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ENGINEERING AND GINNING

Tracking Cotton Fiber Quality and Foreign Matter through a Stripper Harvester

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ABSTRACT

The main objective of this project was to track cotton fiber quality and foreign matter content through the harvesting and conveying/cleaning systems on a brush-roll stripper harvester. Seed cotton samples were collected from four locations on a cotton stripper harvester in 2011 and 2012 along with handpicked seed cotton samples. The four machine locations included: 1) after the harvested cotton was conveyed out of the row unit but before being engaged by the cross auger conveyor, 2) from the separation duct inlet after the cotton was conveyed by the cross auger, 3) from the basket by-passing the field cleaner (before field cleaner, BFC), and 4) 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 High Volume Instrument (HVI) and Advanced Fiber Information System (AFIS) fiber analyses. Results show little difference between the initial entry in the machine until the BFC location, and provide evidence that the field cleaner was the most effective system on a cotton stripper for removing foreign matter. AFIS and HVI results indicate that the harvesting, conveying, and cleaning systems had minimal effects on fiber characteristics not associated with foreign matter. Generally most parameters were not affected significantly until the seed cotton passed through the field cleaner, after which the parameters were reduced to similar levels of hand-harvested seed cotton.

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Stripper harvesting is predominately confined to the Southern Plains of the U.S. due to several factors, including low humidity levels during daily harvest intervals, reduced yield potential due to limited rainfall and irrigation capacity, and tight boll conformations and compact plant structures adapted to withstand harsh weather during the harvest season. In 2010, approximately 50% of the total number of cotton bales produced in the U.S. came from Texas and Oklahoma (USDA, 2011), and a majority of the cotton produced in these states was harvested with stripper harvesters. Cotton strippers typically cost about one-third the price of cotton pickers and have harvesting efficiencies in the range of 95 to 99%, making them ideal for lower yielding cotton conditions (Williford et al., 1994).

Stripper harvesters remove the cotton, bur, sticks, and any leaves left on the plant. The modern-day type of this harvesting is much different than the original type of stripper harvesting, which was first referred to as sledding, and horse drawn sleds were used in Texas as early as 1914 (Colwick, 1965). In the early 1920s, improvements were made by replacing fixed rods on a stripper harvester with a rotating pair of rods (Smith, 1935). These rolls had a fixed gap that allowed the plant, but not the cotton bolls to pass through. In 1951, agricultural engineers in Oklahoma developed a stripping roll covered with brushes to reduce the amount of trash that accompanied the cotton. Improvements also were made in the number of rows, the speed of operation, and conveyance of cotton to the hopper (Hughs et al., 2008).

On modern stripper harvesters, the harvested material is conveyed to the basket by a combination of auger- and pneumatic-based conveying systems. In the case of the auger-based conveying systems (i.e., row unit augers and the main cross auger) the material is moved across panels with open slots, allowing some foreign material to fall out. Cotton is fed into the pneumatic conveying duct at the center of the header near the ground and is carried to the top of the machine where the cotton is separated from the air via a set of finger grates. Heavy foreign material (e.g., green bolls, rocks, stumps) is separated from the cotton either at the base or at the top of the conveying duct through gravitational settling. Additional foreign material is removed from the cotton at the finger grates as the air and some small foreign material pass through the finger grates while the cotton is directed either into the field cleaner or directly into the basket. A valve located at the top of the field cleaner can be set by the operator to allow the cotton to bypass the field cleaner and go directly into the basket or pass into the field cleaner for additional cleaning before going into the basket. The handling action of the auger and pneumatic conveying systems has the potential to break up foreign material and embed it in the fibers as well as break or tangle fibers.

Many studies have investigated the overall quality of stripper-harvested cotton compared to picker-harvested cotton and compared the costs of these two harvest methods (Faulkner et al., 2011a, b; Kerby et al., 1986; Nelson et al., 2001; Wanjura et al., 2012). Several studies also focused on the use of field cleaners on strippers and their effectiveness at removing foreign matter (Brashears, 2005; Smith and Dumas, 1982; Wanjura and Brashears, 1983; Wanjura et al., 2011). All of these studies showed that a field cleaner is an effective system for removing foreign material from stripper-harvested cotton; however, these studies did not address other components of the stripper harvester.

Brashears (1994) observed that attaching pieces of square key stock to the outer edge of the conveyor auger flights on a cotton stripper increased the amount of foreign material removed from harvested bur cotton by 40%, but the influence of these modifications on fiber quality was not reported. Brashears (1984) found that by reducing the width of the bats on the stripper roll, the stick content of the harvested cotton was reduced by 50%, and the number of barky grades reduced by two-thirds. In another study focused on bark contaminated lint as related to stripper harvesting and seed cotton cleaning at the gin, Wanjura and Baker (1979) observed that the auger conveying system on the stripper reduced mean stick length and increased bark sliver content in harvested seed cotton.

Previous research has pointed out the influence of individual subsystems on foreign matter content and sometimes fiber quality but has not addressed the relative influence of the harvesting, conveying, and cleaning systems used on stripper harvesters on a concurrent basis. Thus, the objective of this research was to document the impact of the harvesting, conveying, and cleaning systems used on stripper-type harvesters on cotton foreign matter content and fiber quality under a common set of field conditions. It is anticipated that the findings of this study will be useful in identifying components and systems on the stripper that, if redesigned, could help to improve the cleanliness and better preserve the quality of brush-roll stripper-harvested cotton.

MATERIALS AND METHODS

Harvesting. Cotton was harvested from plots at the Texas A&M AgriLife Research and Extension Center north of Lubbock, TX on 18 and 19 October 2011, and on 6 and 7 November 2012. FiberMax 9170 B2F and Stoneville 5458 B2RF were the cultivars used in both years of this study. In both years, the field was divided into two, 100-row blocks and one cultivar was planted in each block (Figs. 1 and 2 for 2011 and 2012, respectively). Figures 1 and 2 show the approximate collection locations within each of the 100-row blocks. The focus of this work was only the machine effects on fiber quality and foreign matter content and, thus, did not investigate the agronomic performance of either cultivar. However, the cultivars, common to the Southern High Plains region, were selected for their diversity in inherent fiber properties. The cultivars were planted on 1.0-m row spacing on 6 May 2011 and 17 May 2012, and the 236-m long field was furrow irrigated. The cotton was harvested using a four-row John Deere 7460 cotton stripper. During both years, bur cotton was harvested at approximately 4.8 km h^{-1} ground speed, and brush roll and cross auger speeds were set to approximately 660 rpm. The field cleaner top saw set-point speed was 630 rpm.

Cultivar	Replication	Approximate Collection Areas		
Stoneville	Yield Pass			
Stoneville	Rep 5	BFC/AFC	HP	ARU/ACA
Stoneville	Rep 4	BFC/AFC	HP	ARU/ACA
Stoneville	Rep 3	BFC/AFC	HP	ARU/ACA
Stoneville	Yield Pass			
Stoneville	Rep 2	BFC/AFC	HP	ARU/ACA
Stoneville	Rep 1	BFC/AFC	HP	ARU/ACA
Stoneville	Yield Pass			
FiberMax	Yield Pass			
FiberMax	Rep 1	BFC/AFC	HP	ARU/ACA
FiberMax	Rep 2	BFC/AFC	HP	ARU/ACA
FiberMax	Yield Pass			
FiberMax	Rep 3	BFC/AFC	HP	ARU/ACA
FiberMax	Rep 4	BFC/AFC	HP	ARU/ACA
FiberMax	Yield Pass			
FiberMax	Rep 5	BFC/AFC	HP	ARU/ACA

Figure 1. Field and cultivar layout for the collection strips 2011.

Cultivar	Replication	Approximate Collection Areas		
Stoneville	Rep 1	BFC/AFC	HP	ARU/ACA
Stoneville	Yield Pass			
Stoneville	Rep 2	BFC/AFC	HP	ARU/ACA
Stoneville	Yield Pass			
Stoneville	Rep 3	BFC/AFC	HP	ARU/ACA
Stoneville	Rep 4	BFC/AFC		ARU/ACA
Stoneville	Yield Pass			
Stoneville	Rep 5	BFC/AFC		ARU/ACA
FiberMax	Rep 1	BFC/AFC	HP	ARU/ACA
FiberMax	Rep 2	BFC/AFC	HP	ARU/ACA
FiberMax	Yield Pass			
FiberMax	Rep 3	BFC/AFC	HP	ARU/ACA
FiberMax	Rep 4	BFC/AFC		ARU/ACA
FiberMax	Yield Pass			
FiberMax	Rep 5	BFC/AFC		ARU/ACA
FiberMax	Yield Pass			

Figure 2. Field and cultivar layout for the collection strips 2012.

Eight, four-row–wide plots were randomly selected within each cultivar block and used for sample collection and yield measurement. Three plots were harvested from each cultivar the full length of the field and the cotton weighed to determine seed cotton and lint yield. The remaining five plots per cultivar were used for seed cotton sample collection.

Seed cotton samples (approximately 9 kg each) were collected from four locations on the harvester in addition to a handpicked sample (HP) collected directly from the field to isolate the mechanical effect of the harvesting units, cross auger conveyor, pneumatic conveying duct, and field cleaner on foreign matter content and fiber quality (Fig. 3). The HP samples contained low levels of foreign material (leaf, bur, stick, and other vegetative material) as workers were instructed to remove only seed cotton from open bolls on the plants. The four machine sampling locations included: 1) after the harvested cotton was conveyed out of the row unit but before being engaged by the cross auger conveyor (after row unit, ARU), 2) from the separation duct inlet after the cotton was conveyed by the cross auger (after cross auger, ACA), 3) from the basket by-passing the field cleaner (before field cleaner, BFC), and 4) from the basket after the cotton was processed through the field cleaner (after field cleaner, AFC).

Figure 3. Collection locations for cotton lint samples represented on an actual cotton stripper (HP: Handpicked, ARU: After Row Unit, ACA: After Cross Auger, BFC: Before Field Cleaner, AFC: After Field Cleaner).

Simultaneous sampling of the harvested bur cotton at each location on the harvester was problematic from a safety and feasibility standpoint. Therefore, all replicates from one harvester location were collected from both cultivars prior to collecting samples from other harvester locations. Figure 4 shows pictures of each sampling location to provide a more detailed insight to each of the sampling locations. Prior to collecting each sample, the harvester was operated at full engine speed and 4.8 km h^{-1} ground speed so that the material for each sample was harvested under consistent machine loading conditions. The BFC and AFC samples were collected from the basket after the machine had traveled at least 45 m into the unharvested cotton. Prior to collecting the ARU and ACA samples, the right-hand side of the cross auger was removed from the header so that the right-side two row units discharged cotton directly into the open auger trough. A large bag 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 unharvested cotton at 4.8 km h^{-1} until the cross auger trough behind the right-hand row units was full. The machine was stopped and seed cotton samples were collected from the open auger trough (ARU sample) and from the large bag attached to the inlet of the main conveying duct (ACA sample). Handpicked samples were collected from each four-row plot between the areas from which the AFC and ARU samples were collected. Seed cotton moisture content samples were collected concurrently with each seed cotton sample collected from the harvester or handpicked from the field and analyzed according to the procedures described by Shepherd (1972).

Figure 4. From top to bottom are pictures representing the sampling locations from before the sample was introduced to when it was collected: Handpicked, After Row Unit, After Cross Auger, Before Field Cleaner, After Field Cleaner (performed the same).

Ginning. A subsample of each cotton sample collected from the machine or handpicked from the field was taken for foreign matter content analysis by hand and pneumatic fractionation (Shepherd, 1972) prior to ginning. The remaining bur cotton was weighed and processed through an extractor-feeder (Continental Gin Company-Moss Gordin, Birmingham, AL, Type C-95, Serial No. 8866 [BM 948428], top saw 0.36-m diameter at 374 rpm, middle saw 0.36-m diameter at 374 rpm, bottom saw 0.36-m diameter at 77 rpm); 21-saw gin stand (Continental Gin Company, Birmingham, AL, Model 610, Type 16B79, saw cylinder 0.41-m diameter at 720 rpm, doffer brush speed 1830 rpm); and one stage of saw-type lint cleaning (Continental Gin Company, Birmingham, AL, Model 620, Type G120B, upper roller speed 86 rpm, feed roller speed 91.5 rpm, main saw 0.41-m diameter at 882 rpm, doffer brush speed 1472 rpm). A seed cotton sample was collected from the extractor-feeder apron during ginning for gravimetric moisture content analysis (Shepherd, 1972). The moisture samples were weighed using an Ohaus Corporation scale (Model Scout Pro SP402, Capacity 400 g, resolution:0.01 g), whereas fractionation samples were weighed on an A&D company scale (Model HP 20K, Serial No. 13013097, capacity 21 kg, resolution 0.1 g). An Electroscale (Model LC2424, capacity 99.8 kg, Display: Electroscale Weigh Master 551, capacity 90.7 kg, resolution 0.005 kg) was used to weigh the clean lint, seed, and extractor-feeder trash removed from each sample during the ginning process. Lint turnout percentage was calculated for each sample by dividing the clean lint weight by the total weight of seed cotton ginned and multiplying by 100. Two lint samples were collected after the lint cleaner from each sample and were sent to the Texas Tech University, Fiber and Biopolymer Research Institute in Lubbock, TX for High Volume Instrument (HVI) (Uster Technologies HVI 1000) and Advanced Fiber Information System (AFIS) (Uster Technologies AFIS Pro 2) fiber analyses.

The Mixed Procedure (Proc Mixed Model) in SAS (SAS v. 9.3, SAS Institute Inc., Cary, NC) was used to analyze the data for fixed effects of location, variety, and the location by variety interaction, whereas year and replication were included as random factors. Tukey's HSD test (a = 0.05) was used to declare differences among least squares means (LS means) for significant main effects. The SLICE option was included in the LSMEANS statement to produce tests of simple effects for significant two-factor interactions. The SLICE option produces an F test to evaluate the effect of factor A across each level of factor B and vice-versa.

Because year effect was present in all data analyzed, Proc Mixed was utilized to draw a broader inference across the years and growing environments to prevent the interference of a year effect. The representation of two cultivars in a table indicates that there was a statistical difference in cultivars and the data were separated for analysis. Thus, if the cultivars are represented separately, there was a between-cultivar statistical difference for that particular fiber quality parameter, and it should not be interpreted that the cultivars are similar. The statistical groupings indicate the value for a sample location within each cultivar is similar, and there was statistical difference between cultivars for this fiber parameter. Significance is listed by showing the *P*-values in each table.

RESULTS AND DISCUSSION

Ginning moisture contents for 2011 ranged from 4.3 to 8.5% with a mean of 6.2% on a wet basis, and 4.5 to 9.3% with a mean of 6.6% on a dry basis. The ginning moisture contents for 2012 ranged from 4.9 to 8.2% with of mean of 5.9% on a wet basis, and 5.2 to 8.9% with a mean of 6.3% on a dry basis. The moisture contents are similar for each year and fall within ±2% of the values reported by Childers and Baker (1978), who reported that typical moisture contents of High Plains cotton ranged from 5 to 7% when the cotton arrived at the gin. They also reported that it was disadvantageous to dry the cotton under these conditions because the dried cotton was generally worth less than the undried cotton.

Foreign Material. Lint turnout and percent trash, based on total sample weight, is shown in Table 1 for both 2011 and 2012. Analysis of the data showed a trend of decreasing bur cotton trash content as the cotton was conveyed further into the harvester, with minimal trash present in the HP seed cotton. Statistical similarities in the percent trash were reported in the ARU and ACA, and between ACA and BFC. The AFC location had the lowest machine-harvested trash percentage. Lint turnout followed a similar statistical pattern, except that the ARU, ACA, and BFC locations were all similar, with the AFC location having the highest turnout percentage of the machine-harvested seed cotton. This shows that ginning has the ability to remove excessive trash from seed cotton sampled in the middle of the machine, but that a field cleaner aids in removing more of the trash, therefore increasing ginning efficiency, such that the turnout is at a more acceptable level. Significant differences were present for variety, but there was no significant interaction between variety and location within the machine. Thus, for the two varieties tested the most important factor is the machine-location effect not the variety.

The results of the fractionation analysis as a percentage of total sample weight for each location (2011 and 2012) are shown in Table 2. Location was significant for all of the values tested; variety was only significant for the sticks, stems, and leaf trash, and there was not significant interaction between location and variety, again showing that the machine location is the most important factor in the amount of foreign matter collected from the machine treatment locations. The highest trash levels as reported by the fractionation results for burs, sticks, stems, and leaf trash occurred between ARU and BFC, although the field cleaner was able to reduce significantly the amounts of each of these three foreign materials; not to the same level as HP cotton but lower than any of the other locations in the machine. The only statistical differences reported for motes and fine trash were between the HP and the rest of the locations. This shows that machine location did not have a statistical effect on the amount of motes and fine trash as measured by the fractionation test. The Stoneville variety had a slightly higher amount of sticks, stems, and leaf trash than the FiberMax variety. This has to do with specific variety characteristics and is not indicative of any machine effects.

Based on turnout and fractionation data there is a point between the ARU and BFC sampling areas that little to no differences in the amount of foreign matter removed from the seed cotton are observed. Only after the seed cotton passes through the field cleaner are substantial differences between foreign matter removal observed. This data indicate that there is potential for machine redesign after the row units and before the field cleaner to reduce overall trash content prior to the seed cotton entering the field cleaner. Improving the systems prior to the field cleaner (ARU to BFC) could result in less trash transferred from the field to the gin and has the potential to provide additional benefits in lint turnout and trash removal at the gin (Porter et al., 2014).

Table 1. Lint turnout and lint trash content at the extractor feeder by machine location and variety

Parameter	Turnout (%)	Trash (%)
	***P*-Value**	
Machine Loc	**< 0.0001**	**< 0.0001**
Var	**0.0441**	**0.0038**
Machine Loc x Var	**0.7979**	**0.6348**
	Machine Location[Z]	
HP	**37.5 A**	**1.6 D**
ARU	**25.8 C**	**22.5 A**
ACA	**27.3 C**	**20.6 AB**
BFC	**26.8 C**	**17.7 B**
AFC	**32.5 B**	**7.7 C**
	Variety[Y]	
FM	**29.4 B**	**15.1 A**
STV	**30.5 A**	**13.0 B**

***Letters after numbers represent statistical significance**

[Z]HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y]FM = FiberMax, STV = Stoneville

Table 2. Seed cotton fractionation results by machine location and variety

Parameter	Burs %	Sticks and Stems (%)	Leaf Trash (%)	Motes (%)	Fine Trash (%)	Total Trash (%)
			***P*-Values**			
Machine Loc	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Var	0.1816	0.0001	0.0022	0.9193	0.5126	0.8876
Machine Loc x Var	0.6565	0.1471	0.9069	0.4741	0.9428	0.9169
			Machine Location[Z]			
HP	0.9C	0.2D	0.7D	0.8B	0.3B	2.9C
ARU	16.9A	2.6BC	2.7A	1.5A	4.0A	27.8A
ACA	15.3A	3.5A	2.8A	1.8A	4.4A	27.8A
BFC	15.2A	3.1AB	2.3B	1.8A	4.5A	26.7A
AFC	4.3B	2.0C	1.6C	1.5A	3.0A	12.4B
			Variety[Y]			
FM	10.9	1.9B	1.9B	1.5	3.4	19.5
STV	10.1	2.7A	2.2A	1.5	3.1	19.6

***Letters after numbers represent statistical significance**

[Z] HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y] FM = FiberMax, STV = Stoneville

Table 3. AFIS dust, trash, visible foreign matter (VFM) and seed coat nep (SCN) count by machine location and variety

Parameter	Dust (Cnt/g)	Trash (Cnt/g)	VFM (%)	SCN (Cnt/g)
		P-Values		
Machine Loc	< 0.0001	< 0.0001	< 0.0001	0.0098
Var	0.0015	< 0.0001	< 0.0001	0.0205
Machine Loc x Var	0.6492	0.0839	0.0609	0.6621
		Machine Location[Z]		
HP	108.9D	23.3D	0.51 D	17.8 B
ARU	337.25B	79.6B	1.6B	22.3 A
ACA	403.6A	96.1A	1.9A	20.9 AB
BFC	389.6A	92.3A	1.8 AB	20.8 AB
AFC	241.7C	58.2C	1.1 C	19.9 AB
		Variety[Y]		
FM	277.6B	60.8B	1.2B	19.4B
STV	314.8A	79.0A	1.5A	21.2A

***Letters after numbers represent statistical significance**

[Z] HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y] FM = FiberMax, STV = Stoneville

Dust, trash, visible foreign matter (VFM), and seed coat neps (SCN) as reported by AFIS for 2011 and 2012 are reported in Table 3. There were significant differences between both location and variety for all of the four AFIS parameters. However, there was no interaction of location by variety. As with the fractionation results, the Stoneville variety had higher values on dust, trash, VFM, and SCN. In dust, trash, and VFM, the ACA location had the highest value for all three, then as the seed cotton moved on through the machine the values dropped, but not significantly until the seed cotton passed through the field cleaner. There was little difference between machine sample locations and the number of SCN reported. The trends in the foreign matter portion of this data, specifically the dust, trash, and VFM, is similar to the same trends reported from the turnout and fractionation data, supporting the conclusions that little foreign matter was being removed between the ACA and BFC locations.

As shown in Table 4 there were significant differences between machine locations and between varieties, but no significant interaction between location and variety for leaf grade or neps per gram. The Stoneville variety had a higher leaf grade, but a lower number of neps per gram. Leaf grade had a slight increase as the seed cotton passed through the machine until it reached the field cleaner. Table 5 is a further investigation of the leaf grade data by utilizing a Slice Option in the least-squared means statement. This table shows that variety, and all locations except for HP, had significant interactions for leaf grade. The data reported for neps per gram did not follow the same trend; the highest number of neps was at the ARU location, but once the past this area there was no significant difference between machine locations or the HP cotton for the number of neps per gram.

Table 4. HVI leaf grade and AFIS neps count by machine location and variety

Parameter	Leaf Grade	Neps per G
	***P*-Values**	
Machine Loc	< 0.0001	< 0.0001
Var	< 0.0001	< 0.0001
Machine Loc x Var	0.0162	0.1192
	Machine Location[Z]	
HP	0.9_{D}	271.6_{B}
ARU	2.0_{BC}	347.3_{A}
ACA	2.4_{A}	306.0_{B}
BFC	2.3_{AB}	301.7_{B}
AFC	1.8_{C}	300.0_{B}
	Variety[Y]	
FM	1.5_{B}	353.0_{A}
STV	2.2_{A}	257.7_{B}

*Letters after numbers represent statistical significance

[Z]HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y]FM = FiberMax, STV = Stoneville

Cotton Fiber Characteristics. The only maturity and fineness parameters that were different among machine locations were micronaire and immature fiber content (IFC), whereas there were no differences among machine locations on fineness and maturity ratio (Table 6). Although fiber micronaire ranged from 4.2 to 4.4 and was found to be different among machine locations, these micronaire levels are not practically different. The differences viewed here are more than likely due to natural variability in cotton micronaire within a single variety and across multiple varieties. The HP and AFC locations had the lowest levels of IFC, with the ARU the highest. Overall, there was not a wide range of IFC among machine locations, even though significant differences were present. For all four maturity and fineness parameters reported, variety was a significant effect. The Stoneville variety had a higher micronaire, fineness, and maturity ratio, and a lower IFC. There was no significant interaction between the location and variety for any of the maturity and fineness parameters.

Table 5. *P*-Values for the test of simple effects for HVI leaf grade between machine location and variety using the Slice Option in the Least Square Means

Simple Effect	*P*-Value
Variety[Y]	
FM	< 0.0001
STV	< 0.0001
Machine Location[Z]	
HP	0.7546
ARU	< 0.0001
ACA	< 0.0001
BFC	< 0.0001
AFC	0.0005

[Z]HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y]FM = FiberMax, STV = Stoneville

Length, length by weight, upper quartile length (UQL), length by number, and the upper 5% length are shown in Table 7. Length by number was the only length parameter different among machine locations. However, it is not practical for the length to increase as the fiber travels through the machine. These differences are attributed more logically to natural variation, potentially caused by field variation, sample variability, or even plant variability. Similar trends have been observed in several other studies (Bednarz et al., 2007; Bradow et al., 1997; Bradow and Davidonis, 2000; Ge et al., 2008; Johnson et al., 1999, 2002; Wanjura et al., 2010). All five length parameters were different between variety and the interaction of location by variety. The test of simple effects for the length parameters between machine locations and variety using the Slice option are represented in Table 8. Fiber length had a significant interaction for all machine locations. Length by weight, UQL, and length by number had a significant interaction with the FiberMax variety and the HP, BFC, and ARU machine locations, whereas the upper 5% length had a significant interaction between the FiberMax variety and all machine locations. Thus, it can be inferred by these results that the machine location had a greater effect on the length parameters of the FiberMax variety than on the Stoneville variety.

Table 6. Maturity and Fineness parameters by machine location and variety

Parameter	Micronaire	Fineness (mTex)	IFC[X] (%)	Maturity Ratio
		***P*-Values**		
Machine Loc	0.0111	0.3764	0.0069	0.1022
Var	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Machine Loc x Var	0.2834	0.2138	0.2898	0.1542
		Machine Location[Z]		
HP	4.4$_A$	168.9	7.0$_B$	0.9
ARU	4.2$_B$	166.6	7.7$_A$	0.9
ACA	4.3$_{AB}$	167.8	7.4$_{AB}$	0.9
BFC	4.3$_{AB}$	166.9	7.5$_{AB}$	0.9
AFC	4.3$_{AB}$	167.6	7.2$_{AB}$	0.9
		Variety[Y]		
FM	4.0$_B$	157.5$_B$	7.6$_A$	0.88$_A$
STV	4.6$_A$	177.6$_A$	7.1$_B$	0.90$_B$

***Letters after numbers represent statistical significance**

[Z]HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y]FM = FiberMax, STV = Stoneville

[X]IFC = Immature Fiber Content

Table 7. Length parameters by machine location and variety

Parameter	Length (in) [cm]	Length (w) (in) [cm]	UQLX (in) [cm]	Length (n) (in) [cm]	L5%W (n) (in) [cm]
			P-Values		
Machine Loc	0.5015	0.0825	0.234	0.0094	0.3414
Var	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Machine Loc x Var	0.023	0.0123	0.0361	0.0183	0.0327
			Machine LocationZ		
HP	1.11 [2.82]	0.93 [2.36]	1.15 [2.92]	0.73A[1.85]	1.32 [3.35]
ARU	1.11 [2.82]	0.91 [2.31]	1.14 [2.90]	0.71B[1.80]	1.31 [3.33]
ACA	1.12 [2.84]	0.92 [2.34]	1.15 [2.92]	0.72AB [1.83]	1.32 [3.35]
BFC	1.12 [2.84]	0.93 [2.36]	1.15 [2.92]	0.72AB [1.83]	1.32 [3.35]
AFC	1.12 [2.84]	0.93 [2.36]	1.16 [2.95]	0.73A [1.85]	1.32 [3.35]
			VarietyY		
FM	1.14A[2.90]	0.94A[2.39]	1.17A[2.97]	0.73A [1.85]	1.35A[3.43]
STV	1.09B[2.77]	0.91B [2.31]	1.13B[2.87]	0.71B [1.80]	1.28B [3.25]

***Letters after numbers represent statistical significance**

[Z]HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y]FM = FiberMax, STV = Stoneville

[X]UQL = Upper Quartile Length

[W]L5% = Represents the fiber length which is only exceeded by 5% of all fibers.

Uniformity parameters reported by both HVI and AFIS are shown in Table 9. The parameters reported included uniformity, length by weight coefficient of variation (CV), short fiber content (SFC) by weight, length by number CV, and SFC by number. Length by weight, SFC by weight, length by number, and SFC by number were different among machine locations. All of these parameters were the best at the ARU location and diminished as the seed cotton passed through the rest of the machine locations. Length by weight, SFC by weight, and SFC by number were different between varieties. Uniformity and SFC by weight were different with machine location*variety, thus the Slice analysis is shown in Table 10. The most significant interaction of machine location*variety with uniformity occurred at the ACA location. Also, SFC by weight had a significant interaction with the FiberMax variety and the HP, BFC, and AFC machine locations. This is consistent with length parameters reported in Table 8.

Table 8. *P*-Values for the test of simple effects of significant Loc by Var length factors using the Slice Option

Simple Effect	Length (in) [cm]	Length (w) (in) [cm]	UQL[X] (in) [cm]	Length (n) (in) [cm]	L5%[W] (n) (in) [cm]
			Variety[Y]		
FM	0.1325	0.002	0.0154	0.0003	0.0219
STV	0.098	0.4603	0.4975	0.4848	0.4843
			Machine Location[Z]		
HP	< 0.0001	< 0.0001	< 0.0001	0.0039	< 0.0001
ARU	< 0.0001	0.0422	0.0012	0.5434	< 0.0001
ACA	< 0.0001	0.2004	0.0029	0.7943	< 0.0001
BFC	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001
AFC	< 0.0001	< 0.0001	< 0.0001	0.0046	< 0.0001

[Z] HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y] FM = FiberMax, STV = Stoneville

[X] UQL = Upper Quartile Length

[W] L5% = Represents the fiber length which is only exceeded by 5% of all fibers.

Table 9. Uniformity parameters by machine location and variety

Parameter	Uniformity	Length (w) CV[X] (%)	SFC[W] (w) (%)	Length (n) CV (%)	SFC (n) (%)
			P-Values		
Machine Loc	0.7015	0.0101	0.0098	0.0004	0.0025
Var	0.9724	0.0003	0.0003	0.0847	0.0091
Machine Loc x Var	0.007	0.0591	0.0477	0.1159	0.0552
			Machine Location[Z]		
HP	80.72	36.37_{B}	11.11_{B}	52.19_{C}	29.99_{B}
ARU	80.63	37.45_{A}	12.39_{A}	54.59_{A}	32.85_{A}
ACA	80.91	37.04_{AB}	11.79_{AB}	53.94_{AB}	31.80_{AB}
BFC	80.82	36.67_{AB}	11.48_{AB}	53.44_{ABC}	31.15_{AB}
AFC	80.91	36.27_{B}	11.04_{B}	52.58_{BC}	30.15_{B}
			Variety[Y]		
FM	80.79	37.20_{A}	11.07_{B}	53.66	30.52_{B}
STV	80.80	36.32_{B}	12.05_{A}	53.03	31.86_{A}

*Letters after numbers represent statistical significance

[Z] HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y] FM = FiberMax, STV = Stoneville

[X] CV = Coefficient of Variation

[W] SFC = Short Fiber Content

Table 10. ***P*-Values for the test of simple effects of significant Loc by Var uniformity factors using the Slice Option**

Simple Effect	Uniformity	SFC[X] (w) (%)
	Variety[Y]	
FM	0.0799	0.0014
STV	0.0787	0.3281
	Machine Location[Z]	
HP	0.0554	0.0281
ARU	0.0885	0.4809
ACA	0.013	0.6135
BFC	0.2415	0.0008
AFC	0.4079	0.017

[Z] HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y] FM = FiberMax, STV = Stoneville

[X] SFC = Short Fiber Content

Table 11 shows that strength, reflectance, and yellowness were different among machine locations and variety, but there was no interaction between location and variety. Strength and yellowness increased after the HP location and then were reduced after the seed cotton passed through the machine and field cleaner. Reflectance decreased once the fiber was introduced into the machine. However, it should be noted there was little difference between sampling locations for all three parameters in Table 11.The slight differences were mainly between the HP location and the machine locations. Thus, the data could represent a statistical difference but not a practical difference because the differences are insignificant from a fiber quality perspective.

Table 11. Strength, reflectance (Rd) and yellowness (+b) by machine location and variety

Parameter	Strength (g/Tex)	Rd	+b
	***P*-Values**		
Machine Loc	0.0178	< 0.0001	< 0.0001
Var	0.0099	< 0.0001	< 0.0001
Machine Loc x Var	0.0826	0.5947	0.2015
	Machine Location[Z]		
HP	30.7_{B}	81.4_{A}	7.8_{B}
ARU	31.0_{AB}	78.9_{BC}	8.3_{A}
ACA	31.5_{A}	78.7_{C}	8.2_{A}
BFC	31.0_{AB}	78.7_{C}	8.2_{A}
AFC	30.8_{B}	79.5_{C}	8.1_{A}
	Variety[Y]		
FM	31.2_{A}	81.1_{A}	7.6_{B}
STV	30.8_{B}	77.8_{B}	8.7_{A}

*Letters after numbers represent statistical significance

[Z] HP = Handpicked, ARU =After Row Unit, ACA = After Cross Auger, BFC = Before Field Cleaner, AFC = After Field Cleaner

[Y] FM = FiberMax, STV = Stoneville

SUMMARY

The main objective of this study was to track cotton fiber quality and foreign matter content through the harvesting units and conveying/cleaning systems on a brush-roll stripper harvester. The FiberMax variety contained more trash at the extractor feeder, had a higher leaf grade in the lint, and longer fiber than the Stoneville variety. In general, foreign matter content was similar at the ARU, ACA, and BFC machine locations, and then decreased significantly as the seed cotton passed through the field cleaner. Foreign matter content at the machine locations was always higher than HP. The interaction of machine location*variety could be due to the higher leaf pubescence of the Stoneville variety. The highest meaningful turnout (not including HP) occurred after the field cleaner. Fiber length and length uniformity was not much different for machine locations, although there was an interaction of machine location*variety with these parameters that could have been due to natural variability in the field and from the samples collected. Overall, the results of this work indicate that there is little difference in the amount of foreign matter removed between the ARU and BFC locations on a brush-roll stripper harvester, and there are few differences between non-foreign matter fiber quality parameters as the seed cotton passed through the machine. This indicates a potential for improvement within these machine locations on a cotton stripper harvester.

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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.

REFERENCES

Bednarz, C.W., R.L. Nichols, and S.M. Brown. 2007. Within-boll yield components of high yielding cotton cultivars. Crop Sci. 47:2108–2112.

Bradow, J.M., P.J. Bauer, O. Hinojosa, and G. Sassenrath-Cole. 1997. Quantitation of cotton fibre-quality variations arising from boll and plant growth environments. Eur. J. Agron. 6(3):191–204.

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(1):34–64.

Brashears, A.D. 1984. Modifications of stripper rolls to reduce stick content in bur cotton. p.155 *In* Proc. Beltwide Cotton Prod. Res. Conf., Atlanta, GA. 8-12 Jan. 1984. Natl. Cotton Counc. Am., Memphis, TN.

Brashears, A.D. 1994. Conveyor auger modifications to increase foreign matter removed by cotton strippers. p. 539–541 *In* Proc. Beltwide Cotton Conf., San Diego, CA. 5-8 Jan. 1994. Natl. Cotton Counc. Am., Memphis, TN.

Brashears, A.D. 2005. Reducing seed cotton losses from field cleaners. p. xxx–xxx *In* Proc. Beltwide Cotton Conf., New Orleans, LA. 4-7 Jan. 2005. Natl. Cotton Counc. Am., Memphis, TN.

Childers, R.E., and R.V. Baker. 1978. Effects of moisture conditioning on ginning performance and fiber quality of high plains cotton. Trans. ASAE. 21:379–384.

Colwick, R.F., and Technical Committee Members. 1965. Mechanized harvesting of cotton. Southern Coop. Ser., Bull. No. 100. Southern Association of Agricultural Experiment Station Directors (SAAESD), Raleigh, NC.

Faulkner, W.B., J.D. Wanjura, E.F. Hequet, B.W. Shaw, and C.B. Parnell, Jr. 2011a. Evaluation of modern cotton harvest systems on irrigated cotton: fiber quality. Appl. Eng. Agric. 27(4):507–513.

Faulkner, W.B., J.D. Wanjura, R.K. Boman, B.W. Shaw, and C.B. Parnell, Jr. 2011b. Evaluation of modern cotton harvest systems on irrigated cotton: economic returns. Appl. Eng. Agric. 27(4):515–522.

Ge, Y., J.A. Thomasson, R. Sui, C.L. Morgan, S.W. Searcy, and C.B. Parnell. 2008. Spatial variation of fiber quality and associated loan rate in a dryland cotton field. Precision Agric. 9(4):181–194.

Hughs, S.E., T.D. Valco, and J.R. Williford. 2008. 100 years of cotton production, harvesting, and ginning systems engineering:1907-2007. Trans. ASABE. 51(4):1187–1198.

Johnson, R., J. Bradow, P. Bauer, and E. Sadler. 1999. Spatial variability of cotton fiber yield and quality in relation to soil variability. Proc. Fourth International Conf. Precision Agric., 19-22 July 1998, St. Paul, MN. ASA, CSSA, SSSA, Madison, WI.

Johnson, R.M., R.G. Downer, J.M. Bradow, P.J. Bauer, and E.J. Sadler. 2002. Variability in cotton fiber yield, fiber quality, and soil properties in a southeastern coastal plain. Agron. J. 94:1305–1316.

Kerby, T.A., L.M. Carter, S.E. Hughs, and C.K. Bragg. 1986. Alternate harvesting systems and cotton quality. Trans. ASAE. 29(2):407–412.

Porter, W.M., J.D. Wanjura, R.K. Taylor, M.D. Buser, and E.M. Barnes. 2013. Comparison of a belt and auger conveyance system for a cotton stripper header. Paper No. PM-10658-2013. ASABE International Meeting 21-24 July 2013, Kansas City, MO. ASABE St. Joseph, MI.

Nelson, J.M., S.K. Misra, and A.D. Brashears. 2001. Cost comparison of alternative stripper and picker cotton harvesting systems. Appl. Eng. Agric. 17(2):137–142.

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

Smith, L.A., and W.T. Dumas. 1982. A cleaner for cotton strippers. Trans. ASAE. XX:291–296.

Smith, H.P. 1935. Progress in the study of the mechanical harvesting of cotton. Texas Agricultural Experiment Station, College Station, Texas.

United States Department of Agriculture [USDA]. 2011. National Statistics for Cotton. National Agricultural Statistics Database [online]. Available at: https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=TEXAS (Accessed 14 March 2017). USDA National Agricultural Statistics Service, Washington, DC.

Wanjura, D.F., and R.V. Baker. 1979. Stick and bark relationships in the mechanical stripper harvesting and seed cotton cleaning system. Trans. ASAE. 22(2):273–282.

Wanjura, D.F., and A.D. Brashears. 1983. Factors influencing cotton stripper performance. Trans. ASAE. 29(3):321–332.

Wanjura, J.D., G.A. Holt, M.G. Pelletier, and J.A. Carroll. 2011. Influence of grid bar shape on field cleaner performance—laboratory screening tests. J. Cotton Sci. 15(2):144–153.

Wanjura, J.D., M.S. Kelley, R.K. Boman, and G.A. Holt. 2010. Harvesting to optimize fiber quality. Paper No.1009229. Proc. ASABE International Meeting, 20-23 June, 2010, Pittsburgh, PA.

Wanjura, J.D., W.B. Faulkner, E.M. Barnes, G.A. Holt, and M.G. Pelletier. 2012. Crop residue inventory estimates for Texas High Plains Cotton. p. 542–552 *In* Proc. Beltwide Cotton Conf., Orlando, FL. 3-6 Jan. 2012. Natl. Cotton Counc. Am., Memphis, TN.

Williford, J.R., A.D. Brashears, and G.L. Barker. 1994. Harvesting. Cotton Ginners Handbook, 11–16. USDA Agricultural Research Service, Washington, D.C.