HOW CURRENT COTTON GINNING PRACTICES AFFECT FIBER LENGTH UNIFORMITY INDEX

Carlos B. Armijo
Derek P. Whitelock
Sidney E. Hughs
USDA-ARS Southwestern Cotton Ginning Research Laboratory
Mesilla Park, NM

Abstract

There is a need to develop cotton ginning methods that improve fiber characteristics that are compatible with the newer and more efficient spinning technologies. A literature search produced recent studies that described how current ginning processes affect HVI fiber length uniformity index. Results from the studies show that uniformity was not affected by seed cotton cleaning machinery (cylinder cleaners and stick machines) or the saw gin stand. Uniformity was affected by the saw-type lint cleaner. Older studies (more than 10 years) have shown that the feed works is the machine part within the saw-type lint cleaner that causes the most damage. The studies in this report confirmed this finding. Although uniformity was not affected by the lint cleaner grid bars, faster saw speeds did reduce uniformity. Roller ginning preserved uniformity better than saw ginning. Roller gin lint cleaning reduced uniformity, but to a lesser degree than saw-type lint cleaning.

Introduction

There is a need to develop cotton ginning methods that improve fiber characteristics that are compatible with the newer and more efficient spinning technologies. Air-jet spinning in particular produces high quality yarns at a high production rate and lower cost, but requires cotton with low short fiber content and high length uniformity. Providing the textile industry with a longer and more uniform fiber to manufacture yarns more efficiently would expand market share and increase the demand for cotton products, and give U.S. cotton a competitive edge to synthetic fibers.

The purpose of this report is to document how current ginning practices affect High Volume Instrument (HVI) fiber length uniformity index (hereafter referred to as "uniformity"). This report will comment only on the uniformity of Upland cotton, the predominant type of cotton grown in the U.S. (Pima cotton comprises only 3-5% of the U.S. crop), and focuses only on studies from the last 10 years.

Materials and Methods

Uniformity is defined as the ratio of mean fiber length and upper half mean fiber length expressed as a percentage (Cotton Incorporated, 2013). Uniformity is categorically divided into the following: very high (above 85); high (83-85); intermediate (80-82); low (77-79); and very low (below 77). It is advantageous to achieve the highest uniformity both for marketing and higher financial return to the producer. Although the characteristics of a cultivar overwhelmingly dictate a particular cultivar's uniformity, production and ginning practices affect uniformity. The goal of producers and ginners is to minimize the detrimental effects to uniformity from harvesting and ginning.

The cotton ginning process can be divided into the following: seed cotton unloading; moisture control; seed cotton cleaning and extracting; ginning (saw and roller type gin stands); lint cleaning (saw and roller type lint cleaners); and packaging lint cotton. "Seed cotton unloading" and "packaging lint cotton" do not have much potential to affect uniformity. However, the remaining processes do have potential to affect uniformity and are the subject of this report. Study results follow.

Results and Discussion

Figure 1 gives a perspective of the past and current levels of uniformity (Cotton Incorporated, 2000 and 2015). Uniformity in the Far West has decreased from 81.7 to 81.0 over the past 15 years. Uniformity has increased over this time period in the other regions with the Mid-South seeing the largest increase (81.3 to 82.4). In general, uniformity lies within the "intermediate" range of 80-82 across the U.S. Uniformity can vary within a short time period due to new cultivars coming online, or production events such as weather or insects. In the following studies, the cultivars were diverse, and represented cottons throughout all of the growing regions. Although uniformity was different among cultivars, uniformity did not have a cross product effect with treatment*cultivar in all the studies reviewed, so discussion will center on treatment effects.

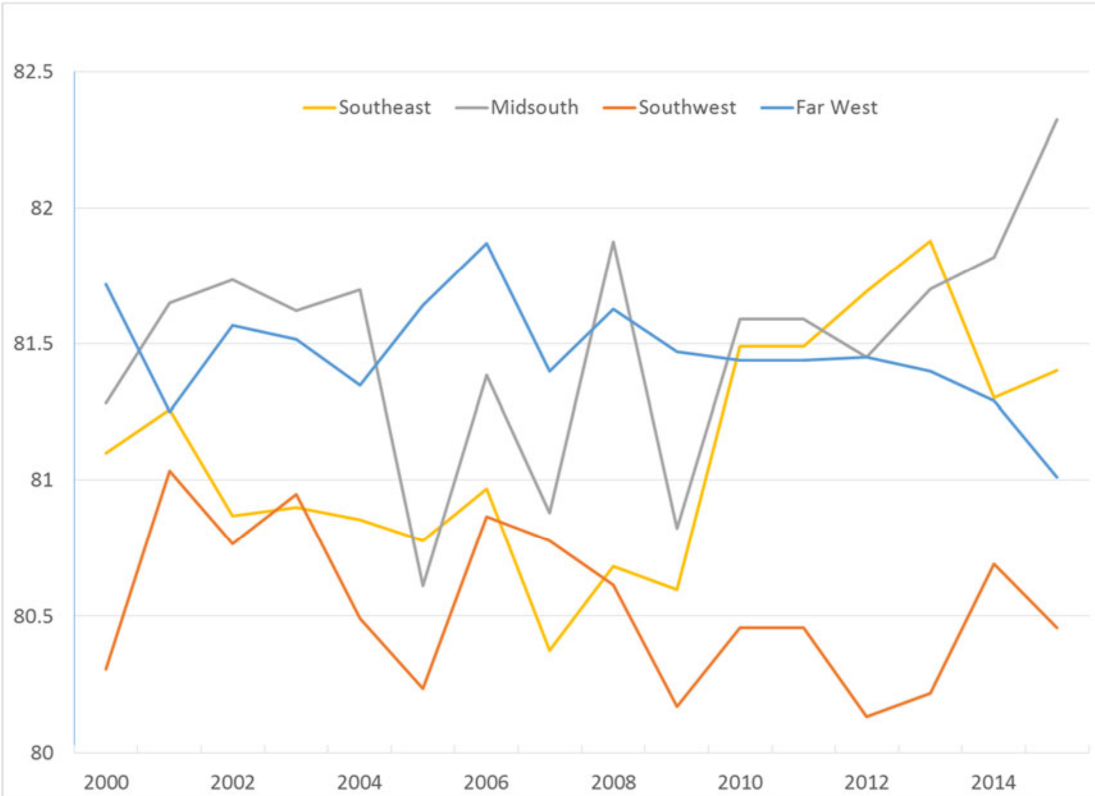

Figure 1. Length uniformity (%) by region.

Seed Cotton Cleaning

Table 1 shows results of a study by Wanjura et al. (2012) that investigated the influence of harvest method (picker/stripper), number of seed-cotton extractor cleaners (one or two stick machines), and seed cotton cleaning rate (low, medium, and high) on fiber and yarn quality on cotton produced in the Texas High Plains (two cultivars on six plots). Result showed that uniformity was significantly better with the picker harvester, averaging 81.2% compared to the stripper harvester which averaged 80.9%. Uniformity was not different between seed cotton cleaning level or among seed cotton cleaning rates and averaged 81.1 %, respectively.

Table 1. Uniformity results of a harvesting and gin cleaning study by Wanjura et al. (2012).[z]

Treatment	Uniformity (%)
Harvesting	
Picked	81.2 a
Stripped	80.9 b
Seed Cotton Cleaning	
One Stick Machine	81.1 a
Two Stick Machines	81.1 a
Seed Cotton Cleaning Rate	
High	81.1 a
Medium	81.1 a
Low	81.1 a

[z] Means followed by the same letter under a treatment heading are not different (P≤0.05).

Table 2 shows results of a study by Armijo et al. (2009) that determined the impact of harvester configuration (spindle size and speed) and seed cotton cleaning level (no cleaning, the standard 3 cleaners, and 6 cleaners) on fiber quality. The study included a cultivar known to have fragile seed coats. Results showed uniformity was not different among harvester treatments (13- and 14-mm spindle) or among seed cotton cleaning level and averaged 83.1 and 83.2%, respectively.

Table 2. Uniformity results of a harvesting and seed cotton cleaning study by Armijo et al. (2009).[z]

Treatment	Uniformity (%)
Picker Treatment	
13-mm spindle (most common)	83.0 a
14-mm spindle	83.3 a
14-mm spindle running fast	83.1 a
Gin Treatment (seed cotton cleaning)	
No Cleaning	83.2 a
Incline, Stick, Incline	83.3 a
Incline, Stick, Incline, Stick, Stick, Incline	83.0 a

[z] Means followed by the same letter under a treatment heading are not different (P≤0.05).

<u>Moisture Effects and Maturity</u>

Table 3 shows results of a study by Byler et al. (2014) that examined the influence of early and late defoliation on fiber damage using two Mid-South cultivars. Four ginning treatments were nested within each defoliation level: (1) no heat w/ seed cotton cleaning and no lint cleaning, (2) no heat w/ seed cotton cleaning and one saw-type lint cleaner, (3) no heat w/ seed cotton cleaning and three saw-type lint cleaners, and (4) heat w/ seed cotton cleaning and one saw-type lint cleaner which is typical in commercial ginning. Results showed that uniformity was different between defoliation times; uniformity averaged 82.5 and 83.1% for early and late defoliation, respectively. Uniformity was also different among gin treatments. Compared to no lint cleaning, uniformity was 0.5 percentage points lower when using three saw-type lint cleaners; this occurred with both early and late defoliation times. When using one saw-type lint cleaner, uniformity was reduced 0.1 percentage points on cotton defoliated early and it was reduced 0.3-0.5 percentage points on cotton defoliated late compared to no lint cleaning. Lint cleaning studies shown later in this report will confirm that saw-type lint reduces uniformity.

Table 3. Uniformity results of a maturity and processing study by Byler et al. (2014).[z]

Treatment	Uniformity (%)
Defoliated Early	
No heat, no lint cleaning	82.7 bc
No heat, 1 saw-type lint cleaner	82.6 c
No heat, 3 saw-type lint cleaners	82.2 d
Heat, 1 saw-type lint cleaner*	82.6 c
Defoliated Late	
No heat, no lint cleaning	83.4 a
No heat, 1 saw-type lint cleaner	83.1 ab
No heat, 3 saw-type lint cleaners	82.9 bc
Heat, 1 saw-type lint cleaner*	82.9 bc

[z] Means followed by the same letter are not different (P≤0.05).

Table 4 shows results of a 2-year study by Le (2007) that examined fiber quality properties produced by a saw-type lint cleaner in response to low and high levels of feed rate, saw speed, combing ratio and lint moisture. Two Mid-South cultivars were used (hairy and smooth leaf). In this study, lint moisture content was the treatment that significantly affected uniformity. In the first year of the study, uniformity averaged 80.6 and 81.2% at 4 and 6% lint moisture content, respectively. This equated to a 0.6 percentage point increase in uniformity due to 2% higher lint moisture content. Similar results were found in the second year: a 0.4 percentage point increase in uniformity resulted from an increase of 2% lint moisture content. This study also showed that uniformity varied between the hairy and smooth leaf cultivars by 0.6 percentage points.

Table 4. Uniformity results of a lint cleaner study that included moisture content by Le (2007).[z]

Treatment	Uniformity (%)	
	2003 Study	2004 Study
Saw Speed (rpm)		
877	81.0 a	81.6 a
115	80.9 a	81.4 a
Feed Rate (kg/m/h)		
447	80.8 a	81.5 a
745	81.0 a	81.4 a
Combing Ratio		
25	80.9 a	81.6 a
50	81.0 a	81.4 a
Cultivar		
Hairy Leaf	82.1 a	82.7 a
Smooth leaf	79.7 b	80.3 b
Lint Moisture (%)		
4	80.6 a	81.3 a
6	81.2 b	81.7 b

[z] Means followed by the same letter in each column under a treatment heading are not different ($P \leq 0.05$).

Table 5 shows results of a study by Byler (2005) that added a modest amount of moisture to seed cotton during ginning to determine the impact on fiber properties. One treatment included ginning with heat only in pre-cleaning, and a second treatment added humid air to the second tower dryer. Two Mid-South cultivars were used in the study. Samples were taken before and after lint cleaning. Although uniformity was not measured directly, Advanced Fiber Information System (AFIS) fiber length, fiber length CV, and short fiber content (by weight) were different between treatments. Before lint cleaning, fiber length averaged 24.3 and 24.7 mm with drying only and seed cotton moisture restoration, respectively. After lint cleaning, fiber length averaged 23.8 and 24.2 mm with drying only and seed cotton moisture restoration, respectively. In other words, fiber length was better by 0.3-0.4 mm with added moisture, but lint cleaning reducing fiber length by 0.5 mm. Fiber length CV and short fiber content saw the same trend. Before lint cleaning, fiber length CV averaged 32.9 and 32.5% with drying only and seed cotton moisture restoration, respectively. After lint cleaning, fiber length CV averaged 33.8 and 33.2% with drying only and seed cotton moisture restoration, respectively; a lower fiber length CV is more favorable. Before lint cleaning, short fiber content averaged 8.7 and 8.0% with drying only and seed cotton moisture restoration, respectively. After lint cleaning, short fiber content averaged 9.6 and 8.9% with drying only and seed cotton moisture restoration, respectively. In other words, short fiber content was better (lower) by 0.7 percentage points with added moisture, but lint cleaning increased short fiber content by 0.9 percentage points.

Table 5. AFIS Fiber length and short fiber content (by weight) of a seed cotton moisture addition study by Byler (2005).[z]

Treatment	Fiber Length (mm)		Fiber Length CV (%)		Short Fiber (%)	
	Before L.C.	After L.C.	Before L.C.	After L.C.	Before L.C.	After L.C.
Drying Only	24.3 a	23.8 a	32.9 a	33.8 a	8.7 a	9.6 a
Seed Cotton Moisture Restore	24.7 b	24.2 b	32.5 b	33.2 b	8.0 b	8.9 b

[z] Means followed by the same letter in each column are not different ($P \leq 0.05$).

Byler et al. (2006) provided a historical review on the effect of moisture addition to seed cotton before ginning on fiber length. The review by Byler et al. (2006) covered studies from the 1940's to the 1990's (earlier time period than this report). Studies documented the decrease in fiber length quality when ginning at moisture contents below 5%. One study gave a possible explanation of why this occurs: the ratio of the force required to remove the fiber from the seed to the strength of the fiber decreases with increasing moisture content. The consensus of the studies supported ginning at moisture content levels above 6% to preserve fiber length quality.

Saw Gin Stand

Table 6 shows results of a study by Armijo et al. (2006) that examined the effects of the type of seed roll box and seed roll density on fiber quality. Four ginning treatments were tested: (1) traditional seed roll box (the seed roll is turned by the gin saws), (2) conveyor tube seed roll box (the tube assists turning the seed roll), (3) conveyor tube seed roll box running at slow speed, and (4) paddle roll seed box. The study included a cultivar known to have fragile seed coats. With the paddle roll seed box, there is no conveyor tube; a paddle roll assists turning the seed roll. Also, the paddle roll seed box contains a seed finger roll that returns "not fully ginned seed" back to the gin saws. Results showed that uniformity was not different among seed roll box and averaged 83.6%.

Table 6. Uniformity results of a saw gin seed roll box study by Armijo et al. (2006).[z]

Seed Roll Box Treatment	Uniformity (%)
Traditional (seed roll turned by gin saws)	83.7 a
Conveyor tube (assists turning seed roll)	83.6 a
Conveyor tube, slow speed	83.6 a
Paddle Roll (assists turning seed roll)	83.3 a

[z] Means followed by the same letter are not different (P≤0.05).

Table 7 shows results of a study by Holt et al. (2008) that focused solely on gin stands with the paddle roll seed box (power roll gin stand). The power roll gin stand was compared to three different makes of commercial gin stands (Continental, Lummus, and Consolidated) in three different states or growing areas (Arkansas, California, and Texas). Results showed that uniformity was not different among any of the gin stands at the commercial gins. These results are based on samples taken before lint cleaning. At the Arkansas gin, uniformity averaged 83.7% on the power roll and one Continental Golden Eagle 161 gin stand. At the California gin, uniformity averaged 84.2% on the power roll and two Lummus 158 gin stands. And at the Texas gin, uniformity averaged 84.1 % on the power roll and four Consolidated 164 gin stands.

Table 7. Uniformity results of a power roll gin stand study by Holt et al. (2008).[z]

Gin Location/Gin Stand Type	Uniformity (%)
Arkansas	
Power Roll 161 saw	83.9 a
Continental Golden Eagle 161 saw	83.4 a
California	
Power Roll 158 saw	84.4 a
Lummus 158 saw	84.3 a
Lummus 158 saw	84.0 a
Texas	
Power Roll 164 saw	84.2 a
Consolidated 164 saw	84.4 a
Consolidated 164 saw	83.7 a
Consolidated 164 saw	84.2 a
Consolidated 164 saw	83.8 a

[z] Means followed by the same letter at a gin location are not different (P≤0.05).

Table 8 shows results of a study by Hughs and Armijo (2015) that tested current gin saw tooth designs and evaluated their effects on fiber quality, ginning performance parameters, and textile processing quality. The test involved five different gin saw tooth profiles (treatments) with the following tooth configuration: (1) 328 teeth per saw, (2) 352 teeth per saw (standard profile), (3) 352 teeth per saw, (4) 330 teeth per saw, and (5) 352 teeth per saw. All of the gin saws were 0.4-m (16-inch) diameter. One cultivar, grown in New Mexico, was used in the study. The gin saw motor load was kept constant, but ginning rate (seed cotton) varied among gin saw tooth designs. Samples were taken before and after lint cleaning. Results showed that on samples taken before lint cleaning (gin stand effects only), uniformity was not different among saw tooth designs and averaged 81.2%. However, on samples taken after lint cleaning, uniformity was different among treatments and ranged from 79.6 to 80.3%. Because uniformity was not different among treatments before lint cleaning, these results reflect the variability of lint cleaning.

Table 8. Uniformity results of a gin saw tooth design study by Hughs and Armijo (2015).[z]

Treatment (teeth/saw)	Gin Rate (kg/min)	Uniformity (%)	
		Before Lint Cleaning	After Lint Cleaning
328	89.8 a	81.2 a	80.3 a
352 (conventional)	81.0 b	81.1 a	79.6 b
352 (conventional)	80.2 b	81.0 a	80.3 a
330	71.5 c	81.1 a	80.1 ab
352	67.0 d	81.6 a	80.0 ab

[z] Means followed by the same letter in each column are not different (P≤0.05).

Lint Cleaning

Table 9 shows results of a study by Whitelock et al. (2011) that established a baseline for cotton quality before and after saw-type lint cleaning in gins across the cotton belt (cultivar varied by region). On gins that had only one stage of lint cleaning, uniformity was different within the stage and averaged 81.9 and 81.1% before and after lint cleaning, respectively. This equated to a drop in uniformity of 0.8 percentage points. On gins that had two lint cleaning stages, uniformity was different among stages and averaged 82.3% before lint cleaning, 81.7% after one stage of lint cleaning, and 81.3% after two stages of lint cleaning. This equated to a drop in uniformity of 0.6 percentage points after one stage of cleaning, and 1.0% after two stages.

Table 9. Uniformity results of a gin saw tooth design study by Whitelock et al. (2011).[z]

Gin Type/Treatment	Uniformity (%)
Gins using 1 lint cleaner	
Before Lint Cleaning	81.9 a
After One Lint Cleaning	81.1 b
Gins using 2 lint cleaners	
Before Lint Cleaning	82.3 a
After One Lint Cleaner	81.7 b
After Two Lint Cleaners	81.3 c

[z] Means followed by the same letter under a Gin Type are not different (P≤0.05).

Table 10 shows results of a study by Delhom et al. (2008) that examined the effects of the saw-type lint cleaner feed works and grid bars on fiber quality. The lint cleaner treatments were as follows: (1) by-pass lint cleaning, (2) thru the feed works only, but no grid bars, (3) thru the feed works, one grid bar, (4) thru the feed works, two grid bars, and (5) thru the feed works, five grid bars. Three Mid-South cultivars (hairy leaf, smooth leaf, and semi-smooth leaf) were used in the study. Results showed that uniformity was different among treatments; the by-pass lint cleaning treatment was different from all of the other treatments. Uniformity on the by-pass lint treatment was 82.2%, and the remaining treatments were all the same averaging 81.6%. These results show that the feed works reduced uniformity by 0.6 percentage points, but the grid bars did not reduce uniformity any further.

Table 10. Uniformity results of a lint cleaner feed works and grid bar study by Delhom et al. (2008).[z]

Treatment	Uniformity (%)
By-Pass Lint Cleaning	82.2 a
No grid bars	81.5 b
1 Grid Bar	81.5 b
2 Grid Bars	81.6 b
5 Grid Bars	81.6 b

[z] Means followed by the same letter are not different (P≤0.05).

Table 11 shows results of a study by Delhom et al. (2009) that changed the lint cleaner saw speed without altering other settings of the lint cleaner including the feed works. Four saw speed treatments were included in the test: (1) 605 rpm, (2) 870 rpm, (3) 1135 rpm, and (4) 1400 rpm. The normal saw speed in this test was 870 rpm. Three Mid-South cultivars (hairy leaf, smooth leaf, and semi-smooth leaf) were used in the study. Results showed that uniformity was different among saw speed treatments; uniformity decreased as saw speed increased. Uniformity ranged from 82.0% (605 rpm) to 81.3% (1400 rpm).

Table 11. Uniformity results of a lint cleaner saw speed study by Delhom et al. (2009).[z]

L.C. Saw Speed (rpm)	Uniformity (%)
605	82.0 a
870	81.8 ab
1135	81.6 b
1400	81.3 cc

[z] Means followed by the same letter in each column are not different (P≤0.05).

Table 12 shows results of a field study at three commercial gins by Rutherford et al. (2004) that compared fiber quality from side-by-side installations of conventional Lummus Model 108 saw-type lint cleaners and Lummus Sentinel lint cleaners. The Sentinel lint cleaner was developed in 1999. A conventional saw-type lint cleaner collects ginned fiber on a slow moving condenser drum and forms a batt of lint. The batt then travels thru a feed works assembly and feed plate where the lint is set onto the moving saw. The Sentinel lint cleaner uses a high-speed perforated separator cylinder to feed individual tufts to the saw, eliminating the feed works assembly but retaining the feed plate. (The newer Sentinel II lint cleaner uses a high-speed applicator brush cylinder in place of the separator cylinder). Three commercial gins were used in the study: two in Texas and one in Australia. Cultivar varied by gin plant and growing area. Samples were taken before and after lint cleaning. Results show that uniformity at Gin A was 83.4 before lint cleaning and 82.9% after lint cleaning with the Sentinel lint cleaner (a reduction in uniformity of 0.60 percentage points), and 84.0% before lint cleaning and 82.8 % after lint cleaning with the Model 108 lint cleaners (a reduction in uniformity of 1.43%). At Gin B, uniformity was reduced by 0.71 percentage points with the Sentinel lint cleaner, and uniformity was reduced by 0.48 percentage points with the Model 108 lint cleaner. At Gin C, uniformity was reduced by 0.02 percentage points with the Sentinel lint cleaner, and uniformity was reduced by 1.41 percentage points with the Model 108 lint cleaner. (A formal statistical analysis was not performed.) At Gin A and C, uniformity was reduced by a lesser amount with the Sentinel lint cleaner.

Table 12. Uniformity results of a study with the Lummus Sentinel lint cleaner by Rutherford et al. (2004).

	Uniformity (%)
Gin A	
Before Sentinel	83.4
After Sentinel	82.9
Percentage point change	-0.60%
Before Model 108	84.0
After Model 108	82.8
Percentage point change	-1.43%
Gin B	
Before Sentinel	81.7
After Sentinel	81.1
Percentage point change	-0.71%
Before Model 108	81.0
After Model 108	80.6
Percentage point change	-0.48%
Gin C	
Before Sentinel	81.5
After Sentinel	81.4
Percentage point change	-0.02%
Before Model 108	81.8
After Model 108	80.7
Percentage point change	-1.41%

Table 13 shows results of a study by Hughs et al. (2013) that determined how the length distribution of a medium staple upland cotton was affected by ginning and lint cleaning treatments. The test included five ginning/lint-cleaning treatments: a roller gin with two beater/air-jet (mill type) cleaners, and a saw gin with zero, one, two, or three saw-type lint cleaners. Although uniformity was not reported, Sutter-Webb upper quartile length and mean length were reported. Results showed that both upper quartile length and mean length were different among ginning/lint-cleaning treatments. The roller ginning treatment had the best upper quartile and mean length at 30.5 and 24.1 mm, respectively. The saw ginning treatment with no lint cleaning had the next best fiber lengths at 29.5

and 22.4 mm, respectively. Fiber lengths among the saw ginning treatments got shorter as more lint cleaning was used. Mean length was reduced by 2.68% (0.6 mm) going from saw ginning with no lint cleaning to saw ginning with one lint cleaner. Interestingly, in this study, mean length was not reduced when increasing from saw ginning with one lint cleaner to saw ginning with two lint cleaners and averaged 21.8 mm. Mean length was reduced by 5.83% when a third saw-type lint cleaner was added. Mean fiber length on saw ginning with three lint cleaners averaged 20.6 mm. This equated to 1.2 mm, or nearly two staple lengths shorter, when using three lint cleaners. Comparing roller ginning with mill type lint cleaning to saw ginning with one saw-type lint cleaner, mean length was reduced by 2.3 mm, or three staple lengths.

Table 13. Suter-Webb upper quartile length and mean length of a roller/saw ginning and lint cleaning study by Hughs et al. (2013).[z]

Treatment	Upper Quartile Length (mm)	Mean length (mm)
Roller Gin, Two Lint Cleaners	30.5 a	24.1 a
Saw Gin, No lint Cleaning	29.5 b	22.4 b
Saw Gin, One Lint Cleaner	29.0 c	21.8 c
Saw Gin, Two Lint Cleaners	28.7 c	21.8 c
Saw Gin, Three Lint Cleaners	27.4 d	20.6 d

[z] Means followed by the same letter in each column are not different (P≤0.05).

Roller Ginning

Table 14 show results of a study by Joy et al. (2012) that compared saw ginning to roller ginning. The saw ginning setup included a saw gin stand followed by one saw-type lint cleaner. The roller ginning setup included a high-speed roller gin stand followed two beater/air-jet lint cleaners. Two experimental extra-long-staple (ELS) upland cultivars and two conventional upland cultivars were used in the study. Results showed that uniformity was different between gin types; uniformity averaged 84.2 and 82.8% (a reduction of 1.4 percentage points) for the roller and saw ginning setup, respectively.

Table 14. Uniformity results of a saw and roller ginning study by Joy et al. (2012).[z]

Treatment	Uniformity (%)
Roller Gin, High Speed	84.2 a
Saw Gin	82.8 b

[z] Means followed by the same letter are not different (P≤0.05).

Table 15 shows results of a study by Armijo et al. (2013) that compared high-speed roller ginning, conventional roller ginning, and saw ginning. The roller ginning treatments included (1) no lint cleaning, (2) lint cleaning with one beater/air-jet lint cleaner, and (3) lint cleaning with one pin cylinder/air-jet lint cleaner (similar to the Lummus Guardian lint cleaning). The saw ginning treatments included (1) no lint cleaning, (2) one saw-type lint cleaner, and (3) two saw-type lint cleaners. Three diverse cultivars, one of them stripper harvested, was used in the study. Results showed that uniformity was different among ginning types (combining lint cleaning); uniformity averaged 83.7 and 81.7% with roller ginning (high speed and conventional) and saw ginning, respectively. Results also showed that uniformity was different among lint cleaner types. Uniformity was highest when no lint cleaning was used and averaged 84.2, 83.7, and 82.4% for the high-speed roller gin with no lint cleaning, the conventional roller gin with no lint cleaning, and the saw gin with no lint cleaning, respectively. Uniformity was reduced (more lint damage) with both gin types, and with the use of lint cleaning. Uniformity was reduced on the high-speed roller gin with beater cylinder lint cleaning and pin cylinder lint cleaning by 0.2 and 0.8 percentage points, respectively. Uniformity was reduced on the saw gin with one saw-type lint cleaner and the saw gin with two saw-type lint cleaners by 0.7 and 1.3 percentage points, respectively. There was no interaction among gin type or lint cleaner type and cultivar.

Table 15. Uniformity results of a saw and roller-ginning/lint-cleaning study by Armijo et al. (2013).[z]

Gin and Lint Cleaner Treatments	Uniformity (%)
Gin Stand Type	
Roller Gin, High Speed	83.9 a
Roller Gin, Conventional	83.5 a
Saw Gin	81.7 b
Gin and Lint Cleaner Treatment	
Roller Gin, High Speed, No Lint Cleaning	84.2 a
" , Beater Lint Cleaner	84.0 ab
" , Pin Cylinder Cleaner	83.4 bc
Roller Gin, Conventional, No Lint Cleaning	83.7 abc
" , Beater Lint Cleaner	83.9 ab
" , Pin Cylinder Cleaner	83.1 c
Saw Gin, No Lint Cleaning	82.4 d
" , One Saw-Type Cleaner	81.7 e
" , Two Saw-Type Cleaners	81.1 e

[z] Means followed by the same letter under a treatment heading are not different (P≤0.05).

Table 16 shows results of a roller ginning study by Byler et al. (2017) that used three different types of lint cleaners. A saw gin with one saw-type lint cleaner was also tested for comparison. The four ginning treatments included (1) roller ginning with a pin-cylinder/air-jet lint cleaner (similar to the commercial Lummus Guardian lint cleaner), (2) roller ginning with an experimental cylinder seed cotton cleaner that was coupled to a saw-type lint cleaner without normal fed works, (3) roller ginning with a saw-type lint cleaner, and (4) saw ginning with a saw-type lint cleaner. Four Mid-South cultivars were used in the study. Results showed that uniformity was different among ginning treatments. Roller ginning with the pin cylinder lint cleaner had the highest uniformity of 84.3% followed by roller ginning with the experimental cylinder cleaner at 83.9%. The saw ginning treatment (with one saw-type lint cleaner) had the lowest uniformity at 82.8%. Uniformity on the roller gin with the saw-type lint cleaner was 83.6%; this was 0.7 percentage points lower than roller ginning with the pin cylinder lint cleaner, but 0.8 percentage points higher than the saw gin with one saw-type lint cleaner.

Table 16. Uniformity results of a saw and roller-ginning/lint-cleaning study by Byler et al. (2017).[z]

Treatment	Uniformity (%)
Roller Gin, Pin Cylinder Cleaner	84.3 a
Roller Gin, Experimental Cleaner	83.9 ab
Roller Gin, Saw-Type Cleaner	83.6 b
Saw Gin, Saw-Type Cleaner	82.8 c

[z] Means followed by the same letter are not different (P≤0.05).

Summary

Uniformity was different among cultivars in the studies cited. The cultivars were diverse, and represented cottons throughout all of the growing regions. In all of the studies with multiple cultivars, uniformity did not have a cross effect with the ginning treatments.

Uniformity was reduced by stripper harvesting when compared to picker harvesting. Seed cotton cleaning machinery (cylinder cleaners and stick machines) did not affect uniformity. Interestingly, uniformity was not affected by the saw gin stand seed roll differences.

Saw-type lint cleaning did reduce uniformity, but uniformity was not affected by the grid bars. Instead, faster saw speeds reduced uniformity and the studies in this report confirmed findings from older studies (over 10 years) that showed that the feed works was the machine part within the saw-type lint cleaner that causes the most damage. Although the Lummus Sentinel lint cleaner eliminates the condenser batt and feed rollers in the feed works, it still retains a feed plate to place the fiber on the saw. Thus, it did not consistently have better uniformity than the standard lint cleaner in the study cited.

Roller ginning preserved uniformity better than the saw ginning. This is not surprising as roller ginning is a gentler process. Roller gin lint cleaning reduced uniformity, but to a lesser degree than saw-type lint cleaning.

Several areas of future research that have the potential to preserve uniformity in the ginning process follow:

Re-evaluate the "coupled lint cleaner concept" with current cultivars. The coupled lint cleaner concept connects the gin stand directly to the lint cleaner. This eliminates the need for the feed works (condenser batt, feed rollers, and feed plate) on the lint cleaner. It also reduces some air transport and emissions in the ginning plant. The Lummus Sentinel lint cleaner is based on the coupled lint cleaner concept, but it is not connected directly to the gin stand. Previous evaluations of the coupled lint cleaner concept were done 25 years ago. Cultivars have changed considerably over the last two decades. Re-valuations would include both saw and roller ginning with coupled lint cleaning.

Evaluate the performance of a "blunt" feed plate on the saw-type lint cleaner. The feed plate sets the fiber on the saw, but the fiber is jerked around the nose of the feed plate as it changes directions drastically while being grabbed by the saw. Past research has shown that this drastic change in direction, over the sharp feed plate nose, causes most of the reduction in fiber length uniformity.

Evaluate "saw-tooth" pitch angle" on the saw-type lint cleaner saw. Past research has investigated saw tooth density, but not pitch angle. A less aggressive pitch angle cause less damage, particularly where the fiber is abruptly placed onto the saw at the feed plate.

Resume studies on differential ginning. This is a type of roller ginning that limits the proximity of and the time that the fiber is exposed to the ginning point, thereby removing only the longer fibers. Preliminary research has shown that differential ginning has the potential to preserve fiber length.

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References

Armijo, C. B., G. A. Holt, K. D. Baker, S. E. Hughs, E. M. Barnes, and M. N. Gillum. 2006. Harvesting and ginning a cotton with a fragile seed coat. Journal of Cotton Science 10:311-318.

Armijo, C. B., K. D. Baker, S. Ed Hughs, Edward M. Barnes, and Marvis N. Gillum. 2009. Harvesting and seed cotton cleaning of a cotton cultivar with a fragile seed coat. Journal of Cotton Science 13(2):158-165.

Armijo, C. B., J. A. Foulk, D. P. Whitelock, S. E. Hughs, G. A. Holt, and M. N. Gillum. 2013. Fiber and yarn properties from high-speed roller ginning of upland cotton. Applied Engineering in Agriculture 29(4): 461-471.

Byler, R. K. 2005. The effect of modest moisture addition to seed cotton before the gin stand on fiber length. Journal of Cotton Science 9:145-154.

Byler, R. K. 2006. Historical review on the effect of moisture content and the addition of moisture to seed cotton before ginning on fiber length. Journal of Cotton Science 10:300-310.

Byler, R. K., C. D. Delhom, G. F. Sassenrath, and M. Krifa. 2014. Fiber damage related to maturity and processing. Presented at the 2014 ASABE and CSBE/SCGAB Annual International Meeting, Montreal, Quebec Canada. 13-16 July 2014. American Society of Agricultural and Biological Engineers, St. Joseph, MI. 9 pp.

Byler, R. K. and C. D. Delhom. 2017. Investigation using three different lint cleaners with roller ginning upland cotton in Mississippi. Presented at the 2017 Beltwide Cotton Conferences, Cotton Ginning Conference, Dallas, TX. 04-06 January 2017. National Cotton Council of America, Cordova, TN.

Cotton Incorporated. 2000. U.S. Cotton Fiber Chart 1999/2000. Cotton Incorporated, Cary, NC.

Cotton Incorporated. 2013. The Classification of Cotton [Online]. Available at http://www.cottoninc.com/fiber/quality/Classification-Of-Cotton/Classing-booklet.pdf (verified 30 Jan. 2017).

Cotton Incorporated. 2015. U.S. Cotton Fiber Chart 2014/2015. Cotton Incorporated, Cary, NC.

Delhom, C.D., R. K. Byler, X. Cui, and D. P. Thibodeaux. 2008. Saw-type lint cleaner damage by machinery components. Presented at the 2008 ASABE Annual International Meeting, Providence, RI. 29 June-02 July 2008. American Society of Agricultural and Biological Engineers, St. Joseph, MI. 9 pp.

Delhom, C.D. and R. K. Byler. 2009. Saw-type lint cleaner damage as related to saw speed. Presented at the 2009 ASABE Annual International Meeting, Reno, NV. 21-24 29 June 2009. American Society of Agricultural and Biological Engineers, St. Joseph, MI. 9 pp.

Holt, G. A. and J. W. laird. 2008. Initial fiber quality comparisons of the power roll gin stand to three different makes of conventional gin stands. Applied Engineering in Agriculture 24(3): 295-299.

Hughs, S. E., C. B. Armijo, and J. A. Foulk. 2013. Upland fiber changes due to ginning and lint cleaning. Journal of Cotton Science 17:115-124.

Hughs, S. E. and C. B. Armijo. 2015. Impact of gin saw-tooth design on fiber and textile processing quality. Journal of Cotton Science 19:27-32.

Joy, K., C. W. Smith, E. Hequet, S. E. Hughs, and S. Hague. 2012. Extra long staple upland cotton for the production of superior yarns. Crop Science 52:2089-2096.

Le, S. 2007. Fiber quality properties produced by saw-type lint cleaners. Applied Engineering in Agriculture 23(2): 125-130.

Rutherford, R. D., D. W. VanDoorn, and J. W. Thomas. 2004. Fiber quality characteristics of conventional controlled-batt versus non-conventional flow-through saw-type lint cleaners. *In* Proc. Beltwide Cotton Conf., San Antonio, TX. 05-09 January 2004. Natl. Cotton Council of America, Memphis, TN.

Wanjura, J. D., W. B. Faulkner, G. A. Holt, and M. G. Pelletier. 2012. Influence of harvesting and gin cleaning practices on southern high plains cotton quality. Applied Engineering in Agriculture 28(5): 631-641.

Whitelock, D. P., C. B. Armijo, J.C. Boykin, M. D. Buser, G. A. Holt, E. M. Barnes, T. D. Valco, D. S. Findley, and M. D. Watson. 2011. Beltwide cotton quality before and after lint cleaning. Journal of Cotton Science 15:282-291.