The *Journal of Cotton Science 12:345–356 (2008)*
http://journal.cotton.org, © The Cotton Foundation 2008

ENGINEERING AND GINNING

Quality Effects from the Addition of Moisture to Seed Cotton with Two Surfactants

Richard K. Byler*, Gary R. Gamble, and J. Clif Boykin

ABSTRACT

Moisture was restored to seed cotton before ginning in the conveyer-distributor using an atomizing spray nozzle to increase fiber moisture content in the gin stand. A total of 54 bales were ginned with moisture restoration using an atomizing spray of water or water with either of two surfactants. Samples were taken for determination of moisture content and fiber properties. The moisture content of samples taken immediately after the gin stand was shown to correlate with improved fiber length properties as measured by the Advanced Fiber Information System (AFIS). Three lots from seven bales were spun into yarn with samples taken for sliver and yarn property determination. Seed cotton moisture restoration was correlated with improved fiber length properties and yarn strength, but produced more waste. The use of surfactants did not affect the fiber or yarn significantly when compared to moisture restoration with water alone.

Almost since the initial adoption of the cotton gin drier in the 1940s, scientists have documented the decrease in fiber length quality when ginning at moisture content (mc) below 5% (Byler, 2006; Gerdes et al., 1941). Moore and Griffin (1964) presented a possible explanation: because cotton fiber strength increases over an mc range of 3 to 15%, and the attachment of the fiber to the seed is relatively constant from 3 to 11% mc and then decreases up to 15% mc, the ratio of the force required to remove the fiber from the seed to the strength of the fiber decreases with increasing mc. Much of the fiber is at a mc below 5% when harvested without additional drying, even in the humid Mississippi Delta region. The fiber length property used for the cotton pricing structure was staple length until High Volume Instrument (HVI) fiber length classification was adopted. Staple length is determined by visual inspection by human classers, and generally, the difference in staple length due to the ginning moisture level has not been statistically significant. The negative impact on mills of ginning at lower mc, however, has been documented (Byler, 2006).

Studies have been performed in which moisture was added to increase the lint mc after seed cotton cleaning but before ginning, either by spraying water on the seed cotton or by exposing the seed cotton to moist air (Griffin and Merkel, 1953; Lafferty, 1971; Leonard et al., 1970). Mangialardi et al. (1965) ginned one cultivar with various drying procedures and with moisture added using vapor or spray methods for some treatments before ginning. They measured the fiber length quality with the Suter-Webb array and the fibrograph. They reported no statistical difference in staple length, but most of the other fiber length properties had significant differences related to the treatments. The cottons with a higher mc tended to have more trash content and resulted in significantly higher Pressley fiber strength ($P = 0.01$). Data were presented linking lower mc fiber at ginning to lower yarn break factor ($P = 0.01$). When moisture was added to the seed cotton after drying and cleaning but before ginning, the fiber and yarn properties improved. For the treatment designated "heavy drying" they included two 24-shelf tower driers, both set at 121 °C (250 °F). This treatment resulted in a fiber mc of 2.7% and a fibrograph upper-half mean length of 26.7 mm (1.05 in), whereas heavy drying followed by spray-type moisture restoration resulted in a fiber mc of 8.1% and an upper-half mean length of 27.7 mm (1.09 in).

Byler and Boykin (2006) sprayed atomized water on seed cotton and used Humidaire (Samuel Jackson, Inc., Lubbock, TX) steam moisture application to restore moisture. They found that ginning at a higher fiber mc improved the HVI strength and length and the Advanced Fiber Information System (AFIS; Uster Technologies; Knoxville, TN) fiber length properties and was independent of the method used to achieve the higher fiber mc.

R.K. Byler* and J.C. Boykin, PO Box 256, Stoneville, MS 38776; G.R. Gamble, Ravenel Center Court, Ravenel Center, Rm 10, Clemson, SC 29634
*Corresponding Author: rick.byler@ars.usda.gov

Several studies have shown improved spinning properties of cotton associated with moisture restoration done before ginning (Childers and Baker, 1977; Leonard et al., 1970; Mangialardi et al., 1965). However, the measures of fiber length quality that have been used in cotton marketing have not been shown consistently to respond significantly either when ginning at various mc levels or with moisture restoration before the gin stand (Byler, 2006). Because additional drying consistently has resulted in better cleaning efficiency, the marketing system has not provided an incentive to producers and ginners to concentrate on the problem of fiber length quality reduction due to ginning at low seed cotton mc. Many of the Suter-Webb, fibrograph, AFIS length measurements, and yarn strength measurements made in different studies were improved when ginning occurred after adding moisture to the seed cotton relative to ginning at lower mc. Ginning affects the fiber length quality and it is important for ginning researchers to better understand this problem so that higher quality fiber can be produced for the mills.

Byler (2005) and Byler and Boykin (2006) found that increasing the mc of fiber during ginning improved the HVI fiber length and strength. Byler and Boykin used atomized spray as well as humidified air for moisture restoration. They found that the method of moisture restoration made no difference in fiber quality. Either method improved the HVI length by 0.17 mm (0.007 in) and strength by 0.33 g/ Tex per percentage point increase in fiber mc during ginning.

Anthony (2003, 2004) surveyed gins in the Mid-South for lint moisture levels. In 2002, he found that the average mc of all lint samples per gin of samples taken from the lint slide before moisture restoration varied between 3.7% and 6.2% wet basis (wb). In 2003, he found that the average mc of all samples at each gin of lint mc after ginning, but before moisture restoration, ranged from 3.0% to 5.8% wb. The overall mean mc for all gins was 5.1% in 2002 and 4.4% in 2003. These data show that ginning at lower than recommended mc is common. Among the factors contributing to this are (1) farmers typically harvest during good weather and place the seed cotton in modules that can result in seed cotton becoming drier than ideal for ginning, (2) the improvement of cotton value because of better cleaning efficiency, and (3) the limited ability of the grading system to detect the fiber damage done by ginning at lower mc.

Researchers are interested in ginning methods that improve the fiber length properties affecting price and mill processing. Thus, there is interest to include an additional appropriate measurement of fiber length that better predicts fiber-processing at the mill in official USDA Agricultural Marketing Service (AMS) classing (Bradow and Davidonis, 2000; Cui et al., 2004; Knowlton, 2004; and Krifa, 2004). Additions to the mc of the lint before the gin stand is limited under commercial ginning conditions due to the short time the seed cotton is available for treatment in the gin plant and the mass flow rate of material through the plant.

The purpose of this work was to study the effect on fiber and yarn quality of adding moisture to seed cotton by spraying water on the cotton in the conveyer distributor, before the gin stand. Two surfactants were used, in addition to plain water, to attempt to get more moisture into the fiber in the short time available in the gin plant before the gin stand.

MATERIALS AND METHODS

The two surfactants chosen for inclusion in the study are already in use in the cotton industry: Dyne-Amic® (Helena Chemical Co.; Collierville, TN) (surfactant 1) used with chemical application during cotton production and AN114022 spindle cleaner (John Deere; Moline, IL) (surfactant 2) used during cotton harvesting. The concentration recommended by the manufacturers was about 15 times greater for surfactant 2 than for surfactant 1. For the initial test, clumps of approximately 16 g of seed cotton were taken from one lot at a uniform mc loosely confined within cotton gauze, and then submerged in water, water with 0.1% by weight of surfactant 1, or water with 1.56% by weight of surfactant 2 for 5 s. The gauze and seed cotton were then reweighed. These data were used to determine if the surfactants helped spread water into the seed cotton.

Three 57-L high-density polyethylene drums were used to hold the three fluids applied to the seed cotton under the dropper above the conveyer-distributor. A separate pump (Model 8000-543-238, Shurflo Pump Mfg. Co.; Cypress, CA) was used to deliver each fluid to the atomizing spray nozzle (Model SUQR-300, Spraying Systems Co.; Wheaton, IL) located above the conveyer-distributor. The air pressure was kept constant at 552 kPa (80 psi) and three spray application levels were used: zero; low, 138 kPa (20 psi); and high, 276 kPa (40 psi). The plume of atomized water was directed parallel to the conveyer-distributor above the auger and below the dropper so the mist would mix with the seed cotton falling from the dropper. Several bales were ginned while adjusting the fluid pressure with the different fluids to determine the maximum application pressure that could be used and not cause seed cotton flow problems into the gin stand. This pressure was found to be 276 kPa (40 psi) for all three fluids. The drum containing the fluid to be applied was placed on a scale and weighed during each application for an accurate application measurement.

The seed cotton tested was grown commercially south of Leland, MS. Two modules of cultivar DP444 BG/RR (444) and two modules of cultivar DP434 RR (434) (Delta and Pine Land; Scott, MS) that were spindle picked on Sept. 23, 2005 and ginned between Oct. 18 and Oct. 21, 2005. Conventional seed cotton drying and cleaning were used consisting of: first tower drier, cylinder cleaner, stick machine, second tower drier, and second cylinder cleaner. The selected atomized water spray was applied before the seed cotton was ginned with a Continental gin stand and cleaned with one saw-type lint cleaner then baled. In addition to the moisture addition by the atomizing spray nozzles, some additional moisture was added using a Humidaire with Conditioning Hopper (Samuel Jackson Inc.; Lubbock, TX) above the gin stand for selected bales.

The basic treatment unit was a bale produced from 660 kg (1450 lb) of seed cotton. Table 1 shows the 12 treatments included in this study. After the first bales were ginned, the remaining bales were randomly assigned a treatment and each treatment was used before another treatment was applied. The modules were ginned alternately by cultivar. Fifty-four bales were ginned in the test with some treatments repeated more often than others. For each bale, 10 lint samples—five before and after the lint cleaner were obtained for mc analysis by the oven method and for wet basis mc determination (Shepherd, 1972). Three seed cotton samples were obtained per bale as the cotton entered the gin and three additional samples were taken at the gin stand feeder apron after moisture treatment for mc determination. Five lint samples were obtained before and five others after the lint cleaner for fiber quality determination by the AFIS. The resulting mc and fiber quality data were analyzed using SAS (Release 8.02, SAS Institute, Inc.; Cary, NC) procedures MIXED and the statement LSMEANS. All means reported herein are least squares means determined by statistical analysis, except where arithmetic mean is noted.

In the spring of 2006, seven bales were shipped to the ARS Cotton Quality Research Laboratory in Clemson, SC (Clemson Lab.). The treatments these bales received are documented in Table 2. The work at the Clemson Lab was intended to detect any fiber quality and spinning problems related to the surfactant application. Each of the bales had three repeat lots processed and examined for opening and cleaning waste, card waste, spinning performance, single end strength,

Table 1. Moisture treatments of the bales

Treatment	Drying temperature, °C		Moisture addition	
	First dryer	Second dryer	Spray	Hopper
1	43	Off	Off	Off
2	43	Off	Off	On
3	43	Off	High water	On
4	66	52	Off	Off
5	66	52	Low water	Off
6	66	52	High water	Off
7	66	52	Off	On
8	66	52	High water	On
9	66	52	Low surfactant 1	Off
10	66	52	High surfactant 1	Off
11	66	52	Low surfactant 2	Off
12	66	52	High surfactant 2	Off

strength coefficient of variation (CV), elongation, yarn evenness data, and long term yarn data. Each lot consisting of 45 kg (100 lb) of lint was processed on the Truezschler Opening Line and 803 Card (Truetzschler: Monchengladbach, Germany). Card sliver was produced at 4.5 g/m processed at the rate of 68 kg/h. First and second finisher drawings were performed and roving was produced with a 1.3-twist multiplier at a spindle speed of 1200 rpm. The lots were ring spun into 22-Tex yarn with a 3.5-twist multiplier. Stops were recorded. The Statimat-M (Uster Technologies, Inc; Knoxville, TN) was used for yarn measurements including strength, strength CV, and elongation. The ILE DS-65 Evenness Tester (Industrial Laboratory Equipment; Charlotte, NC) was used to measure thick places and thin places. Long term defects were measured using the Classimat II (Uster Technologies Inc.; Knoxville, TN).

Table 2. Treatments of bales analyzed at the Cotton Quality Research Laboratory

Treatment	Cotton cultivar	Moisture treatment
6	444	High water
12	444	High surfactant 2
4	444	Drying only
6	434	High water
4	434	Drying only
10	434	High surfactant 1
12	434	High surfactant 2

Selected AFIS measurements of samples taken in the gin were complemented by AFIS measurements obtained from samples obtained at the Clemson Lab (AFIS Version 4). The data for bales with Humidaire moisture application and low-level spray were eliminated from the data for samples from the gin to produce a compatible data set. The data from the gin included five lots from each of 24 bales and the data from the spinning lab included three lots from each of seven bales, so more measurements from the gin than from the Clemson Lab are included in the data.

RESULTS

For the test of the wetting ability of the surfactants at the concentrations used, the average initial weight of the seed cotton before being immersed in water was 16.1 g and the weight increase after removal from the water was 81.1%. The average initial weight of the seed cotton immersed in water with surfactant 1 and surfactant 2 was 16.3 g and 16.1 g respectively, and the seed cotton increased in weight 200.2% and 174.4% respectively. Thus, it was clear that the surfactants were effective in dispersing water into the cotton locks when submerged in the fluids used in the tests.

The total weight of fluid applied to each bale was measured: for the 138-kPa water pressure setting, the arithmetic mean of the weight applied was 9.4 kg and for the 276-kPa setting, 13.9 kg was applied. The lint mc data were analyzed using the SAS procedure MIXED. The repeated reading within a single bale was the random effect. The model included effects due to cultivar, use of the Humidaire, spray level, and the material added to the spray water. There were a total of 54 bales from the two modules from each of two cultivars with five samples per bale before and five after the lint cleaner. Table 3 shows a summary of the mc results; the standard errors of these mc estimates were slightly less than 0.1 percentage point. There were statistically significant differences in the mc of the lint related to the module it came from, the Humidaire moisture treatment, and the spray water treatment, but the differences related to the material

Table 3. Moisture content, percent wet basis, least squares means, and statistical significance of differences between means

	Samples taken before lint cleaner	Samples taken after lint cleaner
Module number	**Moisture content**	
101	5.11	5.26
3398	5.46	5.23
3298	5.66	5.17
3299	5.93	5.49
Average over modules	5.54	5.29
	Change in moisture content due to moisture restoration	
With Humidaire	0.28	0.23
With low spray	0.62	0.55
With high spray	1.12	0.80
	Change in moisture content due to surfactant	
High water alone	0.98	0.79
High water with surfactant 1	0.89	0.70
High water with surfactant 2	1.36	0.95
	Statistical probability > *F* by chance	
Module differences	< 0.0001	0.011
Humidaire addition	0.057	0.023
Spray addition	< 0.0001	< 0.0001
Material within spray	0.37	0.17
Drying level	0.26	0.37

within a spray level were not significant. Thus, the surfactants did not help achieve a higher lint mc as had been proposed. The mc data from before the lint cleaner, the best indicator of the mc in the gin stand, showed that the Humidaire added 0.28 percentage points and the low- and high-spray settings added 0.62 and 1.12 percentage points respectively.

Table 4 shows the upper-quartile fiber length in cm, as measured by the AFIS, for the samples collected before and after the lint cleaner in the gin. There were significant differences in fiber length related to the cultivar, as expected. However, the differences attributed to cultivar also could have been related to other causes not studied, such as differences in growth conditions or weather between the two cultivars. It was important to control for the combined effects attributed to cultivar statistically, but the important question was whether the treatments affected the fiber independently of the cultivar. The Humidaire treatment was correlated with an increase in fiber length as was the spray water addition at either level, with the higher spray level resulting in greater fiber length. The differences in the mean upper-quartile fiber length related to the spray materials of samples taken before the lint cleaner were not statistically significant.

The summary of the analysis of AFIS short fiber data for samples taken in the gin is shown in Table 5. This data showed significant differences related to cultivar and significantly lower short fiber contents associated with the mc addition with Humidaire and spray. The materials used in the spray, two surfactants with water and plain water, did not cause statistically significant differences in the short fiber content.

The data for samples obtained in the gin were limited to those treatments used to produce the bales tested at the Clemson Laboratory so that the data could be compared to that obtained for samples taken during yarn production in Tables 6 through 10. In Table 6, the AFIS upper-quartile length calculated by weight was greater in every case for samples with atomized spray moisture restoration, but in the finisher sliver the difference was not statistically significant. In none of the five sampling locations did the use of a surfactant significantly affect the length differently than water. One cultivar had greater fiber length in every measurement location, but the difference was statistically significant only with the samples obtained in the gin.

Table 4. Least squares means of AFIS upper-quartile length (cm) calculated by weight and statistical significance of differences between means for samples collected in the gin[z]

	Collected before lint cleaner	Collected after lint cleaner
	Means by cultivar	
Cultivar 434	3.081	3.040
Cultivar 444	3.042	3.006
	Change due to moisture restoration	
Increase with Humidaire use	0.016	0.022
Increase with low spray	0.025	0.020
Increase with high spray	0.041	0.037
	Change by spray material	
Increase with surfactant 1 high spray	0.035 a	0.024 b
Increase with surfactant 2 high spray	0.049 a	0.039 a
Increase with water high spray	0.038 a	0.034 ab
	Statistical probability > *F* by chance	
Cultivar	< 0.0001	< 0.0001
Humidaire	0.0075	< 0.0001
Spray moisture restoration	< 0.0001	< 0.0001
Material within spray	0.45	0.162

[z] Letters indicate means that are significantly different ($P < 0.10$).

Table 5. Least squares means of AFIS short fiber content (%) and statistical significance of differences between means

	Samples taken before lint cleaner	Samples taken after lint cleaner
	Mean by cultivar	
Cultivar 434	8.073	8.501
Cultivar 444	7.890	8.415
	Change due to moisture restoration	
With Humidaire	-0.59	-0.614
With low spray	-0.44	-0.592
With high spray	-0.72	-0.835
	Statistical probability > *F* by chance	
Cultivar	0.023	0.28
Humidaire	< 0.0001	< 0.0001
Spray moisture addition	0.019	0.026
Material within spray	0.33	0.73

Table 6. Least squares means of AFIS upper-quartile length (cm) calculated by weight and statistical significance of differences between the means for samples obtained in the gin with data for treatments including low-spray level and Humidaire removed and during the spinning process

	Gin before lint cleaner	Gin after lint cleaner	Raw stock	Card sliver	Finisher sliver
			Mean by cultivar		
Cultivar 434	3.0694	3.0282	3.088	3.049	3.124
Cultivar 444	3.0353	2.9946	3.075	3.026	3.106
			Mean by spray moisture restoration		
No	3.0326	2.9948	3.061	3.014	3.095
Yes	3.0721	3.0281	3.100	3.059	3.129
			Mean by spray material		
Surfactant 1	3.0670	3.0239	3.090	3.052	3.102
Surfactant 2	3.0810	3.0388	3.099	3.061	3.133
Water	3.0683	3.0226	3.112	3.065	3.154
			Statistical probability > *F* by chance		
Cultivar	< 0.0001	<0.0001	0.21	0.12	0.16
Spray moisture restoration	< 0.0001	<0.0001	0.011	0.013	0.10
Material within spray	0.47	0.12	0.55	0.87	0.24

Table 7. Least squares means and statistical significance of differences of the AFIS measurement of short fiber (%) of samples taken at the gin and during the spinning process for the bales tested at the Clemson Lab

	Gin before lint cleaner	Gin after lint cleaner	Raw stock	Card sliver	Finisher sliver
			Mean by cultivar		
Cultivar 434	8.421	8.916	7.34	10.35	8.81
Cultivar 444	8.178	8.729	7.48	9.89	8.74
			Mean by spray moisture restoration		
No	8.641	9.219	7.65	10.40	9.13
Yes	7.958	8.425	7.35	9.81	8.57
			Mean by spray material		
Surfactant 1	8.09	8.40	8.10	9.68	9.21
Surfactant 2	7.94	8.40	7.25	10.47	8.28
Water	7.86	8.48	6.70	9.30	8.22
			Statistical probability > *F* by chance		
Cultivar	0.040	0.13	0.025	0.20	0.72
Spray	< 0.0001	< 0.0001	0.098	0.16	0.23
Material	0.53	0.92	0.0002	0.068	0.33

Table 8. Least squares means and statistical significance of differences of the AFIS measurement of neps (count per g) of samples taken at the gin and during the spinning process for the bales tested at the Clemson Lab

	Gin before lint cleaner	Gin after lint cleaner	Raw stock	Card sliver	Finisher sliver
		Mean by cultivar			
Cultivar 434	187.9	258.8	190	34.6	37.6
Cultivar 444	231.5	313.6	265	44.7	56.5
		Mean by spray moisture restoration			
No	213.4	290.7	215	38.5	45.8
Yes	206.0	281.5	249	39.8	48.3
		Mean by spray material			
Surfactant 1	205.8	284.5	282	35.7	48.5
Surfactant 2	203.5	274.7	215	42.8	47.3
Water	208.6	285.2	249	41.0	49.0
		Statistical probability > *F* by chance			
Cultivar	<0.0001	< 0.0001	0.0010	0.097	< 0.0001
Spray	0.020	0.022	0.15	0.80	0.48
Material within spray	0.65	0.27	0.16	0.66	0.91

Table 9. Least squares means and statistical significance of differences of the AFIS measurement of trash (count per g) of samples taken at the gin and during the spinning process for the bales tested at the Clemson Lab

	Gin before lint cleaner	Gin after lint cleaner	Raw stock	Card sliver	Finisher sliver
		Mean by cultivar			
Cultivar 434	113.3	82.0	77.1	2.46	2.00
Cultivar 444	132.5	89.2	73.6	2.03	3.33
		Mean by spray moisture restoration			
No	119.1	80.7	70.0	2.00	2.33
Yes	126.6	90.5	77.9	2.41	3.15
		Mean by spray material			
Surfactant 1	121.8	90.0	66.2	2.06	3.78
Surfactant 2	125.0	91.7	93.0	3.00	2.50
Water	133.2	90.0	74.5	2.17	3.17
		Statistical probability > *F* by chance			
Cultivar	< 0.0001	0.0084	0.41	0.35	0.010
Spray	0.023	0.0004	0.42	0.51	0.16
Material within spray	0.13	0.91	0.14	0.43	0.30

Table 10. Least squares means and statistical significance of the AFIS measurement of visible foreign matter (%) of samples taken at the gin and during the spinning process for the bales tested at the Clemson Lab

	Gin before lint cleaner	Gin after lint cleaner	Raw stock	Card sliver	Finisher sliver
		Mean by cultivar			
Cultivar 434	2.275	1.609	1.60	0.080	0.0483
Cultivar 444	2.677	1.740	1.63	0.046	0.0650
		Mean by spray moisture restoration			
No	2.379	1.534	1.52	0.055	0.0517
Yes	2.573	1.814	1.67	0.066	0.0617
		Mean by spray material			
Surfactant 1	2.487	1.763	1.47	0.046	0.0617
Surfactant 2	2.551	1.946	1.88	0.065	0.0617
Water	2.682	1.746	1.67	0.088	0.0617
		Statistical probability > *F* by chance			
Cultivar	< 0.0001	0.027	0.72	0.055	0.012
Spray	0.0095	< 0.0001	0.22	0.59	0.12
Material within spray	0.32	0.13	0.10	0.38	1.00

The data for AFIS short fiber content was less consistent (Table 7). The short fiber content for the samples with spray moisture restoration were significantly lower for samples obtained in the gin, but the differences were not considered to be significant for the card and finisher sliver. The short fiber content was higher with no moisture restoration than with it in all cases. The Clemson Lab processed all fiber at approximately the same mc, so any additional short fiber created at the Clemson Lab would not be different due to the treatments at the gin. In addition, there were many fewer AFIS measurements at the Clemson Lab. These two factors may have combined to make the observed differences in short fiber not statistically significant. For two of the locations in the spinning process the spray materials affected the short fiber content differently.

The AFIS nep count, Table 8, was significantly higher for cultivar 444 than for cultivar 434 in every case. The spray moisture restoration resulted in lower nep counts for the samples taken in the gin, but the differences for samples obtained at the Clemson Lab were not significant. The observed difference in significance may be explained the same way as the short fiber differences were previously. The differences associated with the different spray materials were not statistically significant for any of the sampling locations.

Summaries of the AFIS trash and visible foreign matter measurements are shown in Tables 9 and 10. The cultivar effects were fairly consistent between the two measurements, but these measurements changed radically during the lint processing. The effect of the fluid spray on the seed cotton also varied considerably, but had little effect on the sliver samples. The trash and visible foreign matter level was increased significantly by the spray for samples taken at the gin, whereas in the sliver, the increase was small and the differences were not statistically significant.

Tables 11 through 14 summarize the analysis of the spinning and yarn measurement data. In Table 11, the opening and cleaning waste was shown to be greater for the samples with moisture restoration by spray, but there were no additional significant differences. The total card waste showed differences related to cultivar, spray moisture restoration, and the spray material with somewhat more waste produced from the samples with moisture restoration and the most with moisture restoration with water.

Table 12 summarizes the basic yarn data. The actual ends down did not vary significantly related to any of the variables being studied. The spray moisture restoration significantly improved the single end strength and the other measurements tended to be better with spray restoration, but the differences were not considered to be statistically significant. Surfactant 1 tended to correlate with better yarn properties, but the relationship was statistically significant only for single strand strength and elongation, and the strand strength difference between surfactant 1 and water was not significant.

Table 11. Least squares means and statistical significance of spinning waste measurements (% by weight)

	Opening and cleaning waste	Total card waste
	Mean by cultivar	
Cultivar 434	**1.512**	**4.396**
Cultivar 444	**1.509**	**4.206**
	Mean by spray moisture restoration	
No	**1.410**	**4.272**
Yes	**1.614**	**4.319**
	Mean by spray material	
Surfactant 1	**1.627**	**4.273**
Surfactant 2	**1.567**	**4.277**
Water	**1.648**	**4.408**
	Statistical probability > *F*	
Cultivar	**0.98**	**< 0.0001**
Moisture restoration with spray	**0.0001**	**0.093**
Material within spray	**0.22**	**0.001**

The analysis of the yarn evenness data is summarized in Table 13. The different evenness measurements all responded the same as each other except for the evenness finish draw. All of the other evenness measurements did not vary with the spray application or with the spray material, but did vary with the cultivar. The evenness finish draw did not vary with the cultivar, but was lower with the spray moisture application and was higher with water than with the surfactants. The Classimat data are summarized in Table 14. The major faults did not vary with any of the variables studied. The minor faults were different between the two cultivars, but did not vary otherwise. The samples from spray moisture restoration resulted in lower long thicks, but did not vary with cultivar or spray material. The long thins varied with each of the variables studied with fewer resulting from the samples with moisture restoration and fewest with surfactant 1 moisture restoration.

Table 12. Least squares means and statistical significance of spinning and single strand data

	Actual ends down	Single strand strength, g/ Tex[z]	Single strand elongation (%)[z]	Single strand strength, CV (%)	Yarn appearance, (number)
			Mean by cultivar		
Cultivar 434	**3.83**	**14.495**	**6.884**	**8.08**	**79.2**
Cultivar 444	**4.17**	**16.483**	**6.686**	**7.36**	**81.9**
	Mean by spray moisture restoration				
No	**3.50**	**15.288**	**6.845**	**7.88**	**79.2**
Yes	**4.50**	**15.690**	**6.724**	**7.56**	**81.9**
	Mean by spray material				
Surfactant 1	**2.94**	**15.928 a**	**6.919 a**	**7.31**	**82.4**
Surfactant 2	**5.67**	**15.477 b**	**6.670 b**	**7.90**	**81.0**
Water	**4.00**	**15.800 a**	**6.695 b**	**7.32**	**82.5**
	Statistical probability > *F* by chance				
Cultivar	**0.92**	**< 0.0001**	**0.016**	**0.0034**	**0.14**
Moisture restoration with spray	**0.54**	**0.0009**	**0.15**	**0.14**	**0.17**
Material within spray	**0.24**	**0.021**	**0.024**	**0.11**	**0.78**

[z] Means within a column followed by the same letter are not significantly different (*P* < 0.10).

Table 13. Least squares means and statistical significance of data from the evenness tester

	Neps /1000 m	Thick places /1000 m	Thin places /1000 m	Irregularities, CV (%)	Card sliver, CV (%)	Evenness finish draw, CV[z]
			Mean by cultivar			
Cultivar 434	42.0	390	32.3	16.43	3.18	3.41
Cultivar 444	28.9	285	19.5	15.71	3.42	3.57
			Mean by spray moisture restoration			
No	32.8	355	29.0	16.17	3.24	3.64
Yes	38.1	320	22.7	15.97	3.36	3.34
			Mean by spray material			
Surfactant 1	32.4	328	24.1	16.02	3.48	3.22 b
Surfactant 2	40.7	332	25.9	16.07	3.41	3.18 b
Water	37.9	305	19.1	15.85	3.27	3.55 a
			Statistical probability > F by chance			
Cultivar	0.0001	0.0002	0.029	0.0002	0.054	0.29
Moisture restoration with spray	0.18	0.15	0.29	0.24	0.32	0.017
Material within spray	0.22	0.55	0.57	0.48	0.53	0.045

[z] Means within a column followed by the same letter are not significantly different ($P < 0.10$).

Table 14. Least squares means and statistical significance of infrequent yarn defects measured by Classimat (count per 1000 m)

	Major faults	Minor faults	Long thicks	Long thins[z]
		Mean by cultivar		
Cultivar 434	2.13	141.5	8.15	96.0
Cultivar 444	3.03	101.9	2.93	39.2
		Mean by spray moisture restoration		
No	2.33	134.2	9.67	82.5
Yes	2.82	109.3	1.41	52.7
		Mean by spray material		
Surfactant 1	3.56	118.2	0[y]	20.7 b
Surfactant 2	2.00	91.0	2.17	54.5 a
Water	3.33	123.7	1.33	64.7 a
		Statistical probability > *F* by chance		
Cultivar	0.19	0.021	0.17	< 0.0001
Spray moisture restoration	0.47	0.15	0.055	0.0020
Material within spray	0.33	0.19	0.93	0.027

[z] Means within a column followed by the same letter are not significantly different ($P < 0.10$).

[y] Negative estimate, not different from 0 and set to 0.

CONCLUSIONS

A total of 54 bales were ginned from two cotton cultivars. For this study the effects on cotton quality of several seed cotton moisture treatments including atomized water spray and atomized water spray with either of two surfactants were analyzed. The surfactants were intended to increase the moisture uptake in the relatively short time available in the gin between the seed cotton entering the conveyer-distributor and reaching the ginning point. Three lots of 45 kg (100 lb) from seven bales were spun into yarn and the sliver and yarn examined for quality.

The mc data showed that the moisture treatments significantly affected the fiber mc after ginning with the Humidiare adding an average of 0.28 percentage points, the low-spray level adding 0.62 percentage points, and the high-spray level adding 1.12 percentage points. When the seed cotton was immersed in water, the surfactants contributed significantly to water dispersion within the locks, however, the water with surfactants did not result in significantly different fiber mc than water alone when the atomized fluids were sprayed on the seed cotton. The AFIS fiber length and short fiber content were improved significantly for the samples with spray moisture addition and the higher moisture application rate resulted in better fiber properties. Only the AFIS upper-quartile length for samples collected after the lint cleaner varied significantly with the spray fluid, with surfactant 2 resulting in a better value.

The samples with atomized spray moisture restoration also had significantly longer upper-quartile length and lower short fiber, in several cases significantly lower during the ginning and spinning processing. The samples with moisture restoration tended to have more AFIS trash and visible foreign matter, not statistically significant in most cases, and more waste in the spinning process. The single strand strength was greater and the Classimat long thicks and long thins measurements better for the samples with moisture restoration, but most of the yarn measurements were not significantly different based on moisture restoration. Most of the measurements did not vary related to the spray material, the short fiber was better with use of water than the surfactants and the total card waste was greater. The single strand strength was lower with surfactant 2 than with surfactant 1 and water and the single strand elongation was greater with surfactant 1 than the other two. The addition of the surfactants studied to water did not materially affect the fiber or yarn in any significant way, but the moisture restoration resulted in somewhat improved fiber length and yarn strength. The measured effects of the treatments did not interact with the cultivar showing that the effects did not depend on the cultivar, which may have represented growing and weather effects in addition to cultivar.

The magnitude of the fiber length improvement was limited. Although the cost of the installed system was minimal, the financial improvement to the value of the cotton also would be limited. A complete system would need to be controlled better than simply turning the water off when there was no seed cotton. Ideally, the control system should be tied to an accurate measure of fiber mc behind the gin stand for the best control of when moisture restoration is appropriate during ginning. The advisability of installing such a system would depend on the results of economic analyses of the cost of the system compared to the increased return to the growers for the slightly improved fiber quality.

ACKNOWLEDGMENTS

The authors appreciate the assistance of Dan Branton and Mac Baker for providing the seed cotton used in this study.

DISCLAIMER

Mention of a trademark, warranty, proprietary product, or vendor is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

REFERENCES

Anthony, W. S. 2003. Survey of moisture restoration at midsouth gins in 2002. Cotton Gin Oil Mill Press 104(7):10–12.

Anthony, W. S. 2004. Survey of bale moistures at midsouth gins in 2003. Cotton Gin Oil Mill Press 105(15):8–11.

Bradow, J. M., and G. H. Davidonis. 2000. Quantitation of fiber quality and the cotton production-processing interface: a physiologist's perspective. J. Cotton Sci. 4:34–64.

Byler, R.K. 2005. The effect of modest moisture addition to seed cotton before the gin stand on fiber length. J. Cotton Sci. 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. J. Cotton Sci. 10:300–310.

Byler, R. K. and J. C. Boykin. 2006. Seed cotton moisture conditioning using an atomizing nozzle in the conveyer-distributor. Applied Eng. Agric. 22(6):819–826.

Childers, R. E. and R. V. Baker. 1977. Effect of moisture conditioning on ginning performance and fiber quality of high plains cotton. Trans. ASAE 21(2):379–384.

Cui, X., D. Thibodeaux, K. Q. Robert, and T. A. Calamari. 2004. Statistical parameters of cotton short fibers. p. 2383–2386. *In* Proc. Beltwide Cotton Conf., San Antonio, TX. 5–9 Jan. 2004. National Cotton Counc. Am., Memphis, TN.

Gerdes, F. L., R. A. Rusca, and V. L. Stedronsky. 1941. Drying of seed cotton at gins. USDA-AMS. U.S. Gov. Print. Office, Washington, DC.

Griffin, A. C. Jr. and C. M. Merkel. 1953. Moisture content of seed cotton in relation to cleaning and ginning efficiency and lint quality. USDA Production and Marketing Administration, Cotton Branch. U.S. Gov. Print. Office, Washington DC.

Knowlton, J. L. 2004. Evaluation of short fiber measurement methods. p. 2370–2377. *In* Proc. Beltwide Cotton Conf., San Antonio, TX. 5–9 Jan. 2004. Natl. Cotton Counc. Am., Memphis, TN.

Krifa, M. 2004. AFIS length distribution in cotton spinning preparation. p. 3072–3076. *In* Proc. Beltwide Cotton Conf., San Antonio, TX. 5–9 Jan. 2004. National Cotton Counc. Am., Memphis, TN.

Lafferty, D. G. 1971. Restoring moisture to seedcotton at the gin: effects on lint quality and market value. Report, Agricultural Experiment Station, University of Arkansas, Fayetteville, AR.

Leonard, C. G., J. E. Ross and R. A. Mullikin. 1970. Moisture conditioning of seed cotton in ginning as related to fiber quality and spinning performance. USDA-ARS, Marketing Research Report 859. U.S. Gov. Print. Office, Washington DC.

Mangialardi, G. J., A. C. Griffin, and E. H. Shanklin. 1965. Moisture restoration to cotton at the gin: effects on fiber and spinning properties. USDA-ARS, Marketing Research Report 708. U.S. Gov. Print. Office, Washington DC.

Moore, V. P. and C. Griffin, Jr. 1964. The relationship of moisture to cotton quality preservation at gins. USDA-ARS publication 42-105. U.S. Gov. Print. Office, Washington DC.

Shepherd, J. V. 1972. Standard procedures for foreign matter and moisture analytical tests used in cotton ginning research. USDA Agricultural Handbook No. 422. U.S. Gov. Print. Office, Washington, DC.