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INVESTIGATION OF THE EFFECTS OF LINT CLEANING MACHINERY LOADING ON FIBER QUALITY AT A COMMERCIAL ROLLER GIN

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Abstract

Recommendations for roller gin lint cleaner capacities are 1.5 – 2 bales per hour (bph) per foot of cleaner width, but no research on the quality effects of that loading has been published. A recent survey of US roller gins showed that typical loading of Pima lint cleaning equipment ranged from 0.75 to 2.25 bph/ft. Data were taken at an average size (20 bph) roller gin during the fall 2004 ginning season to assess the effects of lint cleaning machinery loading on fiber quality. Lint fiber samples were taken before and after cleaning with an inclined cleaner and centrifugal-type lint cleaner loaded at different rates ranging from 0.5 to about 1.7 bph/ft. Lint fiber samples were classed at the AMS Classing Office (Phoenix, AZ). Most of the differences in lint classing parameters due to loading were not significant. Leaf grade and bale value, after lint cleaning, were significantly better (about ½ grade and $40 higher) for lower loading rates (≤ 1.3 bph/ft) on a lint cleaning sequence that included a lint fan, stationary condenser, 6-ft wide inclined cleaner, and 8 ft air-jet; indicating that at higher loading rates (≥ 1.7 bph/ft) lint cleaning efficiency was reduced. As a result of lint cleaning, leaf grades significantly decreased about one full grade (from 3.2 to 2.2) and bale values significantly increased from about $457 to $528. The results justify further study.

Introduction

Pima cotton is roller ginned to preserve the fiber quality. Hughs and Gillum (1991) found that in order to remove foreign matter and minimize damage, numerous seed cotton cleaning machines (ranging from three to eight) are used at roller gins, while the average number used was two or three and aggressiveness of the lint cleaners was considerably less than lint cleaners in saw gins. Their results showed that there were 49 roller gins in the US in 1989 and that 83% of gins used either one or two cleaners (incline or impact), and one air-jet for lint cleaning. They concluded that gins realized an “average overall gain in bale value” from “some lint cleaning” and their fiber tests supported the “reasoning that color grade is the limiting factor in determination of composite grade.”

Twenty-seven roller gins operated in the U.S. during the 2004-05 ginning season (Supima, 2004). A recent survey (Whitelock, D.P., C.B. Armijo, and S.E. Hughs, unpublished data, 2004. Mesilla Park, NM: Agricultural Research Service) showed that the typical lint cleaning sequence currently used included one or two incline cleaners and one air-jet type cleaner. The average loading of these lint cleaning machines was 1.46 bales per hour (bph) per foot of machine width and ranged from 0.75 to 2.25 bph/ft. Industry recommendations for Pima lint cleaner loading ranges from 1.5 to 2 bph/ft (D.W. Van Doorn, personal communication, August 2004; E. Edwards, personal communication, August 2004).

The amount of Pima produced in the U.S. has steadily increased over the years and it was estimated that a record crop of Pima cotton (over 700,000 bales) would be produced during the 2004-05 season (USDA-AMS, 2004a). Despite this, there has been very little work on lint cleaning at roller gins. This paper reports on preliminary research to evaluate the effects of lint cleaner loading on lint quality.

Procedures

A typical commercial roller gin was selected as the site for the loading tests. The 16-stand roller gin processed Pima cotton, 97% in modules, at an average rate of 20 bph. The seed cotton cleaning machinery included four inclined cylinder cleaners, a stick machine, and three stages of drying. Before the gin stands, the seed cotton split into two streams, each flowing to eight stands. After ginning, the two streams were conveyed to separate lint cleaning lines. Lint on one side flowed from the stands, through a lint fan, to a stationary condenser that dropped into a 6-ft wide six-cylinder inclined cleaner, and then flowed to an 8-ft wide air-jet type cleaner. Lint on the other side flowed from the stands directly to a rotary condenser that dropped into an 8-ft wide six-cylinder inclined cleaner, and then flowed to an 8-ft wide air-jet type cleaner. The lint streams recombined after the air-jets before traveling on to the battery condenser.

The experiment was designed as a randomized complete block with three ginning rates (high, medium, and low), two sides (Side A and B), and three replications. The experiment was blocked by side with ginning rates and replications randomized within each block. The target ginning rates were accomplished by increasing the ginning rate of each of the eight stands on the side of interest to approximately 2 bph and operating eight, five, or three stands to achieve 16, 10, or 6 bph, respectively, on that side. Stands were “kicked in and out” rather than increasing or reducing the speed of individual stands to help reduce the effects of speeding-up or slowing-down stands on lint quality and to make the overall rate more reproducible. Due to the nature of the feed control system of the gin, the eight stands on the other side, not under investigation, had to be operated at normal capacity during each test. This made it difficult to measure the actual ginning rate for the side of interest. The actual ginning rate for the side of interest was determined by calculating the ginning rate for the last bale made during each run and then subtracting one-half the normal ginning rate calculated from times averaged for 35 bales ginned earlier. Since the inclined cleaners on the two sides were of different widths, six different cleaner loading rates were achieved with the three different ginning rates.

Two cotton sub-samples were taken at five different locations during each run. Seed cotton samples were taken for moisture and foreign matter content analysis at the module feeder unloading belt. Lint moisture and classing samples were taken directly behind the gin stands and lint classing samples were taken after the condensers, after the inclined cleaners, and after the air-jet cleaners. Seed cotton moisture analysis was performed by the standard oven drying method and seed cotton foreign matter analysis was performed by the standard pneumatic fractionator method (Shepherd, 1972). Lint samples were analyzed for manual classer’s grade and HVI at the AMS Classing Office in Phoenix, AZ. The seed cotton fractionation analysis was not completed at the writing of this report and therefore the report is limited to the loading rate and classing analysis only.

Each run spanned about three bales and five modules were ginned during the entire test. Back to back modules from the same field were selected to reduce the variability due to the condition of the seed cotton coming into the gin.

Results and Discussion

The actual ginning rates and actual loading rates for the two sides were not as high as the desired target rates (Table 1). Although the ginning rates were not as high as desired, target rate was approximately 2 bph per stand and actual rate was about 1.4 bph per stand, they were consistent enough that there were significant differences among the three rates: high, medium, and low. Lint cleaner loading of greater than 2 bph/ft was not attained during the tests. Average loading ranged from 0.5 bph/ft for low-rate on Side B (8 ft incline cleaner) to 1.7 bph/ft for high-rate on Side A (6 ft incline cleaner). For either side, the high, medium, and low oading rates were significantly different. Between sides, only the medium loading rates were significantly different. Because of this lack of significant differences in loading rates between the two sides, the analysis of the classing parameters among loading rates was performed by side.

Table 1. Target and actual ginning rates, and lint cleaner loading rates.

Rate	Target Ginning Rate	Actual Ginning Rate[a]	Lint Cleaner Loading[a] Side A	Side B
	bph	bph	bph/ft	
High	16	11.3 a	1.7 a	1.5 ab
Medium	10	7.8 b	1.3 b	0.9 c
Low	6	4.1 c	0.7 cd	0.5 d

[a] Means, under the same major column heading, followed by a different letter are significantly different at the 5% level as determined by LSD (pairwise t tests) mean separation procedures.

Most classing parameters were not significantly different among loading rates for either side (Table 2). On Side A, the before lint cleaning color Rd and length uniformity index values for low-rate were significantly different from high and medium loading rates. However, the actual differences in terms of fiber quality were of little consequence. For example, all the mean uniformity values fell within the “High” descriptive designation (83 – 85) set by the USDA-AMS (2004b). Bale value, based on a 480-lb bale and the 27 Dec. 2004 spot quotations, before lint cleaning on Side B was significantly higher for the low loading rate than the medium-rate.

Table 2. Significantly different classing parameters for loading rate, before lint cleaning.

Rate	Significant Parameter	
	Side A	Side B
	Color Rd	Bale Value, $
High	67.7 b	444.40 ab
Medium	67.5 b	406.60 b
Low	69.0 a	486.60 a
	Uniformity, %	
High	84.5 a	
Medium	85.0 a	
Low	83.3 b	

[a] Means, under a parameter, followed by a different letter are significantly different at the 5% level as determined by LSD (pairwise t tests) mean separation procedures.

As with the before lint cleaning data, most of the classing parameters were not significantly different among loading rates for Side A and no parameters were significantly different among loading rates for Side B (Table 3). Even the differences in bale value detected on Side B before lint cleaning were not present after lint cleaning. On the other hand, there were significant differences among loading rates for color +b, leaf grade, and bale value on Side A. The color +b values, though significantly different, were in actuality very small. The analysis showed that loading rates of 1.3 bph/ft and lower, medium and low designations, on Side A (6 ft incline cleaner) resulted in significantly better leaf grades (≥ ½ grade) and, thus, higher bale values (≥ $40 per bale). The results suggest that the high loading rate, 1.7 bph/ft, attained on Side A had adverse effects on the lint cleaning efficiency.

Table 3. Significantly different classing parameters for loading rate, after lint leaning.

Rate	Significant Parameter	
	Side A	Side B
	Color +b	
High	12.5 ab	
Medium	12.2 b	
Low	12.6 a	
	Leaf Grade	
High	2.5 a	
Medium	2.0 b	None
Low	1.8 b	
	Bale Value, $	
High	502.60 b	
Medium	544.80 a	
Low	544.40 a	

[a] Means, under a parameter, followed by a different letter are significantly different at the 5% level as determined by LSD (pairwise t tests) mean separation procedures.

Since most of the classing parameters were not different among loading rates, the data were analyzed at each sampling point, loading rates combined, to determine how the lint quality was affected by different stages within the lint cleaning systems. Figure 1 shows mean values of the classing parameters used to determine bale value at each sampling location. Micronaire, staple length, and color grade changed little as a result of lint cleaning and averaged 3.7, 46.6 32^{nd}-in., 2.1, respectively. Leaf grade ranged from 3.2 to 2.1 and decreased significantly from behind the gin stand to after the condenser to after the incline cleaner. The leaf grade increased from after the incline cleaner to after the air-jet, 2.1 to 2.2, though not significantly. The significant decrease in grade from behind the gin stand to after the condenser and the increase from after the incline to after the air-jet was both interesting and perplexing. A possible explanation for the decrease after the condenser was revealed when the analyzing the data for Side A and Side B separately. This will be discussed in the next section. However, reasons for the increase in leaf grade after the air-jet are not known at this time.

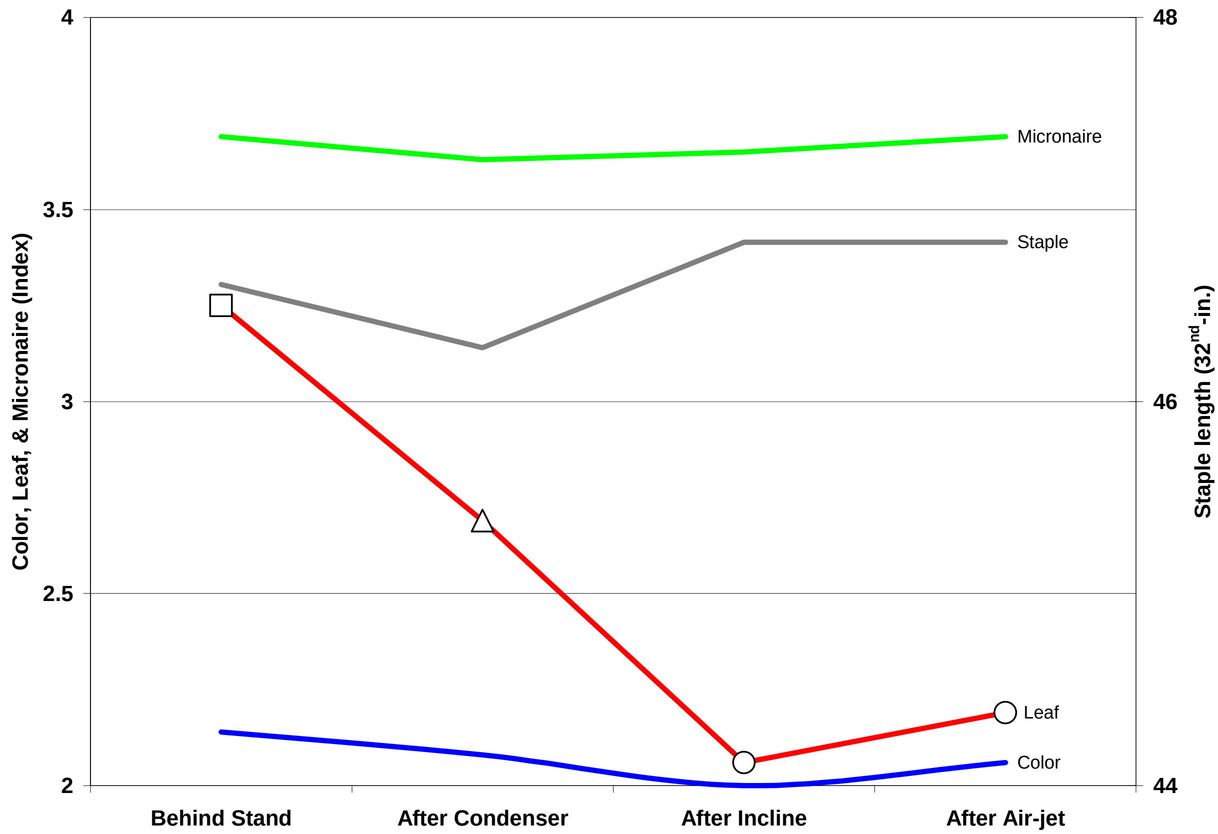

Figure 1. Average micronaire, staple length, leaf grade, and color grade at each sampling location. Points on a curve with different symbols are significantly different at the 5% level as determined by LSD (pairwise t tests) mean separation procedures.

The bale value at the sampling points (different points in the lint cleaning system) is shown in figure 2. Overall there were significant increases in bale value from behind the gin stand ($457) to after the condenser ($500) to after the inclined cleaner ($539), but like leaf grade the overall bale value decreased from after the inclined cleaner to after the air-jet ($428). Looking at Side A, bale value increased significantly from behind the gin stand ($469) to after the condenser ($534) and did not change significantly thereafter. On Side B, bale value increased significantly, from $466 to $532, only from after the condenser to after the incline. The difference between the two sides from behind the stands to after the condenser is that lint on Side A flows through a lint fan and to a stationary screen condenser and the lint on Side B flows directly to a rotary screen condenser. The difference between the two sides from after the condenser to after the incline is that Side A has a 6-ft wide inclined cleaner and Side B has an 8-ft wide inclined cleaner. These results indicate that some characteristic of the lint fan/stationary condenser does a significant amount of lint cleaning, while the rotary condenser does not. Also, a significant amount of lint cleaning occurred at the 8 ft inclined cleaner and not at the 6 ft cleaner.

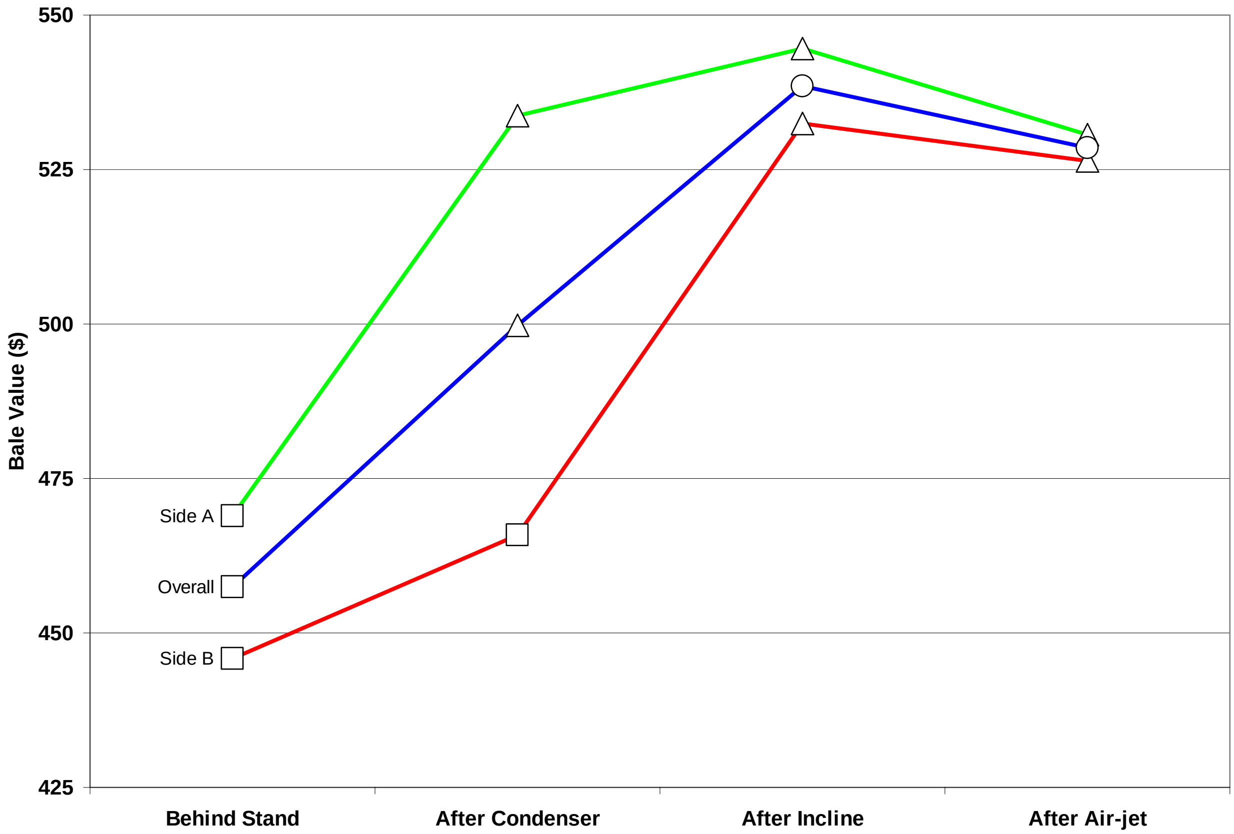

Figure 2. Overall, Side A, and Side B average bale value at each sampling location. Points on a curve with different symbols are significantly different at the 5% level as determined by LSD (pairwise t tests) mean separation procedures.

Conclusions

Tests were performed at a typical commercial gin to evaluate the effects of lint cleaner loading on lint quality. Most of the differences in lint classing parameters due to loading were not significant. However, on Side A that included a lint fan, a stationary condenser, a 6-ft wide inclined cleaner, and an 8 ft air-jet, leaf grade and bale value were significantly better after lint cleaning for the medium and low loading rates than for the higher loading rate. These results indicate that at the higher loading rate lint cleaning efficiency was reduced.

As a result of lint cleaning, leaf grades significantly decreased about one full grade (from 3.2 to 2.2) and bale values significantly increased from about $457 to $528. Interestingly, on Side A, bale value was significantly higher after the lint flowed from the gin stand ($467) through a lint fan and to a stationary condenser ($534). On the other hand, on Side B that had a rotary condenser and no lint fan, bale value did not significantly change from the gin stand to the rotary condenser. Also, bale value increased significantly ($467 to $532) when the lint passed through an 8-ft wide inclined cleaner on Side B, but no significant change was detected as a result of the 6 ft cleaner on Side A. Average bale value decreased ($539 to $528), though not significantly, after passing through an air-jet after each inclined cleaner on either side.

These results justify further study. Fiber analysis will continue with Shirley analysis for foreign matter content which is more sensitive to small variations in trash levels than classer's grade or HVI. AFIS analysis will be performed on the lint samples to provide a more complete picture of the fiber quality. The results warrant further testing under more controlled laboratory conditions where loading rates nearer to and greater than 2 bph/ft can be explored. Also, individual machines, such as incline cleaners, impact cleaners, and air-jet cleaners should be studied.

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.

References

Hughs, S.E. and M.N. Gillum. 1991. Quality effects of current roller-gin lint cleaning. Appl. Eng. Agric. 7(6):673-676.

Shepherd, J.V. 1972. Standard procedures for foreign matter and moisture analytical tests used in cotton ginning research. Agricultural Handbook No. 422. Washington, D.C.: USDA.

Supima Association of America. 2004. U.S. Pima gins [Online]. Available at www.supima.com/gins/index.htm (accessed 28 Dec. 2004). Supima, Phoenix, AZ: Supima..

USDA-AMS. 2004a. Long staple cotton reviewStaple Cotton Review: Nov 2004 [Online]. Available at www.ams.usda.gov/cottonrpts/MNPDF/mp_cn822.pdf (accessed 28 Dec. 2004). Memphis, TN: USDA Agricultural Marketing Service.

USDA-AMS. 2004b. Cotton classification – Understanding the data [Online]. Available at www.ams.usda.gov/cotton/understand.htm (accessed 28 Dec. 2004). Memphis, TN: USDA Agricultural Marketing Service.