TRACKING COTTON FIBER QUALITY THROUGHOUT A STRIPPER HARVESTER Weslev M. Porter **Biosystems and Agricultural Engineering Oklahoma State University** Stillwater, OK John D. Waniura **USDA-ARS Cotton Production and Processing Research Unit** Lubbock, TX Randal K. Tavlor Biosystems and Agricultural Engineering Oklahoma State University Stillwater, OK Randal K. Boman **Oklahoma State University Southwest REC** Altus, OK Michael D. Buser **Biosystems and Agricultural Engineering Oklahoma State University** Stillwater, OK Edward M. Barnes **Cotton Incorporated** Carv, NC

<u>Abstract</u>

It is known that cotton fiber quality begins to degrade with the opening of the boll. Mechanical harvesting processes are perceived to aid in fiber degradation. Previous research indicates that stripper harvested cotton generally has lower fiber quality and higher foreign matter content than picker harvested cotton. The main objective of this project was to track cotton fiber quality and foreign matter content throughout the harvesting units and conveying/cleaning systems on a brush-roll stripper harvester. Seed cotton samples were collected at six locations including: 1) hand-picked from the field, 2) just after the brush rolls in the row unit, 3) just after the row units, 4) from the separation duct after the cotton was conveyed by the cross auger, 5) from the basket with the field cleaner by-passed, and 6) from the basket after the cotton was processed through the field cleaner. Seed cotton samples collected at each location were analyzed for foreign matter content and ginned to produce fiber for HVI and AFIS fiber analyses. Results show that the row unit augers and field cleaner aid in reducing the overall foreign matter content, effectively increasing the gin turnout to that of hand harvested cotton. AFIS and HVI results indicate that the harvesting and conveying systems on the stripper have a minimal effect on fiber length characteristics and the formation and size of neps. Leaf grade increased between the harvesting units and the field cleaner due to the breakup of foreign material caused by mechanical action. The field cleaner helped to reduce leaf grade back to the level observed at the stripper rolls. The results of this work indicate that the cross auger and pneumatic conveying systems on stripper harvesters could be redesigned to help improve seed cotton cleanliness while helping to preserve fiber quality.

Introduction

Cotton fiber quality begins to degrade with the opening of the boll. Mechanical harvesting processes increase the amount of foreign material contained in seed cotton at the gin and are perceived to increase nep and short fiber content at the spinning mill. Stripper harvested cotton generally has lower fiber quality and higher foreign matter content than picker harvested cotton. In a study conducted by Kerby et al. (1986) brush stripped seed cotton contained 27.8% total trash compared to 4.6% for spindle picked seed cotton. Unlike picker harvesters, which use spindles to remove seed cotton from the boll of the plant, stripper harvesters use brushes and bats to indiscriminately remove seed cotton, bolls, leaves, and other plant parts from the stem of the plant. As a result, stripper harvested cotton (Faulkner et al. 2007).

Stripper harvesting is predominately confined to the Southern High Plains of the US due to several factors including: low humidity levels during harvest, tight boll conformations and compact plant structures adapted to withstand harsh weather during the harvest season, and reduced yield potential due to limited rainfall and irrigation capacity Cotton strippers typically cost about one-third the price of cotton pickers and have harvesting efficiencies in the range of 95 - 99% making them ideal for lower yielding cotton conditions. Approximately 35% of the total acreage of cotton

harvested in the U.S. in 2011 came from Texas and Oklahoma (USDA, 2011). A majority of this cotton in these two states is harvested with stripper harvesters. Stripper harvested cotton also leads to higher transportation and processing costs.

Many studies (such as Faulkner et al. 2007., and Nelson et al. 2001.) have investigated the overall quality of stripper harvested cotton versus picker harvested cotton, and a cost comparison of the two harvest methods. Several studies focus on the use of field cleaners and their effectiveness at removing foreign material (Brashears 2005, Smith and Dumas 1982, Wanjura and Baker 1979, Wanjura and Brashears 1983, Wanjura, Holt and Carroll 2009). All of these studies show that a field cleaner is a very effective way of removing foreign material from stripper harvested cotton; however these studies do not address any other components of the stripper harvester. To our knowledge, no previous work addresses the influence of the individual harvesting and conveying systems of a stripper harvester on fiber quality. Thus, the objective of this work is to document cotton quality and foreign matter content at several sequential locations on a stripper harvester. The overall goal of this effort is to identify components and systems on the stripper that if redesigned, could help to improve the cleanliness and better preserve the quality of stripper harvested cotton.

Materials and Methods

In this study the term location refers to a location on the harvester not a location from within the actual field the fiber was collected from. Five locations on the harvester and a hand collected field stand of cotton were identified as points of interest from the fiber quality standpoint to begin the collection process. The data collection for this project occurred at the Texas A&M Research and Extension Center just north of Lubbock, TX. Two varieties were harvested for this project, FiberMax 9170 B2F, and Stoneville 5458 B2F. One hundred rows of each variety were planted in a row irrigated field that was 775 feet long. The cotton was stripper harvested using a four row wide John Deere 7460, thus the collections for each replication occurred from within one 4-row wide 775 foot long strip. A total of eight 4-row passes were harvested from each variety: 5 passes for the machine location and hand harvested sample collections and three additional full length passes used to measure yield. The six locations of interest are cotton handpicked from the field, from the row unit augers (after brush rolls), collections at the end of the row unit/beginning of the cross auger, the end of the cross auger, before the field cleaner, and from the basket of the stripper after the cotton has been field cleaned (Figure 1).



Figure 1. Clockwise from top left to bottom left: Before Field Cleaner, After Field Cleaner, Hand Harvested, After Brush Rolls, After Cross Auger, and After Row Unit.

A total of five replications were conducted for each sampling location per variety. For each replication, approximately 20-lb. of seed cotton was collected from each sampling location. In order to collect an adequate sample amount from the after brush roll, after row unit, and after cross auger locations, it was necessary to stop the

harvester several times in the field. Only one replication per variety was collected from the row unit auger area because with the row unit augers disabled the row unit filled with dirt and debris too quickly (Figure 2).



Figure 2. Excessive dirt in the stripper rolls.

Simultaneous sampling of the harvested seed cotton at each location on the harvester was problematic from a safety and feasibility standpoint. Therefore, all samples from one location were collected from both varieties prior to collecting samples from the other locations. The following sequence of events was conducted to collect the seed cotton samples from each location for each rep:

- 1. Before field cleaner sample collection: The machine was operated at full load into the unharvested cotton with the field cleaner bypassed so that the harvested cotton flowed directly into the basket and not through the field cleaner. After the machine traveled approximately 150 feet into the field, the harvester was stopped and a 20-lb. sample of seed cotton was collected in the basket. The remaining seed cotton in the basket was moved so that there was an empty location in the basket for the next sample to fall into.
- 2. After field cleaner sample collection: The bypass lever on the field cleaner was switched to allow the cotton to pass through the field cleaner before entering the basket. The harvester was operated at full load into the un-harvested cotton in the same rep as in step 1 above for approximately 150 feet. The harvester was stopped and a 20-lb. sample of seed cotton was collected from the field cleaned cotton in the basket. The stripper basket was emptied and moved to the next replication. Steps 1 and 2 were completed for all reps in both varieties before samples were collected from other machine locations.
- 3. Hand harvested sample collection: a 20-lb. sample of seed cotton was hand harvested from each replication in both varieties after step 2.
- 4. After row unit and after cross auger sample collection: The right-hand section of the cross auger was removed from the header allowing the two right-hand row units to empty directly into the open auger trough. A large sack was connected to the bottom of the main cotton conveying duct to collect the cotton moved to the center of the header by the remaining left-hand section of the cross auger. With the main conveying fan disengaged and the row units and cross auger running, the stripper proceeded into the un-harvested cotton located after the hand harvested collection area. The machine was operated until the cross auger trough behind the right hand row units was full at which time the cotton was removed from the open auger trough and placed in a collection bag. This process was repeated until approximately 20 lb. of seed cotton were collected from the open right-hand auger trough (after row unit sample) and in the large sack attached to the base of the main cotton conveying duct (after cross auger sample). Step 4 was conducted for all replications in both varieties before step 5.
- 5. After stripper roll sample collection: The drive gears used to operate the two row unit augers in each row unit were removed from the harvester. The stripper was operated at full engine speed into the un-harvested cotton and stopped when the row unit auger troughs were full of harvested material. The material was removed from the row units and placed in a collection bag and this process was repeated until a total of 20-lb. of harvested material was collected. Step 5 was only conducted for one replication in each variety due to aforementioned reasons.

Cotton samples were hand collected from the field for gravimetric moisture analysis each time a collection occurred (Figure 3). At each sample stop throughout the entire process, temperature and relative humidity were recorded.



Figure 3. Scale and sealing system for moisture samples.

The cotton samples collected from the field were transported back to the USDA-ARS Gin Lab at Lubbock for ginning. The samples were separated by variety and location, and then weighed. Once the samples were weighed they were transported to the top of the extractor-feeder/gin stand. Prior to ginning two hand fractionation samples were pulled from each of the samples. A moisture sample was collected from the extractor-feeder apron during ginning of each lot. Analysis of the hand fractionation samples and the moisture content samples were performed based on the procedures outlined by USDA (1972). Each of the cotton samples collected in the field was processed through an extractor-feeder, 16-saw gin stand, and one stage of saw-type lint cleaning. The cleaned lint was weighed to obtain lint turnout. The trash collected from the extractor-feeder and seeds from the gin stand were collected and weighed to obtain the amount of trash and seeds removed from each sample. Two samples of the cleaned cotton lint from each sample were collected and sent to the Texas Tech University, Fiber and Biopolymer Research Institute in Lubbock, TX for HVI and AFIS fiber analysis.

Results and Discussion

Analysis of the ginning data showed a trend of increasing gin turnout and decreasing seed cotton trash content as the cotton was sampled on the harvester. A significant difference was not seen between varieties for the results of the gin data, thus all data presented represents both the Stoneville and FiberMax varieties. In the graphical and tabular representations of the data the machine location was assigned a numerical value to make it easier for analysis. Table 1 gives the numerical equivalent of the name.

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Machine Location	Numerical Equivalent
Hand Harvested	1
Row Unit Augers/After Brush Rolls	2
After Row Unit	3
After Cross Auger	4
Before Field Cleaner	5
After Field Cleaner	6

Table 1. Numerical equivalent of the machine locations of fiber collection.

Gin turnout was highest for the hand harvested location with an average of approximately 37%. This was expected since only fiber and seed was intentionally removed from the plants. There was minimal trash incorporated into the hand harvested fiber. The second location which occurred after the brush rolls had removed the cotton from the plants had the lowest gin turnout with an average of about 12%. The row unit augers were disabled during this data collection, and a large amount of dirt, dust, and debris was picked up by the row units and conveyed into the row unit auger troughs. It was very easy to see the amount of debris removal that the row unit augers are aiding in. After the row unit once the cotton had entered the cross auger trough, gin turnout increased to near double that of the after brush roll location, or about 25%. The difference in turnout between locations 2 and 3 indicates that the row

unit augers are quite effective at removing debris. Next, the cross auger collection area, there is about a percent or two drop in the average in gin turnout. The mechanical conveyance occurring from the cross auger is affecting the gin turnout of the cotton over that of the cotton collected from the cross auger trough. At the fifth location, the cotton was allowed to flow up the separation duct, by pass the field cleaner and then was collected. There is a much more consistent gin turnout represented in this area. The average gin turnout is not much higher than the previous two locations but the higher consistency means that a consistent amount of similar trash is being removed through this conveyance point. An average 5% increase is seen in the gin turnout when the cotton is allowed to pass through the field cleaner. So looking at the gin turnout data it can be said that the mechanical cleaning processes are having increasing effects on the gin turnout back close to that of the hand harvested cotton.

Percent trash, based on total sample weight, collected from the extractor feeder before the gin stand is shown in Figure 4. The hand harvested and field cleaned cotton has the lowest percent trash. Again the row unit auger collection area had the highest percentage of trash.

Figure 4 below is the statistical groupings based on machine location. It can be seen that use of the field cleaner made it is possible to obtain statistically similar gin turnouts and lower trash contents to that of hand harvested cotton. The non-field cleaned, cross auger, and after brush roll cotton had statistically similar gin turnouts and trash contents. The cotton collected from the row unit was in its own statistical group having a very high trash content and low gin turnout.



Figure 4. Statistical groupings of gin data.



Figure 5. Fiber Micronaire

Micronaire of the two cotton varieties by sampling location is shown in Figure 5. The Stoneville variety had and average micronaire of about 5.2 while the FiberMax had an average micronaire of about 4.3. Independent of the varietal difference there is no significant difference in fiber micronaire between machine locations. Micronaire is an estimate of maturity and fineness thus should not be significantly affected by mechanical handling. As can be seen below in figure 6, fiber length as reported by the HVI has no correlation with the machine sample location. The fiber lengths are equally distributed across each of the sample locations with small varietal differences.



Figure 6. Fiber length reported by the HVI.

Differences among sample locations were observed for length uniformity (Figure 7), strength (Figure 8), and leaf grade (Figure 9). Little variation in uniformity was observed between locations and tended to increase at later sampling locations. Leaf grade increased continuously from locations 1 through 5 because the mechanical action imparted on the cotton during harvesting and conveying causes leaf trash and other foreign material to be broken up and further mixed into the fiber (Figure 9). The field cleaner removed some of the foreign material contained in the seed cotton and helped to reduce leaf grade.



Figure 7. Fiber Uniformity.



Figure 8. Fiber Strength.



Figure 9. Leaf grade by sampling location.

Two parameters that would seem to have been affected by mechanical handling of cotton fiber are Nep size and Nep content. However, no clear trend with sampling location was observed for the nep size (Figure 10) or nep content (Figure 11) data.



Figure 10. Nep size.



Figure 11. Neps per Gram.

Differences were observed among sampling locations for AFIS short fiber content by weight (Figure 12). It was expected that short fiber content would increase throughout the harvest process as the fibers are handled and exposed to additional mechanical action; however, this trend was not observed. One possible reason for the unexpected result is the reduced number of samples collected from the row unit. AFIS trash (Figure 13) and dust content (Figure 14) follow similar trends to each other throughout the machine. The levels have a general increase throughout sample locations until the cotton is pneumatically conveyed and then passed through the field cleaner. The pneumatic conveyance of the cotton through the separation duct allows for some of the dust and larger/heavier trash to fall out, and then more of the trash and dust was removed when the cotton passed through the field cleaner.



Figure 12. Short Fiber Content



Figure 13. Trash Content



Figure 14. Dust Content



Figure 15. Hand fractionation results.

The results of hand fractionation analysis on samples collected at each location are shown in Figure 15. The bars in Figure 15 represent the total percentage of trash and the contribution from each type of foreign material is illustrated in each bar. Consistent with the rest of the gin data, total trash was reduced throughout the machine. It is apparent that the row unit augers do a very good job of reducing fine trash in the cotton. Once past the row units, burs consistently make up the highest percentage of trash with fine trash falling at a close second. The data shown in Figure 15 indicate that the field cleaner performs well at removing total trash and even in removing fine trash and burrs from the samples. The data represented in this graphs shows that an effort to remove burrs and fine trash is most important since they compose the highest amount of the total trash collected from the fiber samples.

<u>Summary</u>

The goal of this work was to identify components and systems on a cotton stripper harvester that, if redesigned, could improve seed cotton cleanliness and better preserve fiber quality. Seed cotton samples were hand harvested in the field and collected at five sequential locations on a cotton stripper harvester. The samples were analyzed for foreign matter content and HVI and AFIS fiber quality. Seed cotton total foreign matter content was highest after the stripper rolls before the cotton was conveyed out of the row units by the row unit augers. The row unit augers decreased total foreign matter content in the seed cotton by removing a substantial amount of fine trash comprised mostly of soil and small plant parts. Total foreign matter content remained at a consistent level during conveyance in the cross auger until the harvested seed cotton was processed through the field cleaner. The field cleaner decreased total foreign matter content by removing burs and some fine trash. Leaf grade and AFIS trash and dust content measurements follow similar trends where parameter levels increase on the stripper from the stripper rolls until the inlet to the field cleaner. Leaf grade, AFIS trash, and AFIS dust content were decreased by the field cleaner back to levels observed just after the stripper rolls. HVI and AFIS fiber analysis results indicated that the harvesting and conveying systems on the cotton stripper did not have a detrimental impact on fiber length characteristics or on the formation or size of neps.

The results of this work indicate that the cross auger and pneumatic conveying system on the stripper could be redesigned to provide additional seed cotton cleaning on the harvester. Pneumatic conveyance of seed cotton requires a substantial amount of engine power that could be reduced if mechanical conveyors were implemented.

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Disclaimer

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

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