

2235 BELTWIDE COTTON QUALITY STUDY

Derek P. Whitelock¹, Michael D. Buser², Carlos B. Armijo¹, Gregory A. Holt², J. Clif Boykin³, Thomas D. Valco⁴, Dennis S. Findley⁵, Edward M. Barnes⁶, and Michael D. Watson⁶

¹USDA-ARS Southwestern Cotton Ginning Research Laboratory, Las Cruces, NM, ²USDA-ARS Cotton Production and Processing Research Unit, Lubbock, TX, ³USDA-ARS Cotton Ginning Research Unit, Stoneville, MS, ⁴USDA-ARS Office of Technology Transfer, Stoneville, MS, ⁵Southeastern Cotton Ginners Assn., Dawsonville, GA, ⁶Cotton Incorporated, Cary, NC

Abstract

A two year, belt-wide commercial cotton gin sampling project was initiated in 2005 for the 2005-06 and 2006-07 ginning seasons to assess the changes in upland cotton quality throughout the ginning process and the ginning season with the ultimate goal of identifying areas where improvements can be made in preservation of fiber quality. This report discusses analysis of the first year data. Overall fiber properties after one stage of lint cleaning were typical of U.S. cotton. In order to compare quality of fiber in seed-cotton samples with ginned lint samples from a commercial gin, hand ginning to lab ginning relationships were developed and used to correct the fiber quality data for lab ginned seed-cotton samples to near pre-ginning values. Trash content analyses showed that cleaning machines typically reduced foreign matter content per lint basis from as high as 50% at the module to about 4% at the lint slide. Short fiber content (SFC) values after ginning were double those at the feeder and increased at a lesser rate with lint cleaning. Nep counts were nearly tripled by the gin stand, then increased steadily as the lint passed through the first and second stage of lint cleaning, but the increases associated with the lint cleaners was much less than that at the gin stand. Length measurements also decreased due to processing. More in-depth data analyses will continue after the 2nd year data are complete. This future work will focus on within-ginning process changes, changes as the ginning season progressed, interactions among fiber properties (i.e. SFC and micronaire or neps and length), and effects of cleaning.

Introduction

Mechanical handling of cotton will typically increase its nep content, and in many cases result in fiber breakage, increasing short fiber content – undesirable from the textile mill’s perspective. Also, there has been recent discussion that leaf grade 4 is a discounted cotton in international cotton markets although it is the base grade for the U.S. loan chart (Laws, 2006). Foreign matter removal at the modern saw gin is accomplished with seed-cotton cleaning machines (i.e. inclined cleaners and stick machines) prior to ginning (Baker et al., 1994) and lint cleaners (i.e. air-type and saw-type lint cleaners) after lint cleaning (Mangialardi et al., 1994). Prior lint cleaning research has concentrated on saw-type cleaners with grid bars (Mangialardi and Anthony, 2003). It is well documented that this type of lint cleaning, while excellent at removing foreign material, reduces fiber length, and increases SFC and neps. More recent research has continued with saw-type lint cleaners and has concentrated on reducing fiber wastage. There is some debate as to whether reducing the amount of fiber taken out by lint cleaners actually affects overall fiber quality in the bale. Based on discussion at a recent summit held at Cotton Incorporated to address lint cleaning issues, researchers from Cotton Incorporated, the USDA-ARS Ginning Labs, and Texas A&M University developed the “dream”:

To clean fiber and maintain fiber quality as well as or better than current technology, and reduce neps and short fiber content.

It was decided that to realize the “dream” some basic knowledge of lint cleaning needed to be confirmed and established with the better fiber quality measurement techniques used today. To that goal, a two year, commercial cotton gin sampling project was planned for the 2005-06 and 2006-07 ginning seasons. The project was initiated to assess changes in upland cotton quality during the ginning process and throughout the ginning season across the cotton belt, and establish up-to-date baseline fiber quality information for saw-ginned upland cotton.

Procedure

During the 2005-06 and 2006-07 ginning seasons, three gins were targeted in each cotton growing region: Far-west, Southwest, Mid-south, and Southeast (fig. 1). Seed-cotton samples were taken at the module and at the

feeder apron of a selected gin stand at each gin. Lint samples were taken before lint cleaning behind the selected gin stand, and after each coinciding lint cleaner. The sampling intervals were early in the season around 1,000 total bales ginned and then at 5,000 bales per gin stand intervals throughout the season. The same gin stand/lint cleaner lines were sampled each time a gin was visited.

All samples were processed and analyzed at Cotton Incorporated. Seed cotton samples were ginned on a small-scale, ten-saw, laboratory gin stand and a subset of samples was hand ginned. The purpose of hand ginning the seed-cotton samples in this manner was to provide a method for adjusting the fiber quality values to pre-ginning levels for comparison with the ginned lint sampled at the commercial gins. High Volume Instrument (HVI), Advance Fiber Information System (AFIS), and Micro Dust and Trash Analyzer III (MDTA3) analyses were performed on the lint samples obtained from the commercial gins and lint samples from the laboratory and hand ginned cotton samples. Results were analyzed to evaluate changes in fiber quality, especially trash content, SFC, length properties, and neps, at each step in the ginning process and as the ginning season progressed.

Results

Overall HVI, AFIS, and MDTA3 analyses results for samples taken after one lint cleaner are summarized in table 1. Fiber properties for the samples obtained from the sampled gins were typical for the 2005 U.S. cotton crop (Cotton Inc., 2006) and were widely variable, likely due to the differences in growing region and variety. Average micronaire was 4.06, in the premium range for that year, and ranged from 4.90 down to 2.80. Upper half mean length ranged from a medium value of 1.02 in. to an extra-long value of 1.27 in. and averaged 1.11 in. Average uniformity (81.1 %) was slightly higher than the average for the entire 2005 crop (80.7%). Strength averaged 28.6 g/Tex and ranged from the discount level of 24.0 g/Tex to the premium level of 34.7 g/Tex. Old color classification code ranged from 89, which is equivalent to the standard classing color 42, to 105, equivalent to color 11. Average nep count per gram was 293 and varied greatly with a CV of 37%. AFIS SFC by weight, with an average of 10.4%, and MDTA3 trash content, with an average of 2.14%, also varied widely (CV = 26.1 and 38.7, respectively).

The variability of the fiber properties across growing regions is shown in table 2. Micronaire varied from below the 2005 crop average (4.26) in the Southwest and Far-west to above in the Mid-south and Southeast. Uniformity ranged from 80.7% in the Southeast to 82.1% in the Far-west; all at or above the 2005 crop average of 80.7%. Nep size did not vary greatly from one region to another with the largest difference of 38 μm between the Mid-south and Far-west, but nep count did vary greatly with the largest difference between the Mid-south and Southwest of 139 neps/g. While some of the differences in fiber properties can be attributed to ginning practices in the regions (i.e. more intensive cleaning needed for stripper harvested cottons in the Southwest), much of the variability from one region to another is likely due to the differences in varieties typical of the growing regions.

Regression analyses of the fiber properties for hand ginned versus laboratory ginned cotton showed there were relationships that could be used to adjust the laboratory ginned data back to values closer to those prior to lab ginning (fig. 2), enabling comparison of fiber properties at different steps in the ginning process. Though the data were somewhat scattered, R^2 values were above 0.50. An example of the impact of these adjustments on the data is shown in figure 3. SFC after ginning on the laboratory gin averaged about 9% for seed cotton collected from the module and feeder apron. After adjusting with the hand ginned/lab ginned relationship in figure 2, the average SFC was in the range of 4 to 5%, closer to expected values before ginning.

Percent trash content was calculated as the ratio of the weight of trash to the weight of clean lint in a cotton sample as determined by the MDTA3 process. Analysis of trash content at various points in the gin showed that trash levels decreased as the material moved through the ginning process, which was expected (fig. 4). Starting between 10% and 50% of the lint at the module (the highest value being stripper cotton from the Southwest), trash content steadily decreased to about 2.5% after one lint cleaner and less than 2% after the second lint cleaner. These results indicate that the seed-cotton and lint cleaning machinery at the gins across the cotton belt are providing the expected level of foreign matter removal.

Percent change in AFIS SFC, nep count, length by weight, and length by number-longest 5% measurements as cotton moves through the gin (module and feeder properties are adjusted back to pre-ginning levels) is shown in figure 5. There was very little change in properties from the module to the feeder, as shown by

the near 0%-change values at the feeder. This was expected since the fiber was still attached to the seed. Through the gin stand (feeder to 0 LC), SFC about doubled and nep count nearly tripled. The increase in SFC due to lint cleaning was less than expected with an average increase of about 10% from the gin stand to one lint cleaner. Also, there was an unexpected trend for SFC to decrease after the second stage of lint cleaning. Typically, it is held that additional lint cleaning will reduce length and increase SFC (Mangialardi et al., 1994). This reduction in SFC did not occur at every sampling time, as seen in figure 6, but was replicated more than once at different gins. The anomaly will have to be explored with further data analysis and the second year of sampling. Nep count continued to rise with lint cleaning, but at a lesser rate than the increase at the gin stand. Length by weight and length by number-longest 5% were almost mirror images of SFC, decreasing with processing, with the same improvement after the second lint cleaner. All four properties degraded more at the gin stand than at the lint cleaners, as shown by the steeper slope of the lines from feeder to 0 LC than from 0 LC to 1 LC and 2 LC in figure 5.

Another interesting anomaly, not shown in figure 5, was an apparent improvement of certain fiber properties (i.e. SFC, nep count, length by weight, and length by number-longest 5%) due to air-type cleaning for a particular gin included in the study (figure 7). This gin was the only gin where samples were taken between the gin stand and the air-type cleaner, so this occurrence could not be substantiated or contradicted with data from the other gins. It is known that this type of lint cleaner is less effective at cleaning and improving grade than saw-type cleaners, but it is considered not to have an effect on fiber length and neps (Mangialardi et al. 1994). In the second year of sampling, greater effort was made to obtain lint sample before the air-type lint cleaner to further investigate this anomaly.

Conclusions

A two year, belt-wide commercial cotton gin sampling project was conducted during the 2005-06 and 2006-07 ginning seasons to assess the changes in upland cotton quality during the ginning process and throughout the ginning season across the cotton belt. The first year of sampling and sample analysis was completed in 2006 and the second year sampling was completed in 2007 and sample analysis continues

Analysis of the first year data show that fiber properties were typical of U.S. cotton and that properties varied greatly across cotton growing regions. This variability was probably mainly due to differing varieties grown in the regions.

Preliminary analysis showed that the ten-saw laboratory gin altered fiber properties enough that hand ginning/lab ginning relationships were needed to correct fiber data for ginned cotton samples back to near pre-ginning values in order to make unbiased comparisons of fiber properties of seed-cotton and ginned lint from different points in the ginning process. The relationships developed fit the data with $R^2 > 0.50$.

Trash content analyses showed that cleaning machines removed foreign matter fairly well. Average trash content, on a per lint basis, changed from as high as 50% to about 4% from the module to the lint slide. SFC doubled at the gin stand, increased at a lesser rate at the 1st lint cleaner, and unexpectedly decreased at the 2nd lint cleaner. Nep count nearly tripled at the gin stand, then increased steadily for one and two lint cleaners, but again at a decreased rate compared to the gin stand. Length measurements also decreased due to ginning and lint cleaning, but similar to SFC, increased after two lint cleaners.

Some unexpected findings, like a decrease in SFC and neps and increased length measurements at the air-type cleaner and after the 2nd lint cleaner, led to more directed sampling in the second year of the study. After the second year fiber analyses are complete, more in-depth data analyses will continue focusing on within-ginning process changes, changes as the ginning season progressed, interaction among fiber properties (i.e. SFC and micronaire or neps and length), and effects of cleanings.

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.

Acknowledgements

The authors would like to thank the cooperating gin managers and personnel who generously allowed us to sample their gins and, in some cases, conducted the sampling. We would also like to thank the Cotton Ginners Associations across the Cotton Belt for helping to line up cooperating gins.

References

Baker, R.V., W.S. Anthony, and R.M Sutton. 1994. Seed cleaning and extracting. p. 69-89. *In* Anthony and Mayfield (ed.) Cotton Ginners Handbook. USDA Agricultural Research Service Handbook No. 503. Government Printing Office, Washington, DC.

Cotton Inc. 2006. Quality summary of 2005 U.S. upland cotton. [Online]. Available at <http://www.cottoninc.com/CropQualitySummary/2005FinalCropQualitySummary/> (verified 6 Aug. 2007). Cotton Incorporated, Cary, NC.

Laws, F. 2006. U.S. growers need to grow cotton outside the middle of the box. Western Farm Press. December 19. [Online]. Available at <http://westernfarmpress.com/news/121906-cotton-category/> (verified 6 Aug. 2007). Penton Media, New York, NY.

Mangialardi, G.J. and W.S. Anthony. 2003. Review and Summation of Lint Cleaner for Cotton Gins. The Cotton Foundation and National Cotton Ginners Association, Memphis, TN.

Mangialardi, G.J., R.V. Baker, D.W. VanDoorn, and B.M. Norman. 1994. Lint cleaning. p.102-119. *In* Anthony and Mayfield (ed.) Cotton Ginners Handbook. USDA Agricultural Research Service Handbook No. 503. Government Printing Office, Washington, DC.

Table 1. Summary of fiber properties after one stage of lint cleaning.

Fiber Property	Mean	Max	Min	CV (%)
High Volume Instrument				
Micronaire	4.06	4.90	2.80	12.6
Upper Half Mean Length (in.)	1.11	1.27	1.02	4.8
Uniformity Index (%)	81.1	84.8	78.3	1.6
Strength (g/Tex)	28.6	34.7	24.0	7.1
Elongation (%)	5.31	7.90	3.70	17.1
Reflectance, Rd (%)	79.2	83.7	70.6	4.3
Yellowness, +b	8.64	10.8	7.00	10.4
Color Code ^z	101	105	89.0	4.3
Non-lint Content (% area)	0.28	1.00	0.10	63.8
Short Fiber Content (%)	8.70	16.5	2.90	30.3
Advance Fiber Information System				
Nep Size (µm)	717	807	668	3.0
Nep Count (g ⁻¹)	293	619	139	36.9
Length by weight (in.)	0.98	1.12	0.86	5.8
Length by weight CV (%)	36.4	42.3	29.4	7.3
Upper Quartile Length by weight (in.)	1.21	1.36	1.08	4.7
Short Fiber Content by weight (%)	10.4	17.4	4.40	26.1
Length by number (in.)	0.72	0.89	0.58	10.0
Length by number CV (%)	60.7	70.5	44.5	9.2
Short Fiber Content by number (%)	34.4	47.1	17.9	18.2
Length by number Longest 5% (in.)	1.35	1.53	1.20	4.7
Length by number Longest 2.5% (in.)	1.45	1.64	1.29	4.7
Total Foreign Matter Count (g ⁻¹)	501	1149	157	39.9
Trash Size (µm)	342	546	263	10.7
Dust Count (g ⁻¹)	412	924	106	39.8
Trash Count (g ⁻¹)	89.5	225.	21.0	45.8
Visible Foreign Matter (%)	1.90	4.52	0.55	40.8
Seed Coat Nep Size (µm)	1182	1480	899	9.9
Seed Coat Nep Count (g ⁻¹)	18.0	54.0	7.00	40.6
Fineness (mTex)	167	184	147	4.0
Immature Fiber Content (%)	11.1	16.8	7.40	17.1
Maturity Ratio	0.82	0.91	0.73	4.5
Micro Dust and Trash Analyzer III				
Trash Content (%)	2.14	6.65	0.75	38.7

^z Old classing code where 89 = color 42, 101 = color 13, and 105 = color 11.

Table 2. Comparison of change in fiber properties after one stage of lint cleaning by U.S. cotton growing region.

Fiber Property	Mid-south	Far-west	Southwest	Southeast
High Volume Instrument				
Micronaire	4.34	4.04	3.45	4.50
Upper Half Mean Length (in.)	1.10	1.18	1.10	1.09
Uniformity Index (%)	81.2	82.1	80.9	80.7
Strength (g/Tex)	28.7	29.7	27.8	28.3
Elongation (%)	4.78	6.00	5.81	4.60
Reflectance, Rd (%)	78.0	81.3	80.7	76.3
Yellowness, +b	8.92	8.13	9.47	8.18
Color Code ^z	101	103	104	97.1
Non-lint Content (% area)	0.44	0.22	0.23	0.31
Short Fiber Content (%)	7.98	6.21	10.1	9.50
Advance Fiber Information System				
Nep Size (µm)	694	732	721	711
Nep Count (g ⁻¹)	182	280	421	232
Length by weight (in.)	1.00	1.04	0.95	0.96
Length by weight CV (%)	33.9	34.8	38.2	36.7
Upper Quartile Length by weight (in.)	1.21	1.27	1.18	1.19
Short Fiber Content by weight (%)	8.24	8.33	12.3	10.9
Length by number (in.)	0.77	0.79	0.68	0.70
Length by number CV (%)	55.8	57.3	63.5	62.1
Short Fiber Content by number (%)	29.3	29.8	38.2	36.1
Length by number Longest 5% (in.)	1.35	1.42	1.32	1.33
Length by number Longest 2.5% (in.)	1.45	1.53	1.41	1.42
Total Foreign Matter Count (g ⁻¹)	509	451	550	524
Trash Size (µm)	373	326	347	340
Dust Count (g ⁻¹)	407	381	443	434
Trash Count (g ⁻¹)	102	70.0	107	90.1
Visible Foreign Matter (%)	2.20	1.59	2.00	2.03
Seed Coat Nep Size (µm)	1147	1237	1131	1200
Seed Coat Nep Count (g ⁻¹)	11.7	21.8	21.1	15.2
Fineness (mTex)	168	167	161	171
Immature Fiber Content (%)	9.51	10.5	13.3	10.2
Maturity Ratio	0.85	0.83	0.78	0.83
Micro Dust and Trash Analyzer III				
Trash Content (%)	2.53	1.88	1.82	2.40

^z Old classing code where 97 = color 32, 101 = color 13, 103 = color 12, and 104 = color 21.

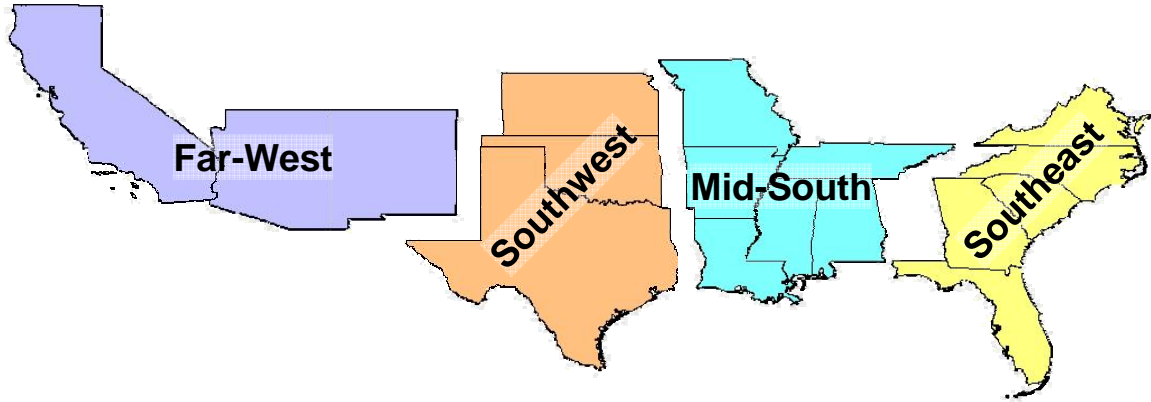


Figure 1. Four cotton growing regions where gins were sampled.

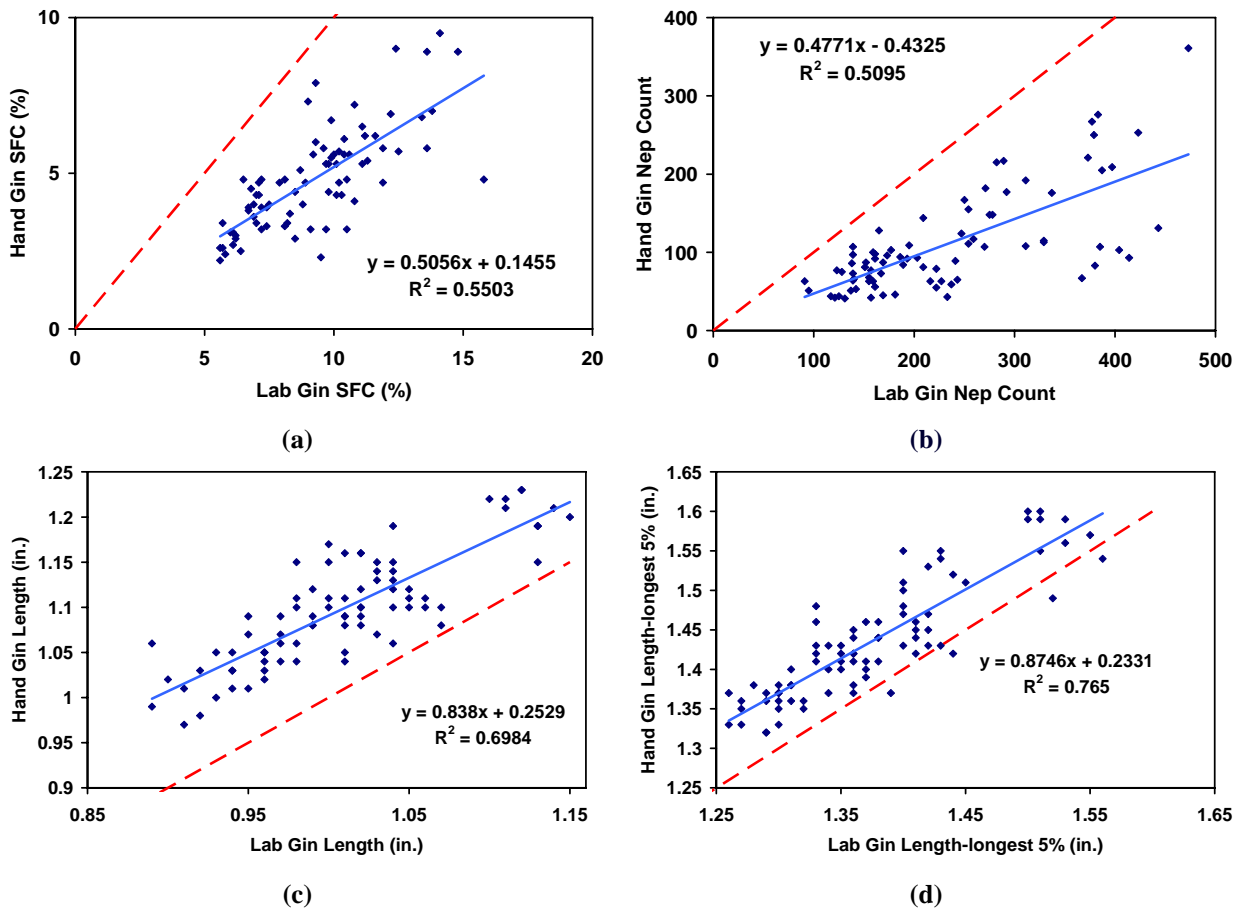


Figure 2. Relationship between hand ginned fiber and fiber ginned on a ten-saw lab gin for (a) AFIS short fiber content (%) by weight, (b) AFIS nep count per gram, (c) AFIS length by weight (in.), and (d) AFIS length by number-longest 5% (in.). Solid line represents regression line and dashed line represents a one-to-one relationship.

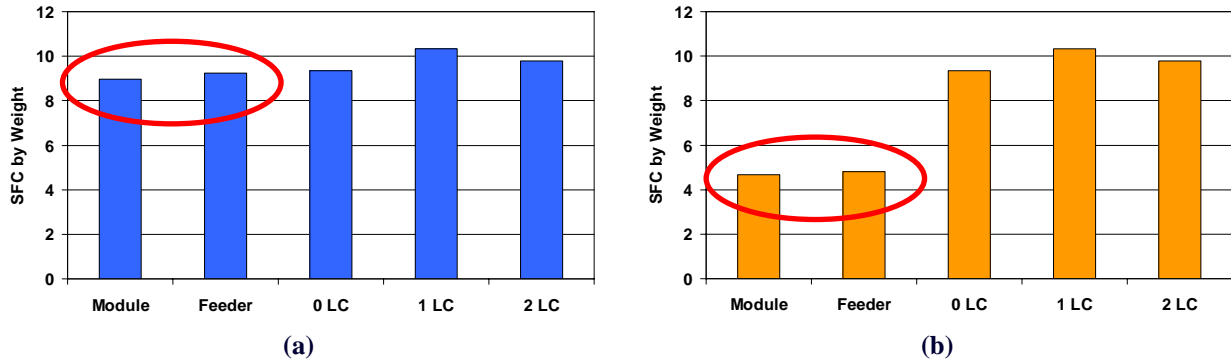


Figure 3. Short fiber content adjustment effect: (a) laboratory ginned (before adjustment) and (b) hand ginned (after adjustment) . The circle indicates the data that were adjusted.

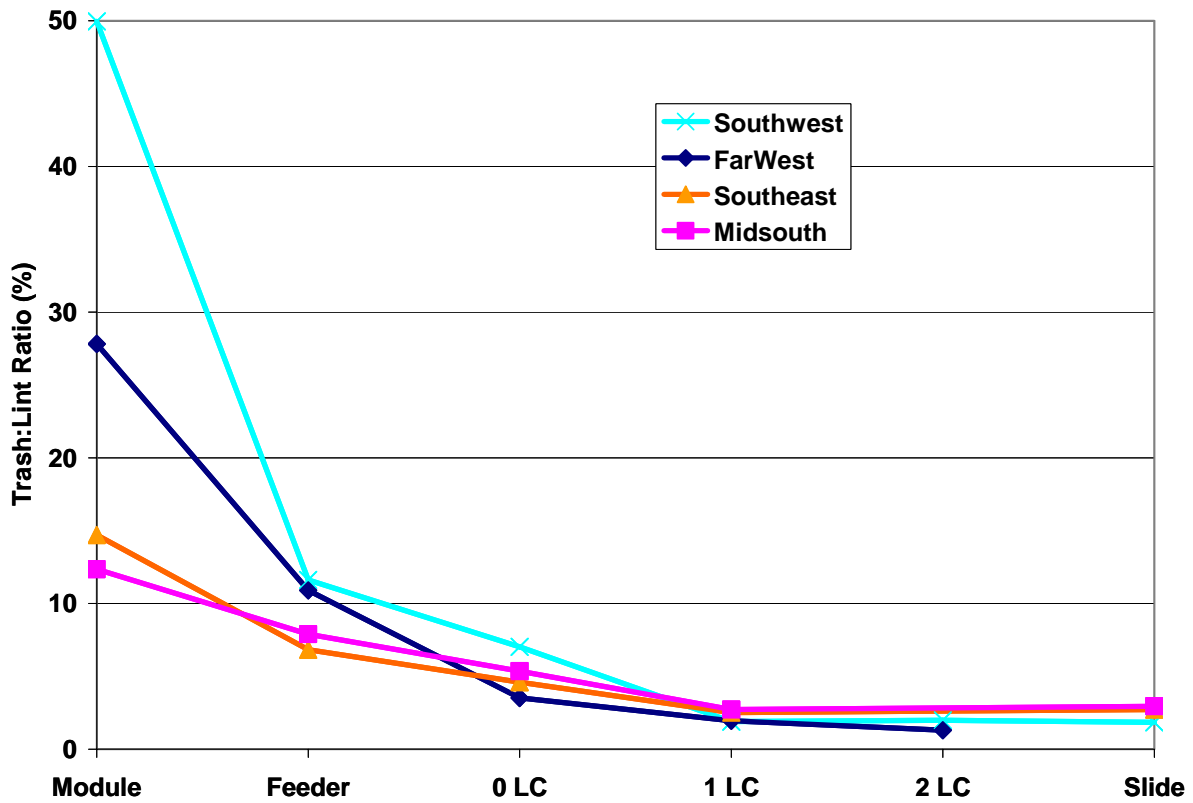


Figure 4. Average trash content (weight of trash to weight of cleaned lint determined from MDTA3 analysis) of cotton as it proceeds through gins in the four cotton growing regions.

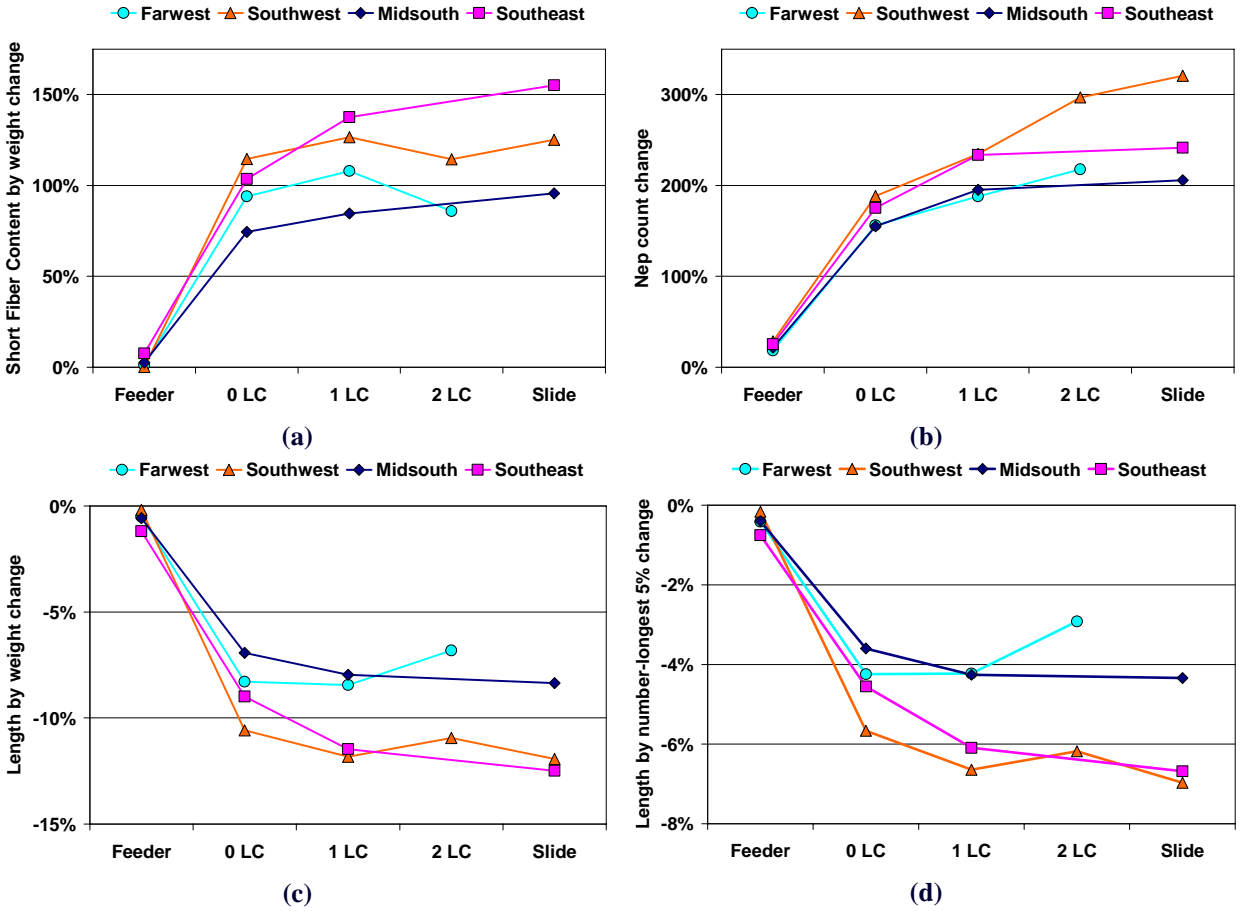


Figure 5. Percentage change from values at the module in average values for (a) AFIS short fiber content, (b) AFIS nep count per gram, (c) AFIS length by weight, and (d) AFIS length by number-longest 5% as cotton proceeds through gins in the four cotton growing regions.

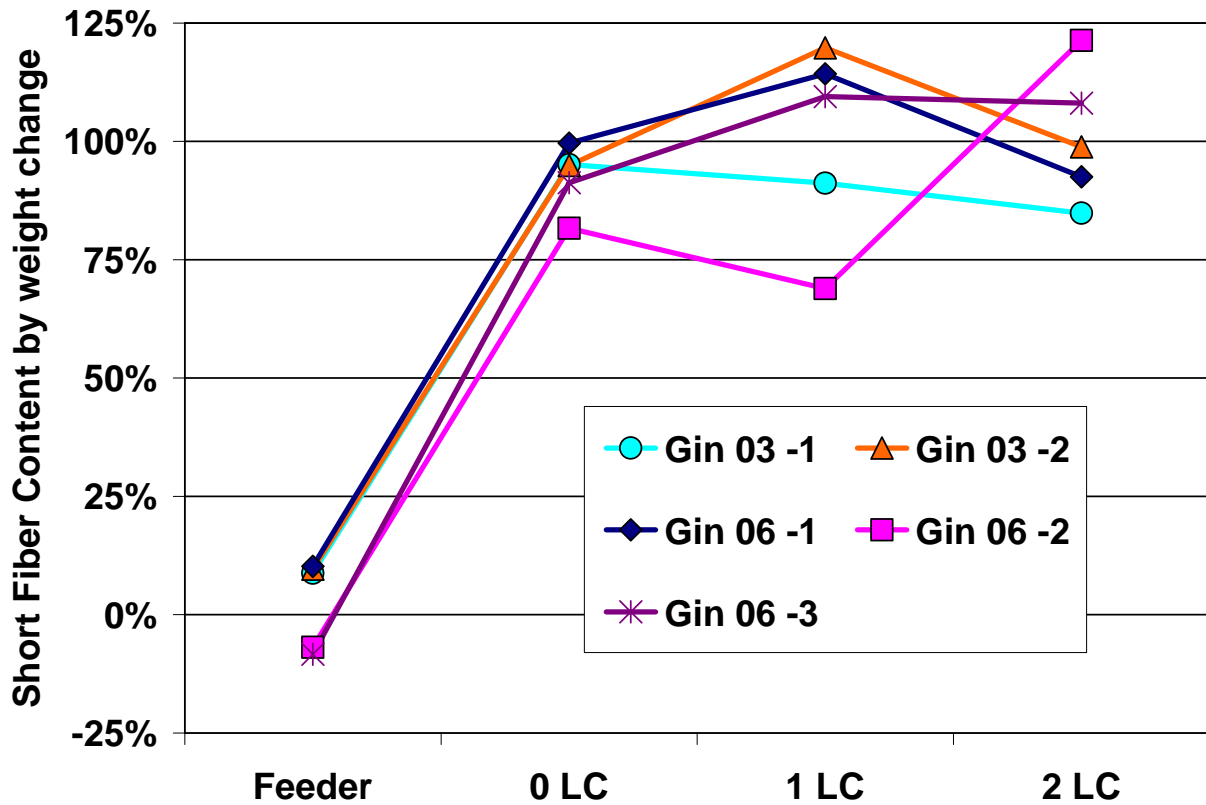


Figure 6. Percentage change of SFC from the module for two gins at different sample times. Illustrates improvement, though inconsistent, of certain fiber properties after two lint cleaners.

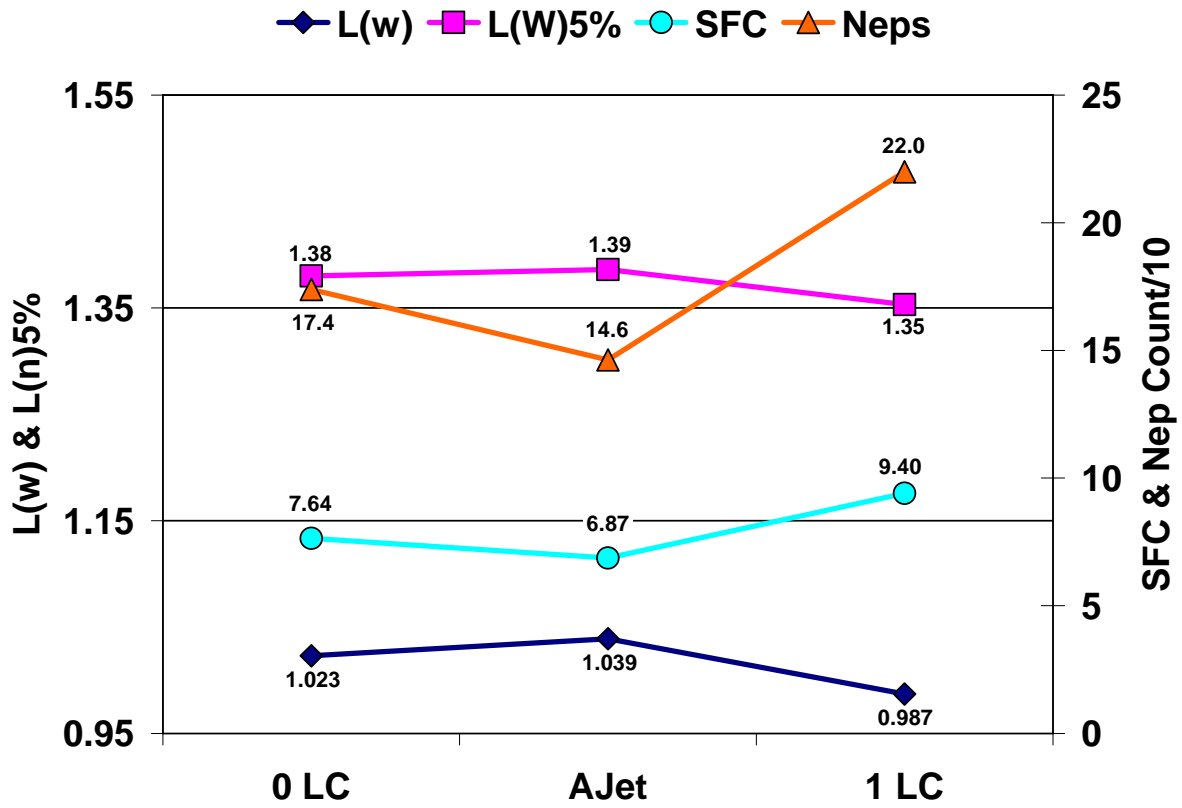


Figure 7. Average AFIS short fiber content (%), nep count per gram, length by weight (in.), and length by number-longest 5% (in.) for lint samples collected behind the gin stand (0 LC), after an air-type cleaner (AJet), and after one stage of saw-type lint cleaning (1LC) for a particular gin participating in the study. Illustrates improvement of certain fiber properties after an air-type cleaner at a particular gin.