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ENGINEERING AND GINNING

Ginning a Cotton with a Fragile Seed Coat

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ABSTRACT

Seed coat fragments that remain in the lint after ginning cause problems during the spinning process and affect the quality of finished goods. A new cotton strain (*Gossypium hirsutum* L.) has been developed that contains a fragile seed coat that breaks easily. An experiment was conducted to determine the effects of saw and roller ginning on this experimental cotton strain with the fragile seed coats. Three ginning treatments, standard saw gin stand, experimental saw gin stand with auxiliary rib guides, and standard roller gin stand, were investigated. The treatments were applied to a commercial Upland cotton used as a control and an experimental Upland strain that contained fragile seed coats. Lint samples collected from the roller gin stand exhibited better fiber properties with respect to color grade, length, uniformity, nep count, short fiber content, and turnout than the saw gin stand configurations. The experimental saw gin stand with attached rib guides did not impact any fiber properties compared with the unmodified saw gin. The experimental cotton cultivar with fragile seed coats had superior fiber quality than the control cultivar, including cottonseed grade, short fiber content, immature fiber content, nep count, micronaire, strength, uniformity, and turnout. Seed coat nep count in the experimental cotton was about three times higher than the control cotton.

Development of cotton cultivars is an ongoing process, and breeders are striving to develop cotton cultivars that satisfy the expectations of both producers and textile mills. Recently, an experimental high-yielding, high-quality cotton strain was developed that has commercial potential; however, the seed coat is fragile and breaks easily. Seed coat fragments that remain in the lint after the ginning process cause problems during spinning (Pilsbury, 1992) and affect the quality of finished goods. The gin plant may be able to alleviate the problem of seed coat fragments. Past research on the relationship between lint cleaning and seed coat fragments concluded that lint cleaning was not a reliable method to reduce seed coat fragments and, in some cases, lint cleaning increased fragment counts, because fragments were broken into smaller pieces (Mangialardi, 1987). Another opportunity in the ginning process to reduce seed coat damage is at the actual ginning point where the fiber is separated from the seed. This could be accomplished by modifications to a saw gin or by using an entirely different ginning process, such as roller ginning.

The objective of this research was to determine the effects of saw and roller ginning on a cotton strain that is known to have fragile seed coats. Conventional saw and roller gin stands were used. The saw gin stand was tested with and without experimental rib guides. Hughs (2002) determined that rib guides reduced the level of cottonseed damage and improved the yarn quality; however, those studies were not conducted with a cotton strain known to have a fragile seed coat. This research applied the three ginning treatments to a conventional Upland cultivar (used as a control) and an experimental strain with a fragile seed coat.

MATERIALS AND METHODS

Figure 1 is a sketch of a conventional saw gin stand showing the saw ginning principle. Figure 2 is a sketch of the experimental rib guides. The conventional ginning ribs normally have a gap of about 2.79 mm (0.110 in) between ribs. With the rib guides installed, the gap decreases to about 0.94 mm (0.037 in), allowing less room for the saw to wander or flex. By keeping the saw more constrained between the rib guides, there is less of a chance that cottonseed will be pulled through the gap and continue with the lint. Figure 3 is a sketch of a conventional roller gin stand showing the roller ginning principle. Greater detail of the saw and roller ginning principles can be found in the Cotton Ginners Handbook (USDA, 1994).

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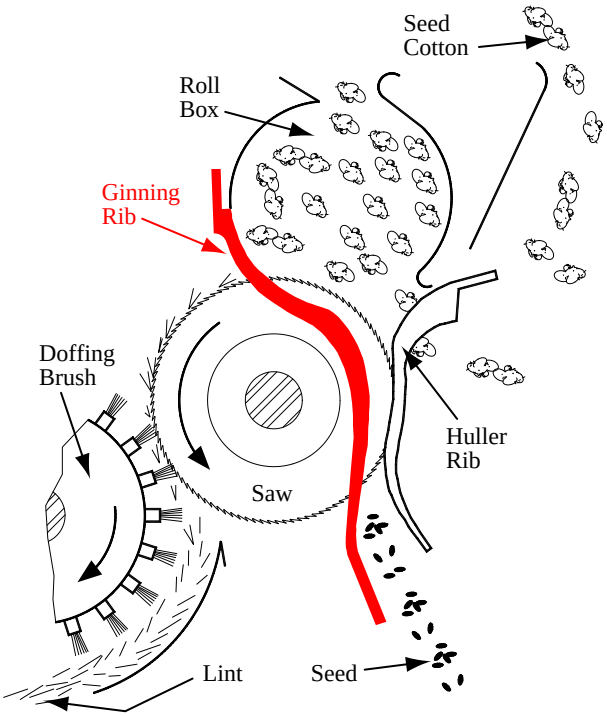

Figure 1. Diagrammatic presentation of a conventional saw gin stand.

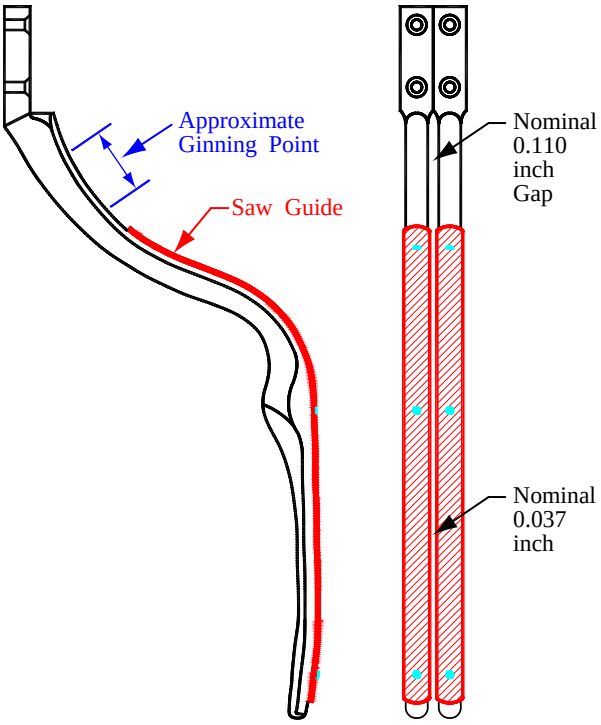

Figure 2. View of the experimental rib guides that were attached to the ginning rib.

The experiment was conducted during March 2004. There were six treatments (three ginning treatments by two cultivars) replicated three times

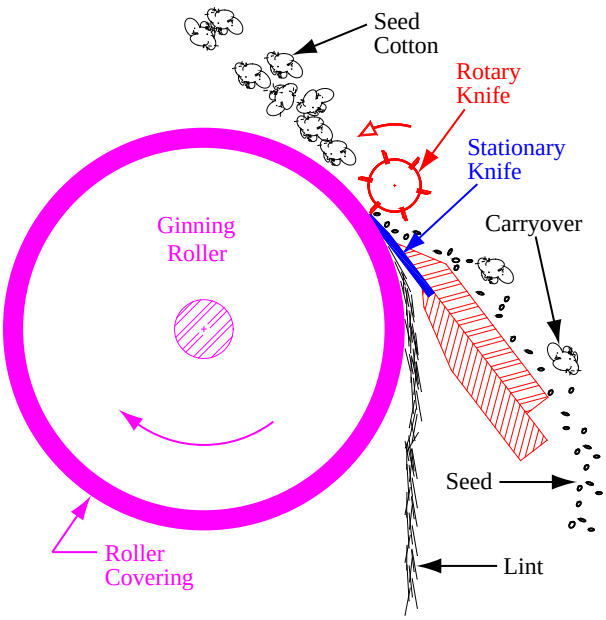

Figure 3. Diagrammatic presentation of a conventional roller gin stand.

each for a total of 18 lots. The ginning treatments included a 46-saw Continental Double Eagle gin stand (Continental Gin Co.; Prattville, AL) in its original configuration, a 46-saw Continental Double Eagle gin stand with the experimental rib guides installed, and a Lummus roller gin stand (Lummus Industries; Columbus, GA) in its original configuration. The cottons were a conventional Upland cotton cultivar and the experimental Upland strain. The ginning treatments and cultivars were randomized within each replication.

Data analyses were performed with PC-SAS (version 6, SAS Institute, Inc., Cary, NC) with a 5% level of significance. Analysis of variance was performed with the General Linear Model (GLM) procedure, and main effect means were separated using Duncan's multiple-range test ($P \leq 0.05$).

Because the cottonseed from the cotton with a fragile seed coat was going to be used for planting seed, all of the fragile seed coat cotton was precleaned at one time (and placed back into trailers) to prevent seed contamination. Pre-cleaning consisted of two 6-cylinder incline cleaners, one stick machine, and no drying. Lint cleaning in the saw gin consisted of two Continental/Moss Gordin Lodestar lint cleaners (Continental/Moss Gordin Gin Co.; Prattville, GA) and lint cleaning in the roller gin consisted of two Aldrich mill-type/air-jet combination cleaners (Aldrich Machine Works; Greenwood, SC).

Sampling included seed cotton before and after conditioning in the overhead, lint before and after cleaning, and cottonseed at the seed belt. The foreign matter content of the seed cotton samples was determined using the pneumatic fractionation method, and the moisture content of the seed cotton and lint samples was determined using the oven drying method (Shepherd, 1972). Fiber properties were determined using the USTER Advanced Fiber Information System (AFIS) and high volume instrumentation (HVI). The AFIS and HVI fiber evaluations were performed at Cotton Incorporated in Cary, NC. The analysis of the cottonseed was performed at Mid-Continent Laboratories of Memphis, TN, according to the Trading Rules of the National Cottonseed Products Association (National Cottonseed Products Association, 1997).

RESULTS AND DISCUSSION

Because the experiment was focused on ginning treatments, the results will center on fiber and cottonseed properties immediately after the gin stand (no lint cleaning). Ginning rate and turnout were different between gin type (saw versus roller), but not for rib guide design. Turnout averaged 38.8 and 40.0% on the saw and roller gin stand, respectively. Turnout was different between cultivars, averaging 35.4 and 43.3% on the control and experimental cottons, respectively. The higher turnout for the experimental cotton is one of its appealing traits. The other measurements were not different (Table 1).

Foreign matter content at the wagon was not different between cultivars and averaged 6.3% (Table 2). There were differences among ginning treatments after seed cotton conditioning (at the feeder). These differences were most likely because of the particular seed cotton separators and feeders in the saw and roller ginning plants. Total foreign matter content after seed cotton conditioning was not different between cultivars and averaged 1.51%.

Cottonseed properties by treatment are presented in Table 3. Linters content was not different among gin treatments or between cultivars and averaged 10.5% overall (Table 3). Total foreign matter content was different among gin types with the saw gin averaging 0.3% and the roller gin averaging 2.1%. It is not uncommon for roller gins to produce cotton seed with higher total foreign matter content than saw gins. The experimental rib guides did not make any difference in total foreign matter content. Cottonseed grade was different between cultivars with the control and experimental cotton averaging 110 and 114, respectively.

There were several AFIS measurements that were different among ginning treatments, but the differences were between the saw and roller gin and not between the standard saw gin stand and the experimental saw gin with the attached rib guides (Table 4 and 5). Fiber

Table 1. Means of ginning rate, turnout, moisture content at the wagon and press, and gin plant conditions among gin treatments and between cultivars

Variable[y]	Ginning rate (bales/h)	Turnout (%)	Moisture content @ wagon (%)	Moisture content @ press (%)	Ambient temp. (°C)	Relative humidity (%)	Barometric pressure (kPa)
				Gin treatment[z]			
Std. saw gin	2.95 a	38.8 b	7.21	5.12	20.3	28.5	88.8 a
Exp. saw gin	3.08 a	38.8 b	6.85	5.09	18.4	34.7	88.5 b
Roller gin	1.05 b	40.4 a	7.05	5.28	19.6	33.4	
				Cultivar[z]			
Control	2.34	35.4 b	7.09	5.06	19.6	31.2	88.5
Experimental	2.37	43.3 a	6.98	5.27	19.3	33.2	88.5
				Significance			
Gin treatment (GT)	<0.0001	0.0005	NS	NS	NS	NS	0.0113
Cultivar (Cult)	NS	<0.0001	NS	NS	NS	NS	NS
GT x Cult	NS	NS	NS	NS	NS	NS	NS

[y] Std. = standard gin; exp. = standard gin with experimental ribs.

[z] Means within a column followed by the same letter in are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

length, short fiber content, and nep count were superior for the roller gin than for the saw gin. Upper quartile length averaged 31.5 and 32.1 mm on the saw and roller gin, respectively. Short fiber content averaged 8.5% for the saw gin and 6.4% on the roller gin. Nep count averaged 225 and 166 counts per gram for the saw and roller gin, respectively.

Differences among cultivars were common in the AFIS results. In general, the experimental cotton was shorter, but had fewer short fibers and neps. Upper quartile length averaged 32.8 and 30.5 mm for the control and experimental cotton, respectively. Short fiber content averaged 8.6% for the control cotton and 7.0% for experimental cotton. Nep count averaged 230 and 180 for the control and experimental cotton, respectively.

Seed coat nep count was not different among ginning treatments, but was different between cul-

Table 2. Means of foreign matter content at the wagon and feeder among gin treatments and between cultivars

Variable[y]	Foreign matter content (%)[z]									
	Wagon					Feeder				
	Hulls	Sticks	Motes	Fine	Total	Hulls	Sticks	Motes	Fine	Total
					Gin treatment					
Std. saw gin	1.46	0.46	1.87	2.12	5.91	0.12 b	0.10 b	0.66 b	0.30	1.18 b
Exp. saw gin	0.97	0.74	2.23	2.78	6.71	0.12 b	0.13 b	0.66 b	0.31	1.22 b
Roller gin	1.31	0.50	2.08	2.50	6.39	0.53 a	0.27 a	0.99 a	0.36	2.14 a
					Cultivar					
Control	1.15	0.59	2.19	2.66	6.59	0.38 a	0.19	0.63 b	0.34	1.54
Experimental	1.35	0.54	1.93	2.28	6.09	0.13 b	0.14	0.90 a	0.30	1.48
					Significance					
Gin treatment (GT)	NS	NS	NS	NS	NS	0.0002	0.0043	0.0001	NS	<0.0001
Cultivar (Cult)	NS	NS	NS	NS	NS	0.0024	NS	0.0001	NS	NS
GT x Cult	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[y] Std = standard gin; exp. = standard gin with experimental ribs.

[z] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Table 3. Means of cottonseed properties among gin treatments and between cultivars

Variable[y]	Linters (%)	Total foreign matter (%)	Moisture (%)	Free fatty acids (%)	Oil (%)	Ammonia (%)	Net quality index	Quantity index	Grade
					Gin treatment[z]				
Std. saw gin	10.7	0.26 b	7.03	0.73	20.0	4.50	100.0 a	112	112
Exp. saw gin	10.8	0.26 b	7.00	0.75	20.2	4.50	100.0 a	113	113
Roller gin	10.0	2.13 a	7.33	0.73	20.1	4.50	98.9 b	112	111
					Cultivar[z]				
Control	10.3	0.78	6.78 b	0.73	20.3 a	4.01 b	99.7	110 b	110 b
Experimental	10.7	0.98	7.46 a	0.73	19.8 b	4.98 a	99.5	114 a	114 a
					Significance				
Gin treatment (GT)	NS	<0.0001	NS	NS	NS	NS	<0.0001	NS	NS
Cultivar (Cult)	NS	NS	0.0002	NS	0.0045	<0.0001	NS	<0.0001	<0.0001
GT x Cult	NS	NS	NS	0.0097	NS	NS	NS	NS	NS

[y] Std = standard gin; exp. = standard gin with experimental ribs.

[z] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

tivars (Table 5). Seed coat nep count averaged 23.4 and 59.4 counts per gram for the control and experimental cotton, respectively. The two-and-a-half-fold increase in seed coat neps of the experimental strain over the conventional cultivar verifies the fragile nature of the seed coat of the experimental cultivar. None of the ginning treatments significantly reduced seed coat nep counts. Trash count and visible foreign matter was also higher in the experimental cotton. Trash count averaged 104 and 156, and visible foreign matter averaged 2.3 and 5.1% for the control and experimental cotton, respectively.

Table 4. Means of fiber properties measured by the Advanced Fiber Information System (AFIS) on samples before lint cleaning (just after ginning) among gin treatments and between cultivars

Treatment[y]	AFIS fiber property[z]								
	Length (mm)	Length CV (%)	Upper quartile length (mm)	Short fiber content (%)	Fineness (mtex)	Immature fiber content (%)	Maturity ratio	Nep	
								Count g^{-1}	Size (µm)
Gin treatment									
Std. saw gin	25.9 b	35.1 a	31.5 b	8.48 a	168	11.9	0.83 b	231 a	781 b
Exp. saw gin	25.9 b	35.1 a	31.5 b	8.43 a	165	12.1	0.83 b	218 a	782 b
Roller gin	27.0 a	32.6 b	32.1 a	6.40 b	168	11.3	0.85 a	166 b	823 a
Cultivar									
Control	26.8 a	35.5 a	32.8 a	8.57 a	161 b	13.0 a	0.80 b	230 a	720 b
Experimental	25.8 b	33.0 b	30.5 b	6.97 b	173 a	10.5 b	0.87 a	180 b	871 a
Significance									
Gin treatment (GT)	<0.0001	0.0004	0.0003	0.0002	NS	NS	0.0405	0.0009	0.0013
Cultivar (Cult)	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	0.0007	<0.0001
GT x Cult	NS	NS	NS	NS	NS	NS	NS	NS	0.0005

[y] Std = standard gin; exp. = standard gin with experimental ribs.

[z] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Table 5. Means of fiber properties measured by the Advanced Fiber Information System (AFIS) on samples taken before lint cleaning (just after ginning) among gin treatments and between cultivars

Treatment[y]	AFIS fiber property[z]						
	Seed Coat Nep		Dust count g^{-1}	Trash count g^{-1}	Total trash count g^{-1}	Trash size (µm)	Visible foreign matter (%)
	Count g^{-1}	Size (µm)					
Gin treatment							
Std. saw gin	43.2	1228	661	129	790	335 b	3.54 ab
Exp. saw gin	38.6	1221	664	144	808	359 a	4.42 a
Roller gin	42.5	1220	864	117	981	294 c	3.26 b
Cultivar							
Control	23.4 b	1166 b	714	104 b	818	294 b	2.34 b
Experimental	59.4 a	1281 a	745	156 a	901	364 a	5.14 a
Significance							
Gin treatment (GT)	NS	NS	NS	NS	NS	<0.0001	0.0377
Cultivar (Cult)	<0.0001	0.0032	NS	0.0002	NS	<0.0001	<0.0001
GT x Cult	NS	NS	NS	NS	NS	NS	NS

[y] Std = standard gin; exp. = standard gin with experimental ribs.

[z] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

The HVI results are summarized in Table 6. Similar to the AFIS results, quality attributes measured by the HVI were superior for the roller gin than for the saw ginning treatments. Upper half mean length averaged 29.8 and 31.0 mm on the saw and roller gin, respectively. Uniformity averaged 83.0% on the saw gin and 84.6% on the roller gin. Color grade averaged 102 and 103 (old code), and short fiber content averaged 8.7 and 7.4% on the saw and roller gin, respectively. There were no differences between the standard and experimental saw gins. Based on HVI results, the experimental cotton compared favorably to the control cotton. Micronaire averaged 3.4 and 4.8 for the control and experimental cotton, respectively. A micronaire of 3.4 would carry a discount. Uniformity averaged 82.6 and 84.4%, and strength averaged 28.24 and 31.68 cN/tex (28.8 and 32.3 g/tex) for the control and experimental cotton, respectively. Short fiber content was lower for the experimental cotton, averaging 7.9% compared with 8.7% for the control cotton.

CONCLUSIONS

Turnout, color grade, length, uniformity, nep count, and short fiber content were improved by roller ginning compared with either saw ginning treatment. There were no differences among ginning treatments in the other fiber properties, including linters content and seed coat nep count. The experimental rib guides did not have a significant effect on fiber characteristics.

There were several fiber measurements that indicated the experimental cotton had better quality than the standard cultivar. Turnout, cottonseed grade, short fiber content, immature fiber content, nep count, micronaire, strength, and uniformity were superior for the experimental cotton. Seed coat nep count and visible foreign matter were worse for the experimental cotton. Seed coat nep counts were about three times higher in the experimental cotton.

Future work will add three harvester treatments to the experiment. The experiment will continue to evaluate different ginning treatments.

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DISCLAIMER

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

Table 6. Means of High Volume Instrument (HVI) results on samples taken just before lint cleaning (just after ginning) among gin treatments and between cultivars

Treatment[x]	HVI fiber properties[y]								
	Micronaire	Upper half mean length (mm)	Uniformity (%)	Strength (cN/tex)	Elongation (%)	Reflectance Rd	Yellowness +b	Color grade index[z]	Short fiber content (%)
Gin Treatment									
Std. saw gin	4.13	29.6 b	82.9 b	29.6	5.00	76.8 b	8.88	101 b	8.88 a
Exp. saw gin	4.09	29.9 b	83.0 b	30.3	4.99	76.4 b	8.97	102 b	8.60 a
Roller gin	4.10	31.0 a	84.6 a	29.9	4.83	78.0 a	8.94	103 a	7.39 b
Cultivar									
Control	3.40 b	31.2 a	82.6 b	28.2 b	5.36 a	78.0 a	9.01	103 a	8.67 a
Experimental	4.81 a	29.2 b	84.4 a	31.7 a	4.52 b	76.1 b	8.85	100 b	7.91 b
Significance									
Gin treatment (GT)	NS	0.0002	0.0033	NS	NS	<0.0001	NS	0.0288	0.0023
Cultivar (Cult)	<0.0001	<0.0001	0.0003	<0.0001	0.0002	<0.0001	NS	<0.0001	0.0184
GT x Cult	NS	NS	NS	NS	NS	NS	NS	NS	NS

[x] Std = standard gin; exp. = standard gin with experimental ribs.

[y] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

[z] Based on the old code, where 100=31, 104=21, 105=11.

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