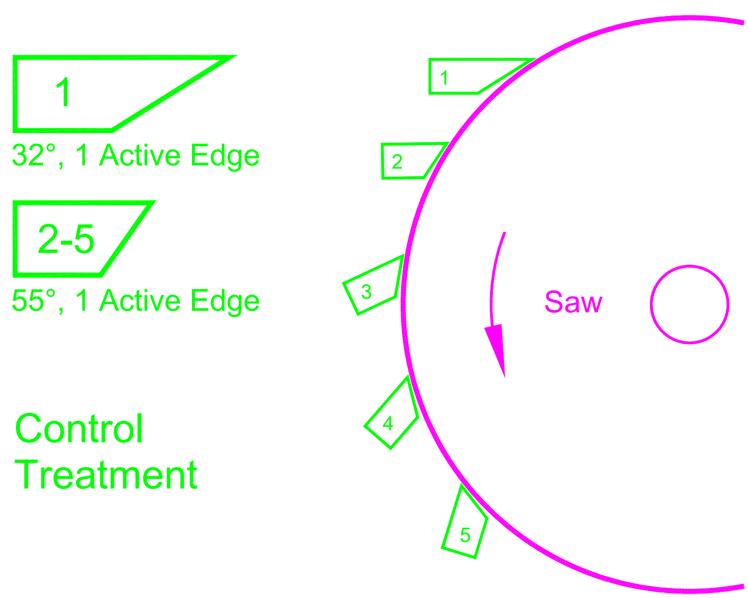

Figure 5. Side view of control grid bars in relation to the lint cleaner saw.

The test consisted of six designs of grid bars (five experimental and one control), two types of cotton, and three replications for a total of 36 lots. The cottons included a upland cultivar (Acala 1517-08), and a cultivar known to have a fragile seed coat which may be more sensitive to differences in grid bar design. Both cottons were grown in the Mesilla Valley of Southern New Mexico. 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. There were two sub-samples taken during each ginning lot of which the quality measurements were averaged together. The trash contents 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 Advanced Fiber Information System (AFIS) and the High Volume Instrument (HVI) at Cotton Incorporated (Cary, NC) were used to determine the fiber properties of lint samples. 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). The experimental design was a randomized complete block with replications serving as blocks. Analysis of variance was performed with the General Linear Models procedure of SAS (version 9.1; SAS Institute, Inc.: Cary, NC) and differences between main effect treatment means were tested with Tukey's studentized range test.

Results and Discussion

To prevent contaminating the samples taken between ginning lots of different cultivars, the two cultivars were pre-cleaned separately prior to running the lint cleaner treatments. Trash content at the wagon was 10.2 and 9.6% (dirty base) for the fragile and Acala cultivar, respectively, and moisture content at the wagon was 4.3 and 5.5% (dry base) for the fragile and Acala cultivar, respectively.

Table 1 shows that trash content (dirty base) at the feeder was different between cultivars; the fragile cultivar was 1.2% and the Acala was 1.9%. Moisture content (dry base) at the feeder was also different between cultivars and averaged 5.0 and 5.2 for the fragile and Acala cultivar, respectively. Moisture content at the lint cleaner was not different between cultivars and averaged 4.3%. Temperature and relative humidity in the ginning plant were not different among grid bars or between cultivars and averaged 26.2°C and 21.2%, respectively. Ginning rate and turnout were not yet available (lint lot weights have not yet been weighed).

Table 1. Means and statistical analysis of trash and moisture content at the feeder, moisture content at the lint cleaner, and gin plant conditions, by grid bar and cultivar treatment.

	Trash Content Feeder	Moist Content Feeder	Moist Content LC	Room Temp.	Room r.h.[y]
	%	%	%	deg C	%
			Grid Bar Treatment		
105° Grid Bar	1.56	4.95	4.17	25.1	16.7 b
60° Grid Bar	1.55	5.31	4.82	26.4	33.5 a
45° Grid Bar	1.63	5.04	4.16	26.3	17.0 b
0°R Grid Bar	1.63	5.07	4.35	25.4	20.8 ab
90°R	1.62	5.05	4.26	26.5	20.7 ab
Control	1.48	5.06	4.08	26.7	18.2 b
			Cultivar Treatment		
Fragile	1.22	4.97	4.17	26.0	21.2
Acala	1.94	5.19	4.45	26.1	21.1
			Observed Significance Level[z]		
Grid Bar	NS	NS	NS	NS	0.0199
Cultivar	<0.0001	0.0363	NS	NS	NS
Cultivar x GB	NS	NS	NS	NS	NS

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test (P≤0.05).
[z] NS = not statistically significant at (P>0.05).

Table 2 shows the cottonseed properties. None of the cottonseed properties were different among grid bar designs, but there were differences between cultivars. The fragile cultivar was 1.7 percentage points higher in linters content, but the cultivars contained the same total foreign matter (0.37%). The fragile cultivar was 1.4 percentage points higher in oil content. Cottonseed grade was different between cultivars and averaged 114 and 115 for the fragile and Acala cultivar, respectively.

Table 2. Means and statistical analysis of cottonseed properties, by grid bar and cultivar treatment.

	Linters	Total foreign matter	Moisture	Free fatty acids	Oil	Ammonia	Net quality Index	Quantity index	Grade
	%	%	%	%	%	%	Index	Index	Index
				Grid Bar Treatment					
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	12.4	0.38	4.21	0.72	20.9	4.21	100	114	114
				Cultivar Treatment					
Fragile	12.9	0.37	4.17	0.60	20.4	4.49	100	114	114
Acala	11.2	0.36	4.17	0.67	21.7	3.93	100	115	115
				Observed Significance Level[z]					
Grid Bar	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cultivar	<0.0001	NS	NS	0.0362	<0.0001	<0.0001	NS	0.0113	0.0123
Cultivar(GB)	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z] NS = not statistically significant at (P>0.05).

Tables 3 and 4 show the AFIS results for lint samples taken after lint cleaning (at the press). With the exception of immature fiber content, none of the AFIS properties were different among grid bar designs, but there were many differences between cultivars. Table 3 shows that length and upper quartile length (by weight) were about 4 and 5 mm (0.16 and 0.20 in) longer, respectively, with Acacla. Short fiber content was different between cultivars and averaged 14.0 and 10.3% for the fragile and Acala cultivars, respectively. The fragile cultivar had 0.8 percentage points more immature fiber and 9% more neps (333 versus 306).

Table 3. Means and statistical analysis of fiber properties measured by the Advanced Fiber Information System (AFIS) on samples after lint cleaning, by grid bar and cultivar treatment.

	Length	Upper quartile length	Short fiber content	Fineness	Immature fiber Content[y]	Maturity ratio	Nep count	Nep size
	mm	mm	%	m-tex	%	-	per g	µm
				Grid Bar Treatment				
105°	23.4	29.0	11.5	162	6.35 b	0.90	300	751
60°	23.3	29.0	11.8	161	6.73 ab	0.87	318	755
45°	23.0	28.7	12.5	162	6.92 a	0.89	344	751
0°R	22.8	28.4	12.7	164	6.61 ab	0.89	315	747
90°R	23.1	28.7	12.4	164	6.73 ab	0.89	319	756
Control	23.2	28.8	12.2	163	6.97 a	0.89	321	743
				Cultivar Treatment				
Fragile	21.3	26.4	14.0	163	7.11	0.87	333	773
Acala	25.0	31.2	10.3	162	6.33	0.91	306	728
				Observed Significance Level[z]				
Grid Bar	NS	NS	NS	NS	0.0165	NS	NS	NS
Cultivar	<0.0001	<0.0001	<0.0001	NS	<0.0001	<0.0001	0.0012	<0.0001
Cultivar x GB	NS	NS	NS	NS	NS	NS	NS	NS

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test (P≤0.05).
[z] NS = not statistically significant at (P>0.05).

Table 4 shows that total trash count was not different between cultivars and averaged 290 counts per g. Visible foreign matter was 0.82 percentage points higher in the fragile cultivar. AFIS seed coat nep count was the fiber property used as an indicator of the level of SCFs. Table 4 shows that seed coat nep count was different between cultivars; the fragile cultivar had 53 seed coat neps and Acala had about 32. This was expected as the fragile cultivar was chosen due to its larger amount of seed coat neps. However, seed coat nep count was not different among grid bar designs, averaging 42.3 counts per gram across both cultivars. A manual count of SCFs has not yet been completed.

Table 4. Means and statistical analysis of fiber properties measured by the Advanced Fiber Information System (AFIS) on samples taken after lint cleaning, by grid bar and cultivar treatment.

	Seed coat nep		Dust	Trash	Total trash	Trash	Visible foreign
	count	size	Count	count	count	size	matter
	per g	mm	per g	per g	per g	µm	%
				Grid Bar Treatment			
105°	41.2	1294	225	53.5	279	369	1.31
60°	42.8	1269	256	57.7	314	374	1.54
45°	45.3	1257	225	49.8	275	366	1.44
0°R	41.0	1258	246	54.3	300	373	1.50
90°R	43.3	1286	237	50.5	287	369	1.48
Control	40.3	1244	234	47.8	282	361	1.31
				Cultivar Treatment			
Fragile	53.0	1302	229	55.8	284	400	1.84
Acala	31.6	1234	246	48.8	295	337	1.02
				Observed Significance Level[z]			
Grid Bar	NS	NS	NS	NS	NS	NS	NS
Cultivar	<0.0001	0.0005	NS	0.0060	NS	<0.0001	0.0001
Cultivar x GB	NS	NS	NS	NS	NS	NS	NS

[z] NS = not statistically significant at (P>0.05).

Table 5 shows the HVI results. With the exception of reflectance, HVI fiber properties were not different among grid bars. Reflectance did not vary greatly and was lowest with the 105° grid bar (80.9) and highest with the 90°R grid bar (81.5). There were differences in most of the HVI properties between cultivars. Acala fiber length was considerably longer, averaging about 5 mm (0.2 in or six staple lengths) longer than the fragile cultivar. Acala was 2.0 percentage points higher in uniformity, and had a slightly more favorable leaf grade (2.0 versus 2.2) than the fragile cultivar. Color grade was not different between cultivars and averaged 105 (old code, 11 new code). Color grade must be analyzed using old code because the new code numbering system is not linear. Examples of the conversion between color grade old code and new code follow: old code 94 = new code 41, old code 100 = new code 31, old code 104 = new code 21, and old code 105 = new code 11.

Table 5. Means and statistical analysis of High Volume Instrument (HVI) results on samples taken after lint cleaning, by grid bar and cultivar treatment.

	Micron-aire	Upper half mean length	Staple Length	Unifor-mity	Stre-ngth	Reflec-tance[y]	Yellow-ness	Color grade	Leaf grade
	Reading	mm	32-in	%	g/tex	Rd	+b	Index	index
					Grid Bar Treatment				
105°	4.44	28.2	35.3	80.8	30.6	80.9 b	9.80	105	2.08
60°	4.39	28.1	35.4	80.8	30.7	81.3 ab	9.94	105	2.08
45°	4.43	28.0	35.3	80.6	30.8	81.2 ab	9.75	105	2.08
0°R	4.43	28.3	35.6	80.8	30.9	81.3 ab	9.78	105	2.17
90°R	4.44	28.1	35.3	81.0	30.5	81.5 a	9.82	105	2.25
Control	4.40	28.2	35.5	80.7	30.3	81.2 ab	9.83	105	2.00
					Cultivar Treatment				
Fragile	4.56	25.7	32.3	79.8	27.6	80.9	10.3	105	2.19
Acala	4.28	30.6	38.5	81.8	33.6	81.6	9.38	105	2.03
					Observed Significance Level[z]				
Grid Bar	NS	NS	NS	NS	NS	0.0341	NS	NS	NS
Cultivar	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	NS	0.0062
Cultivar x GB	NS	NS	NS	NS	NS	0.0487	NS	NS	0.0305

[y] Means followed by the same letter in each column are not different based on Tukey's studentized range test (P≤0.05).
[z] NS = not statistically significant at (P>0.05).

Summary

As expected, there were noticeable differences in fiber properties between the fragile seed coat and Acala cultivars. However, there were essentially no differences in fiber properties among grid bar treatments. Seed coat nep count, which was used as an indicator for the presence of SCFs, was not different among grid bar designs in the lint sample after lint cleaning. It should be noted that there was quite a bit of variability in seed coat nep count. A manual count of SCFs using the Standard Test Method for Seed Coat Fragments and Funiculi in Cotton Fiber Samples (ASTM, 1979) has not been completed, and foreign matter of the lint and lint content of the lint cleaner trash is not yet known. The results from these tests will give a better understanding of the mechanics of the grid bars.

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Disclaimer

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