GINNING PICKER AND STRIPPER HARVESTED HIGH PLAINS COTTON - UPDATE

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Abstract

Texas High Plains cotton has improved over the last ten years with regard to yield and HVI fiber quality. Harvesting and ginning practices are needed which preserve fiber quality and maximize return to the producer. The objective of this work is to investigate the influence of harvest method, number of seed cotton extractor cleaners (e.g. stick machines), and seed cotton cleaning rate on foreign matter content, lint turnout, and fiber quality. During the 2009 and 2010 crop years, irrigated cotton grown in the Texas High Plains was harvested and ginned using treatment combinations defined by harvest method (picker or stripper with field cleaner), number of stick machines used in the seed cotton cleaning system (one or two), and seed cotton cleaning rate (low, medium, or high). The twelve treatment combinations were replicated three times for a total of 36 runs for each of six tests (216 total runs). The six tests were conducted to capture regional variation with regard to soil type, production practices, available volume of irrigation, and cultivar. Picker harvested cotton contained less foreign matter than stripper harvested cotton and affected differences by harvest method for total foreign matter removed by the stick machines, total foreign matter removed during the ginning process, and lint turnout. The use of two stick machines removed more foreign material from seed cotton than using only one and more foreign material was removed by the stick machines for slower seed cotton cleaning rates. Total stick machine seed cotton loss was not different by any of the main effects tested. Seed cotton cleaning system efficiency was greater for stripper harvested cotton and when two stick machines were used but seed cotton cleaning rate had no effect. Fiber quality was influenced most by harvest method where picker harvested cotton exhibited improved HVI and AFIS fiber quality parameters compared to stripper harvested cotton. The use of two stick machines compared to only one improved some HVI and AFIS length characteristics and resulted in lower lint foreign matter content. Seed cotton cleaning rate had a minimal effect on fiber quality. The findings of this work support the current recommendations of using one stick machine in seed cotton cleaning systems processing picker harvested cotton and two stick machines in systems processing stripper harvested cotton.

Introduction

Cotton produced in the Texas High Plains has exhibited substantial improvements in terms of yield and fiber quality over the last ten years. These benefits stem primarily from cultivar changes and improved irrigation practices. In an effort to better preserve fiber quality, some producers in the region have begun to look to spindle pickers to harvest the High Plains crop. Recent work by Faulkner et al. (2009 a and b) indicates that picker harvesters can offer advantages with regard to harvesting productivity, gin turnout, and fiber and yarn quality when compared to brush-roll stripper harvesters.

Cotton grown in the Texas High Plains region is traditionally harvested with brush-roll stripper harvesters. These machines were developed to be a cost effective method for harvesting relatively low yielding cotton (0.5 – 1.5 bales/acre) grown on short plants with closed or “storm-proof” boll conformations. The spindle picker is not well suited to harvest cotton under these conditions. In contrast to spindle pickers, stripper harvesters indiscriminately harvest seed cotton from the plants. As a consequence of the indiscriminate harvesting action, foreign matter content of stripped cotton is often much higher than that of picked cotton. Subsequently, lint turnout values are typically in the range of 25%, 30%, and 35% for stripped - non-field cleaned, stripped - field cleaned, and picked cottons, respectively.

Ginning practices in the High Plains region have evolved to handle high trash levels contained in stripper harvested cotton. The recommended machinery sequence for processing stripper harvested cotton includes: green boll/rock trap, air-line cleaner, feed control, tower drier, inclined cleaner, stick machine, tower drier, inclined cleaner, stick machine, extractor-feeder, gin stand, and two lint cleaners (Baker et al., 1977). Anthony et al. (1986) recommend a similar sequence for processing machine picked cotton but included only the first stick machine listed (i.e. no stick machine just prior to the extractor feeder). Differences in the recommended machinery sequences for ginning picked and stripped cotton reflect the difference in the amount of required seed cotton cleaning to affect efficient ginning and acceptable lint trash grades.

Research on seed cotton cleaning equipment over the years indicates that extractors (e.g. stick machines and burr machines) and cylinder cleaners (e.g. horizontal and inclined cleaners) have little influence on fiber length characteristics while positively influencing color and leaf grades (Anthony, 1982; Anthony et al., 1986; Baker et al., 1977; Baker and Lalor, 1990, Holt et al., 2002). Cleaning efficiency of seed cotton cleaning equipment is influenced by many factors including initial seed cotton foreign matter content, processing rate, moisture content, machine configuration/setting, and distribution of cotton across the machine (Baker et al., 1982; Baker et al., 1994). Although ginners strive for maximum production and thus tend to push the processing rate limits of their cleaning equipment, compromises must be made to balance seed cotton cleaning rate with cleaning efficiency and seed cotton loss (higher processing rates tend to reduce cleaning efficiency and increase seed cotton loss). Moreover, mechanical actions on cotton fibers in the harvesting and ginning process have been shown to increase the amount of neps and short fibers in the bale (Anthony et al., 1986). Short fiber and nep content influence spinning performance and mill waste but neither are reported by the USDA – Agricultural Marketing Service (AMS) which uses the high volume instrument (HVI) classification system for Commodity Credit Corporation (CCC) loan value determination. Recent questions have arisen from the industry concerning appropriate methods for ginning picker harvested cotton from high-quality cultivars that preserve fiber quality and bale value. Thus, the objective of this work was to investigate the influence of harvest method, seed cotton extractor cleaners, and seed cotton processing rate on foreign matter content, lint turnout, and fiber quality for picked and stripped cotton produced in the Texas High Plains.

Materials and Methods

A completely randomized experimental design was used to evaluate the main effects of harvest method (spindle picker or brush-roll stripper with field cleaner), number of stick machines used in the seed cotton cleaning machine sequence (one or two), and seed cotton cleaning rate (low, medium, high). The experiment was conducted six times from 2009 to 2010 and the location and various production conditions for each test are listed in table 1. Three replications of each treatment combination were used for a total of 36 runs per test (216 total).

Table 1. Location and production conditions for six tests conducted during 2009 and 2010.

Test	Location	Year	Irrigation	Soil Type*	Variety	Lint Yield (lb/acre)
A	Lubbock, TX	2009	Pivot - Limited	Acuff loam	DPL 143 B2F	250
B	Lubbock, TX	2009	Pivot - Limited	Acuff loam / Amarillo fine sandy loam	FM 9180 B2F	590
C	Ralls, TX	2009	Sub-surface drip	Pullman silty clay loam	FM 9180 B2F	1100
D	Plains, TX	2009	Pivot	Amarillo loamy fine sand	FM 9180 B2F	1200
E	Lubbock, TX	2010	Furrow	Acuff loam / Estacado clay loam	FM 9180 B2F	800
F	Ralls, TX	2010	Sub-surface drip	Pullman silty clay loam	FM 9180 B2F	1300

*USDA (2009).

Tests A and B were conducted on a cooperating producer's field near Lubbock, TX in 2009. Portions of a center pivot irrigated field were planted with Deltapine 143 Bollgard II® Roundup Ready Flex® (DP 143 B2F; Monsanto, St. Louis, MO) and FiberMax 9180 Bollgard II® Roundup Ready Flex® (FM 9180 B2F, Bayer Crop Science, Research Triangle Park, NC). DP 143 B2F was used for test A while FM 9180 B2F was used for test B to provide seed cotton with a potential range in fiber maturity. DP 143 B2F is a late maturing cultivar while FM 9180 B2F is early maturing. The irrigation volume was limited for this field due to declining well capacity as is evident by the

low yield relative to the other tests. Cotton for tests A and B was planted on May 25, 2009 and harvested November 30, 2009 using a John Deere 9996 (Moline, IL) six-row picker and a John Deere 7445 six-row stripper with field cleaner.

Tests C and F were conducted on the same field near Ralls, TX in 2009 and 2010. FM 9180 B2F was the cultivar used for both tests and the cotton was irrigated by a sub-surface drip system. For test C, the field was planted on May 15, 2009 and harvested November 16, 2009. The field was planted on May 20, 2010 and harvested November 2 with the picker and November 18 with the stripper for test F in 2010. A John Deere 9996 six-row picker and John Deere 7460 eight-row stripper with field cleaner were used to harvest cotton for tests C and F.

Test D was conducted on a center pivot irrigated field near Plains, TX. The field was planted to FM 9180 B2F on May 18, 2009 and harvested November 19, 2009. Irrigation capacity was considerably higher for the field used for test D compared to the field used for tests A and B. Thus, the lint yield was substantially improved for test D compared to tests A and B. A John Deere 9996 six-row picker and John Deere 7460 six-row stripper with field cleaner were used to harvest cotton for test D.

Test E was conducted on a furrow-irrigated cotton field near Lubbock, TX. The field was planted to FM 9180 B2F on May 6, 2010 and harvested November 4, 2010. The cotton was harvested using a John Deere 9996 six-row picker and a John Deere 7445 six-row stripper with field cleaner.

The picker and stripper harvested cotton from each test was transported back to the USDA ARS Cotton Production and Processing Research Unit (CPPRU, Lubbock, TX) for ginning. During each gin run, a seed cotton lot of approximately 250 lbs. was processed through the following initial seed cotton cleaning machinery: green boll/rock trap, feed control, tower drier, inclined cleaner, and stick machine (R320, Consolidated Gin Machinery Co., Lubbock, TX). After passing though the initial seed cotton cleaning machinery, the seed cotton was dumped in a bin located at the distributor auger overflow and weighed. The lot was then picked up and taken through the following final seed cotton cleaning machinery: feed control, tower drier, inclined cleaner, and R320 stick machine. The stick machine in the final seed cotton cleaning sequence was bypassed for half of the seed cotton lots. The cotton was taken though the same seed cotton cleaning equipment during the initial and final seed cotton cleaning passes to reduce any bias that may be introduced if different machines were used. All seed cotton cleaning machinery was 6 ft wide.

The flow rate of the seed cotton through the cleaning equipment was controlled by the feed control. The same three feed control settings were used for all tests to establish the low, medium, and high material flow rates without regard to initial foreign matter content (table 2). Thus, the feed rates for tests with higher turnout were higher in terms of lint mass per unit time than tests with cotton containing higher amounts of foreign matter (i.e. cotton with lower turnout). The feed control setting was adjusted so that the processing time through the final seed cotton cleaning machine sequence approximated that of the initial sequence. After seed cotton cleaning, each lot was processed through an extractor/feeder, 93 saw gin stand, and two stages of saw type lint cleaning.

Table 2. Seed cotton cleaning rates used for tests conducted during 2009 and 2010.

	Seed Cotton Cleaning Rate (lb/min) (bales/hr-ft*)						
Test	A	B	C	D	E	F	Mean
Low	293 (1.6)	283 (1.8)	384 (2.6)	382 (2.4)	323 (2.3)	370 (2.4)	339 (2.2)
Med	418 (2.2)	338 (2.1)	456 (3.1)	464 (2.9)	401 (2.8)	460 (3.0)	423 (2.7)
High	447 (2.4)	419 (2.7)	524 (3.5)	496 (3.1)	465 (3.3)	554 (3.6)	484 (3.1)

*Bales/hr-ft refers to the number of 480 lb lint bales processed per hour per ft of machine width.

One seed cotton sample was collected at the suction telescope and extractor/feeder apron for gravimetric moisture content analysis and fractionation analysis (Shepherd, 1972). An additional seed cotton fractionation sample was collected from the overflow bin after the initial seed cotton cleaning machine sequence. The material rejected by the stick machine was weighed and sampled (one sample) for seed cotton loss after each pass. The waste material from both lint cleaners was collected, weighed, and sampled (one sample per machine) for foreign matter content analysis using the Shirley Analyzer method (ASTM, 2007). USDA ARS personnel at the CPPRU conducted all moisture

content, fractionation, and Shirley Analyzer analyses. Lint samples were collected after the first and second lint cleaners (one sample per machine) for HVI and advanced fiber information system (AFIS) fiber analysis at the Texas Tech University - Fiber and Biopolymer Research Institute (Lubbock, TX).

Lint turnout was calculated using the incoming seed cotton weight and lint weight after one and two lint cleaners. Total trash content (lb/bale, 1 bale = 480 lb) in the seed cotton ginned during each run was calculated as the incoming seed cotton weight less the final lint weight and seed weight.

Ginning performance and fiber quality data were analyzed for main effects and two factor interactions by test using the general linear model (Proc GLM) in SAS (SAS v. 9.2, SAS Institute, Cary, NC) using a 0.05 level of significance. Main effects were evaluated over all tests using the mixed model (Proc Mixed) in SAS. For the mixed model analysis, test and test-by-main-effect interactions were considered random effects. Seed cotton moisture content measured at the suction and extractor feeder apron were used as covariates in both the GLM and mixed model analyses. Separation of least square means testing was conducted in SAS using Tukey's HSD test ($\alpha = 0.05$).

Results and Discussion

Seed cotton fractionation results on samples pulled from the inlet suction telescope at the gin indicate that picker harvested cotton had less foreign material in terms of total trash for all six tests (table 3). Burr content in the seed cotton was less for picked cotton for all tests and stick content was lower for all but test A. Although no significant difference was observed by harvest method for fine trash content in test A, fine trash content was 4.4% for picked cotton and 8.2% for stripped cotton. The mixed model analysis indicated differences for all foreign matter constituents by harvest method only. Since the data presented in table 3 are from fractionation analyses conducted on seed cotton samples taken before entering the gin plant, no difference by the number of stick machines or seed cotton cleaning rate was expected. The significant harvest method x stick machine interaction for fine trash and harvest method x seed cotton cleaning rate for burr and total trash content are a consequence of natural variation in the seed cotton foreign matter content.

Table 3. Fractionation results by test and harvest method (pick = picker, strip = stripper w/field cleaner) from seed cotton samples collected at the suction telescope before ginning.

	Test A		Test B		Test C		Test D		Test E		Test F		Mean*	
Foreign Matter Component	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip
Burrs (B)	1.3	16.7	1.1	11.6	2.2	11.8	3.1	11.0	1.7	5.3	2.3	11.0	2.0	11.2
Sticks (S)	0.4	5.9	0.3	5.7	1.0	4.2	0.9	5.1	0.4	2.0	0.3	2.8	0.5	4.3
Fine Trash (F)	4.4	8.2	3.4	5.5	3.0	4.4	3.6	6.0	4.4	5.2	4.5	11.9	3.9	6.9
Total Trash (T)	6.1	30.8	4.7	22.8	6.2	20.3	7.6	22.1	6.6	12.5	7.1	25.8	6.4	22.4
Main Effects and Interactions**														
Harvest Method	B, T		B, S, F, T		B, S, F, T		B, S, F, T		B, S, T		B, S, F, T		B, S, F, T	
# Stick Machines	-		-		-		-		-		-		-	
SC Cleaning Rate	-		-		-		-		-		-		-	
HM x SM	-		-		-		F		-		-		-	
HM x Rate	-		-		B, T		-		-		-		-	
SM x Rate	-		-		-		-		-		-		-	

*Means in this column are reported from the mixed model analysis across all tests.
**Main effects and interactions were significant for the foreign matter fractions listed.

Total foreign matter removed by the stick machines used during seed cotton cleaning is shown in table 4. As expected, more foreign material was removed by the stick machines from stripped cotton than picked cotton in all tests. Over all six tests, an average of 178 lb/bale was removed from stripped cotton compared to 31 lb/bale from picked cotton. Seed cotton cleaning machinery sequences using only one stick machine removed less foreign material than those using two. Across all tests, seed cotton cleaning machinery sequences using two stick machines removed 33 lb/bale more foreign material compared to sequences using only one. Seed cotton cleaning rate

significantly influenced the amount of foreign matter removed by the stick machines for tests A, B, and F, where the trend of increasing foreign matter removal with decreasing cleaning rate was observed. Significant harvest method x no. stick machine interactions were observed for all but test E. This interaction is linked to the initial seed cotton foreign matter content as the difference between the total foreign matter removed by one and two stick machines was greater for stripped cotton compared to picked (figure 1). Additionally, the difference in foreign matter removed by one and two stick machines was greater for stripped cotton in test A compared to the other tests. This is likely due to the difference in maturity between cultivars among tests as DPL 143 B2F requires a longer growing season to reach maturity compared to FM 9180 B2F. The harvest method x seed cotton cleaning rate interaction was significant for tests A, F, and the mixed model mean.

Table 4. Least square means for total foreign material (lb/bale) removed by the stick machines during seed cotton cleaning.

Test	A	B	C	D	E	F	Mean*
Harvest Method (HM)							
Picked	42	20	24	40	32	34	31
Stripped	257	165	174	198	81	186	178
p > F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Stick Machines (SM)							
One	120	75	82	105	51	95	88
Two	179	110	115	132	61	125	121
p > F	<.0001	<.0001	0.0002	<.0001	0.0035	<.0001	0.0038
SC Cleaning Rate (R)**							
High	136[a]	87[a]	89	118	53	107[a]	99[a]
Med	157[b]	93[a,b]	108	116	56	106[a]	106[a,b]
Low	156[b]	97[b]	98	122	59	116[b]	109[b]
p > F	0.0176	0.0079	ns	ns	ns	0.0004	0.0136

*Means in this column are reported from the mixed model analysis across all tests.

**Least square means within a column followed by the same letter are not different by Tukey's HSD test ($\alpha = 0.05$)

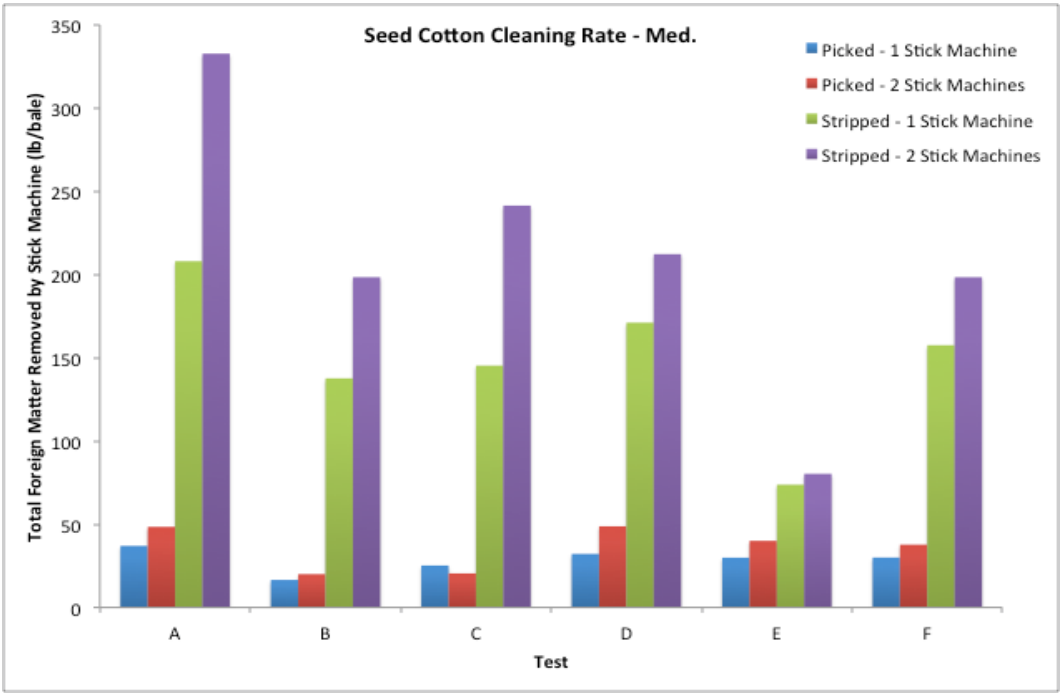

Figure 1. Total foreign matter removed by the stick machines for the medium seed cotton cleaning rate.

Stick machine seed cotton loss was not different by any of the main effects tested (table 5). The harvest method x cleaning rate interaction was significant for test A and the no. stick machines x cleaning rate interaction was significant for tests A, B, and the mixed model mean. Seed cotton loss data were not available from tests E and F. Anecdotal evidence from ginners indicates that higher processing rates tend to lead to increased levels of seed cotton loss; however, we did not observe this finding. Potential reasons for additional seed cotton loss at higher processing rates under commercial conditions include: poor moisture control during seed cotton cleaning (e.g. excessive drying), improper saw to grid bar clearances, broken/worn grid bars, and incorrect saw speeds due to worn drive components, worn/damaged channel saws, and worn/damaged doffer brushes.

Table 5. Least square means for stick machine seed cotton loss (lb/bale) by test (data for tests E and F are unavailable).

Test	A	B	C	D	Mean*
Harvest Method (HM)					
Picked	6.1	0.7	0.6	0.2	1.4
Stripped	0.7	0.5	0.3	0.5	1.0
p > F	ns	ns	ns	ns	ns
Stick Machines (SM)					
One	3.6	0.6	0.4	0.4	1.3
Two	3.1	0.6	0.5	0.3	1.2
p > F	ns	ns	ns	ns	ns
SC Cleaning Rate (R)					
High	3.4	0.5	0.5	0.4	1.3
Med	3.1	0.7	0.5	0.3	1.2
Low	3.6	0.6	0.3	0.4	1.2
p > F	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

Total foreign matter removed during the ginning process (table 6) includes all of the material removed by the seed cotton cleaning, ginning, and lint cleaning systems combined. Less total foreign material was removed from picker harvested cotton for all but test E. Harvest method significantly influenced total foreign matter content for the mixed model analysis which showed that 170 lb/bale (1 bale = 480 lb) total foreign matter was removed from picker harvested cotton whereas 473 lb/bale was removed from cotton harvested by a stripper equipped with a field cleaner. Total foreign matter removal was not different between seed cotton cleaning sequences using one or two stick machines for all but test E. The overall means for one and two stick machines from the mixed model were not different. This finding indicates that additional cleaning is taking place in machinery later in the ginning process to compensate for cleaning not performed by the second stick machine for seed cotton cleaning machine sequences using only one stick machine. Total foreign matter removed during ginning was different by seed cotton cleaning rate for only Test A where the medium rate increased total foreign matter removal compared to the low and high rates. Significant harvest method x cleaning rate and no. of stick machines x cleaning rate interactions were observed for tests A and F, respectively.

Table 6. Least square means for total foreign matter removed during ginning (lb/bale).

Test	A	B	C	D	E	F	Mean*
Harvest Method (HM)							
Picked	225	163	156	178	146	129	170
Stripped	820	439	387	478	218	519	473
p > F	<.0001	<.0001	<.0001	<.0001	ns	<.0001	0.0030
Stick Machines (SM)							
One	532	298	267	328	204	333	328
Two	513	304	275	327	160	316	315
p > F	ns	ns	ns	ns	0.0274	ns	ns
SC Cleaning Rate (R)**							
High	477[a]	298	283	330	188	322	318
Med	587[b]	309	272	333	176	313	330
Low	505[a]	296	258	321	181	337	317
p > F	0.0019	ns	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.
**Least square means within a column followed by the same letter are not different by Tukey's HSD test ($\alpha = 0.05$)

The least square means for total trash removed by the extractor feeder just prior to the gin stand (table 7) indicate differences by harvest method and number of stick machines across all tests and for the mixed model. Over all tests, about 39.6 lb/bale more trash was removed from stripped cotton by the extractor feeder compared to picked cotton. The extractor feeder removed an additional 19.3 lb/bale of foreign material from cotton processed through only one stick machine compared to two. Total foreign material removed by the extractor feeder decreased significantly with decreasing seed cotton cleaning rate for test D and the mixed model mean. This indicates that for slower seed cotton processing rates, the seed cotton cleaning machinery upstream of the extractor feeder is able to remove more foreign material thus requiring less to be removed by the extractor feeder. The harvest method x no. of stick machines interaction was significant for all tests and the mixed model mean. Similar to the stick machine foreign matter removal analysis, this interaction indicates that the difference in extractor feeder trash between seed cotton cleaning sequences using one and two stick machines is greater for stripped cotton due to the increased initial foreign matter content. The stick machine by cleaning rate interaction was significant for test D only.

Table 7. Least square means for foreign matter (lb/bale) removed by the extractor feeder by test.

Test	A	B	C	D	E	F	Mean*
Harvest Method (HM)							
Picked	15.2	7.9	8.3	11.2	7.0	2.5	10.1
Stripped	104.3	51.5	47.3	40.8	17.6	44.8	49.7
p > F	<.0001	<.0001	<.0001	<.0001	0.0005	<.0001	0.0112
Stick Machines (HM)							
One	76.1	38.4	37.7	36.2	16.9	30.9	39.5
Two	43.5	21.0	17.9	15.8	7.7	16.4	20.2
p > F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0019
SC Cleaning Rate (R)**							
High	61.0	31.1	29.3	28.9[a]	12.0	26.4	31.4[a]
Med	62.8	29.8	27.7	25.0[b]	13.5	24.3	30.7[a]
Low	55.6	28.2	26.4	24.0[b]	11.4	20.3	27.5[b]
p > F	ns	ns	ns	0.0002	ns	ns	0.0072

*Means in this column are reported from the mixed model analysis across all tests.
**Least square means within a column followed by the same letter are not different by Tukey's HSD test ($\alpha = 0.05$).

The overall cleaning efficiency of the seed cotton cleaning system is shown in table 8. Differences by harvest method were observed for test C and the mixed model mean where the seed cotton cleaning system efficiency was higher for stripped cotton (68%) compared to picked cotton (58%). The number of stick machines significantly influenced the seed cotton cleaning system efficiency for tests B and F and the mixed model mean. Seed cotton cleaning system efficiencies were higher for machine sequences using two stick machines (66%) compared to those using only one (60%). Seed cotton cleaning rate had no significant influence on the seed cotton cleaning system efficiency. One reason for this finding is that the system efficiency values reported in table 8 include the cleaning performed by the extractor feeder. Seed cotton cleaning system efficiency was calculated by [(Suction Telescope Total Trash Content – Feeder Apron Total Trash Content) / Suction Telescope Total Trash Content]. The extractor feeder is used to regulate the flow of material into the gin stand and was operated at a constant material flow rate during all 216 gin runs conducted during this project. Thus the extractor feeder was able to remove more trash from cotton with higher trash content (at the inlet to the extractor feeder) resulting from higher processing rates effectively equalizing the trash content of the seed cotton measured at the feeder apron. No significant interactions were observed for the seed cotton cleaning system efficiency data.

Table 8. Least square means of cleaning efficiency (%) for the seed cotton cleaning system by test.

Test	A	B	C	D	E	F	Mean*
Harvest Method (HM)							
Picked	37.7	43.4	51.2	69.3	66.0	70.0	57.9
Stripped	56.3	61.6	65.8	73.5	75.0	78.3	68.3
p > F	ns	ns	0.0209	ns	ns	ns	0.0136
Stick Machines (SM)							
One	42.6	48.4	52.4	69.7	68.6	71.9	60.0
Two	51.5	56.7	64.7	73.1	72.5	76.4	66.1
p > F	ns	0.0230	ns	ns	ns	0.0295	<.0001
SC Cleaning Rate (R)							
High	46.8	52.0	57.5	72.0	68.8	74.5	62.9
Med	48.3	55.0	57.2	70.8	70.0	74.1	62.6
Low	45.9	50.6	60.9	71.3	72.8	73.9	63.7
p > F	ns	ns	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

Lint turnout measured after one lint cleaner was different by harvest method for all tests and the mixed model (table 9). Picker harvested cotton had an overall turnout of 34.1% compared to 28.1% for the stripped cotton. Two stick machines in the seed cotton cleaning system for test E produced a significantly higher turnout (35%) after one lint cleaner than the sequence using one stick machine (33.9%). None of the other tests indicated significant differences by the number of stick machines used. Seed cotton cleaning rate was significant for test A only where the turnout for the high and medium cleaning rates were different (high = 26.9%, medium = 25.6%). The no. stick machines x cleaning rate interaction was significant for tests B and F only.

Table 9. Least square means of lint turnout (%) after 1 lint cleaner.

Test	A	B	C	D	E	F	Mean*
Harvest Method (HM)							
Picked	30.4	34.2	35.5	33.6	35.5	35.7	34.1
Stripped	22.0	28.2	30.1	27.2	33.4	27.6	28.1
p > F	<.0001	<.0001	<.0001	<.0001	0.0244	<.0001	0.0002
Stick Machines (SM)							
One	26.2	31.2	32.7	30.2	33.9	31.4	30.9
Two	26.2	31.2	32.9	30.6	35.0	31.9	31.3
p > F	ns	ns	ns	ns	0.0121	ns	ns
SC Cleaning Rate (R)							
High	26.9[a]	31.4	32.7	30.2	34.4	31.7	31.2
Med	25.6[b]	31.1	32.8	30.6	34.6	31.8	31.1
Low	26.2[a,b]	31.1	33.0	30.5	34.5	31.4	31.1
p > F	0.0255	ns	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.
**Least square means within a column followed by the same letter are not different by Tukey's HSD test ($\alpha = 0.05$).

The difference in lint turnout between one and two lint cleaners was significant by harvest method for test B and F only (table 10). Over all tests, turnout for picker harvested cotton was reduced by 0.55% by the second lint cleaner and by 0.58% for stripped cotton but the difference by harvest method was not significant. No significant differences were observed in the lint turnout difference data by the number of stick machines used in the seed cotton cleaning machinery sequence of seed cotton cleaning rate. A significant stick machine x cleaning rate interaction was observed for test F.

Table 10. Least square means of lint turnout differences between one and two lint cleaners [Diff. % = LC1 Turnout % – LC2 Turnout %].

Test	A	B	C	D	E	F	Mean*
Harvest Method (HM)							
Picked	0.83	0.48	0.46	0.37	0.64	0.57	0.55
Stripped	0.75	0.58	0.50	0.35	0.61	0.62	0.58
p > F	ns	0.0038	ns	ns	ns	0.04	ns
Stick Machines (SM)							
One	0.84	0.54	0.49	0.35	0.63	0.60	0.58
Two	0.74	0.52	0.47	0.37	0.62	0.59	0.55
p > F	ns	ns	ns	ns	ns	ns	ns
SC Cleaning Rate (R)							
High	0.83	0.55	0.47	0.36	0.61	0.60	0.57
Med	0.77	0.54	0.47	0.38	0.64	0.58	0.56
Low	0.78	0.51	0.49	0.35	0.62	0.61	0.56
p > F	ns	ns	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

Visible foreign matter content (measured by the Shirley Analyzer method) in the waste from lint cleaners one and two is shown in tables 11 and 12, respectively (data for tests E and F are not available). After one lint cleaner, visible foreign matter was different for all tests by harvest method and by the number of stick machines used in the seed cotton cleaning sequence but not by seed cotton cleaning rate. The visible foreign matter content after one lint cleaner for stripper harvested cotton was approximately twice that of picker harvested cotton over all tests. The

overall means reported from the mixed model analysis were not different by any of the main effects tested for lint cleaner #1 waste visible foreign matter. Significant harvest method x stick machine and stick machine x cleaning rate interactions were observed for test D lint cleaner #1 waste visible foreign matter.

Table 11. Least square means of visible foreign matter (lb/bale) in the waste material from lint cleaner #1.

Test	A	B	C	D	Mean*
Harvest Method (HM)					
Picked	27.37	11.73	10.89	8.72	14.94
Stripped	64.65	29.37	20.46	17.55	32.74
p > F	0.0110	<.0001	<.0001	<.0001	ns
Stick Machines (SM)					
One	49.79	21.85	17.01	14.53	25.86
Two	42.23	19.25	14.34	11.73	21.82
p > F	0.0104	0.0133	0.0314	0.0013	ns
SC Cleaning Rate (R)					
High	47.25	20.83	15.27	14.22	24.48
Med	48.65	21.19	16.14	12.86	24.58
Low	42.14	19.62	15.62	12.31	22.47
p > F	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

Visible foreign matter content in the lint cleaner waste was substantially lower for the #2 lint cleaner compared to the #1 lint cleaner. For the #2 lint cleaner waste, significant differences in the visible foreign matter content were observed by harvest method for tests B, C, and D. The number of stick machines influenced the visible foreign matter in the #2 lint cleaner waste for test C only (one stick machine = 3.03 lb/bale, two stick machines = 2.65 lb/bale). The amount of visible foreign matter in the #2 lint cleaner waste decreased significantly from the high cleaning rate (3.94 lb/bale) to the low rate (3.23 lb/bale) for test B. The least square means from the mixed model analysis were not different by any of the main effects tested (table 12). The harvest method x seed cotton cleaning rate was significant for test B only.

Table 12. Least square means of visible foreign matter (lb/bale) in the waste material from lint cleaner #2.

Test	A	B	C	D	Mean*
Harvest Method (HM)					
Picked	6.82	2.33	2.13	1.87	3.05
Stripped	11.24	4.92	3.55	2.54	5.80
p > F	ns	<.0001	<.0001	0.0009	ns
Stick Machines (SM)					
One	9.69	3.79	3.03	2.20	4.67
Two	8.37	3.46	2.65	2.21	4.18
p > F	ns	ns	0.0156	ns	ns
SC Cleaning Rate (R)**					
High	9.43	3.94[a]	2.85	2.22	4.64
Med	8.93	3.71[a]	2.86	2.27	4.39
Low	8.75	3.23[b]	2.80	2.12	4.24
p > F	ns	0.0085	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

**Least square means within a column followed by the same letter are not different by Tukey's HSD test ($\alpha = 0.05$).

The clean lint content (measured by the Shirley Analyzer method) in the waste from the #1 and #2 lint cleaners is shown in tables 13 and 14, respectively (data for tests E and F are not available). No differences by any of the main effects tested were observed for the clean lint content in the #1 lint cleaner waste. Overall, the #1 lint cleaner removed an average of 9.37 lb/bale of clean lint whereas the #2 lint cleaner removed an average of 4.47 lb/bale of clean lint. Differences were observed in the clean lint content in the #2 lint cleaner waste by harvest method and seed cotton cleaning rate for Test C. The mixed model indicated a difference in the least square means for clean lint content in the #2 lint cleaner waste by harvest method only (picked = 4.31 lb/bale, stripped = 4.62 lb./bale). Interactions were not significant for the amount of clean lint removed by either lint cleaner.

Table 13. Least square means of clean lint content (lb/bale) in the waste material from lint cleaner #1.

Test	A	B	C	D	Mean*
Harvest Method (HM)					
Picked	12.60	8.86	9.26	8.32	9.22
Stripped	8.65	8.72	9.23	9.34	9.52
p > F	ns	ns	ns	ns	ns
Stick Machines (SM)					
One	10.70	8.89	9.36	8.86	9.42
Two	10.55	8.69	9.12	8.80	9.32
p > F	ns	ns	ns	ns	ns
SC Cleaning Rate (R)					
High	10.83	8.71	9.03	9.41	9.57
Med	10.42	8.62	9.36	8.58	9.23
Low	10.62	9.04	9.34	8.50	9.32
p > F	ns	ns	ns	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

Table 14. Least square means of clean lint content (lb/bale) in the waste material from lint cleaner #2.

Test	A	B	C	D	Mean*
Harvest Method (HM)					
Picked	6.56	4.26	4.01	3.26	4.31
Stripped	5.24	4.58	4.26	3.54	4.62
p > F	ns	ns	0.0478	ns	0.0094
Stick Machines (SM)					
One	6.15	4.36	4.13	3.25	4.46
Two	5.64	4.48	4.13	3.55	4.47
p > F	ns	ns	ns	ns	ns
SC Cleaning Rate (R)					
High	5.81	4.32	$4.11^{a,b}$	3.35	4.41
Med	5.83	4.51	3.98^{a}	3.51	4.43
Low	6.07	4.44	4.31^{b}	3.34	4.55
p > F	ns	ns	0.0299	ns	ns

*Means in this column are reported from the mixed model analysis across all tests.

HVI fiber analysis on lint samples collected after one and two lint cleaners (tables 15 and 16, respectively) indicated a substantial range in micronaire across tests (data for tests E and F are not available). Micronaire ranged from 2.3 (test A – stripped) to 3.6 (test C – picked). This range in micronaire is due primarily to the difference in cultivar as the average micronaire for DPL 143 B2F and FM 9180 B2F were 2.4 and 3.2, respectively for tests A and B conducted the same year in the same field. Micronaire differences by harvest method were observed for all tests for

samples taken from both lint cleaners. Picker harvested cotton exhibited a higher micronaire than stripper harvested cotton in each case. This is due to the difference in maturity by harvest method affected through the selective harvesting action of the picker. Stripper harvesters indiscriminately collect seed cotton and foreign material from the plants whereas picker harvesters only remove seed cotton from mature, well opened bolls. This same phenomenon is observed in the immature fiber content (IFC) and maturity ratio (MR) data presented in tables 17 and 18. For samples collected after one lint cleaner, harvest method is the primary driver of differences among IFC and MR. Samples collected after two lint cleaners indicate differences in IFC and MR data by harvest method and seed cotton cleaning rate.

Length was not different by any of the main effects tested for the #1 lint cleaner samples (although there was a significant stick machine x cleaning rate interaction for test D). After 2 lint cleaners, length was different by the number of stick machines for test A and by seed cotton cleaning rate for tests B and D and the mixed model analysis. Uniformity index after one lint cleaner was different by harvest method for tests C and D and the mixed model and also by cleaning rate in the mixed model. After two lint cleaners, uniformity was different by rate for tests B and D and the mixed model and by harvest method in the mixed model. Strength was different by harvest method for tests B and C and by cleaning rate for test C and the mixed model after one lint cleaner. After two lint cleaners, strength was different by harvest method for test B only and by seed cotton cleaning rate for tests A and B.

Increasing the number of stick machines improved the reflectance significantly after one lint cleaner for tests A, B, and C. Reflectance for picked cotton was higher than stripped cotton after one lint cleaner for tests B and C. After two lint cleaners, two stick machines improved reflectance for test A. Picking significantly improved reflectance after two lint cleaners for test B only. Yellowness after one lint cleaner was improved by two stick machines for test A and for picked cotton for tests B, C, D and the mixed model. Picking also improved yellowness after two lint cleaners for tests B, C, and D and the mixed model analysis. Leaf grade after one and two lint cleaners was primarily influenced by harvest method where picked cotton had lower leaf grades than stripped.

Table 15. Least square means of HVI fiber analysis results from lint samples collected after one lint cleaner.

	Test A		Test B		Test C		Test D		Mean*	
Fiber Property	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip
Micronaire	2.5	2.3	3.3	3.1	3.6	3.5	3.5	3.0	3.1	3.1
Length	1.17	1.15	1.18	1.17	1.17	1.16	1.14	1.14	1.17	1.15
Uniformity	78.5	77.3	82.1	81.6	82.1	81.5	82.2	81.5	80.6	81.1
Strength	25.5	25.2	28.9	29.5	30.1	30.4	30.2	30.1	28.0	29.4
Reflectance	79.4	75.4	82.5	80.1	82.7	82.1	84.3	84.2	81.2	81.5
Yellowness	7.7	8.3	7.1	7.4	6.9	7.3	7.3	7.7	7.4	7.6
Leaf	3.3	6.9	2.2	3.4	2.0	2.5	1.3	1.1	2.9	2.8
Significant Main Effects and Interactions										
Micronaire	HM		HM, SM		HM		HM		-	
Length	-		-		-		SM X R		-	
Uniformity	-		-		HM		HM		HM, R	
Strength	-		HM		HM, R, HM X R		-		R	
Reflectance	SM		HM, SM		HM, SM		SM X R		-	
Yellowness	SM		HM		HM		HM		HM	
Leaf	HM		HM		-		SM, HM X R		SM	

*Means in this column are reported from the mixed model analysis across all tests.

Table 16. Least square means of HVI fiber analysis results from lint samples collected after two lint cleaners.

	Test A		Test B		Test C		Test D		Mean*	
Fiber Property	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip
Micronaire	2.5	2.3	3.4	3.1	3.6	3.5	3.4	3.0	3.1	3.1
Length	1.14	1.16	1.15	1.15	1.16	1.15	1.13	1.13	1.15	1.14
Uniformity	77.3	77.7	81.0	81.1	81.9	81.7	81.6	81.1	80.1	80.7
Strength	25.2	25.6	28.1	28.8	30.2	30.3	30.0	29.8	27.9	29.1
Reflectance	80.1	78.5	83.4	82.2	83.2	82.7	84.8	85.0	82.2	82.8
Yellowness	7.9	8.6	7.0	7.4	7.1	7.3	7.4	7.7	7.5	7.6
Leaf	2.4	4.9	1.0	2.4	1.6	2.0	1.1	1.1	2.0	2.1
Significant Main Effects and Interactions										
Micronaire	HM		HM		HM		HM		HM	
Length	SM		R, HM X SM		-		R		R, HM X SM	
Uniformity	-		R, HM X SM, HM X R		-		HM, R		R, HM X SM	
Strength	R, HM X SM		HM, R, SM X R		-		-		-	
Reflectance	SM		HM		-		SM X R		-	
Yellowness	-		HM		HM		HM, SM, SM X R		HM	
Leaf	-		HM		HM X SM		-		-	

*Means in this column are reported from the mixed model analysis across all tests.

Differences in AFIS nep content after one and two lint cleaners were primarily influenced by harvest method (tables 17 and 18). A considerable increase in overall nep content was observed between tests A (985 average neps/g) and B (522 average neps/g) and is likely a consequence of the difference in maturity and immature fiber content between cultivars. Differences in mean length by number (LxN) after one lint cleaner were observed by harvest method for tests A, C, and D and the mixed model and favored picking. After two lint cleaners, differences in LxN by harvest method were observed for tests B and C and again favored picking. Differences in LxN after one lint cleaner were also observed by number of stick machines and cleaning rate for tests A and C, respectively. For samples collected after either lint cleaner, tests indicating significant differences in LxN by the number of stick machines favored sequences using two stick machines. Total trash content (Total) and visible foreign material (VFM, measured by AFIS) in the lint samples collected after one lint cleaner indicated differences by harvest method for all tests and favored picking. After two lint cleaners, picking significantly reduced Total and VFM for tests B and C and the use of two stick machines significantly reduced Total and VFM for Test A.

Table 17. Least square means of selected AFIS fiber analysis results from lint samples collected after one lint cleaner.

	Test A		Test B		Test C		Test D		Mean*	
Fiber Property	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip
Nep Content	938	1032	448	595	370	459	387	553	574	621
LxN	0.72	0.64	0.73	0.73	0.76	0.74	0.74	0.71	0.73	0.72
SFC x N	34.6	40.5	31.6	32.8	29.2	30.8	30.5	33.8	32.4	33.5
Total	1760	3644	571	1211	552	718	398	650	1182	1194
VFM	4.4	7.6	1.5	3.1	1.5	2.0	1.0	1.6	2.8	2.9
IFC	10.6	12.8	9.7	11.0	8.7	9.3	9.5	11.3	9.8	10.8
MR	0.78	0.76	0.80	0.79	0.83	0.82	0.82	0.79	0.80	0.79
Significant Main Effects and Interactions*										
Nep Content	-		HM, SM, SM X R		HM		HM		HM	
LxN	HM, SM, SM X R		-		HM, R		HM		HM	
SFC x N	HM, SM, SM X R		HM		HM, R		HM		HM	
Total	HM, SM		HM		HM, SM		HM, HM X SM		-	
VFM	SM		HM		HM, SM		HM		-	
IFC	HM		HM		HM, R		HM		HM	
MR	-		HM		-		HM		HM	

*Means in this column are reported from the mixed model analysis across all tests.

Table 18. Least square means of selected AFIS fiber analysis results from lint samples collected after two lint cleaners.

	Test A		Test B		Test C		Test D		Mean*	
Fiber Property	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip	Pick	Strip
Nep Content	1011	1498	579	760	477	558	595	664	765	771
LxN	0.64	0.67	0.73	0.70	0.76	0.73	0.72	0.72	0.71	0.71
SFC x N	40.4	38.3	31.5	34.8	28.7	31.5	31.8	32.6	33.5	33.8
Total	1187	1862	357	699	340	443	289	329	691	685
VFM	3.1	4.5	1.1	1.9	1.0	1.3	0.9	1.0	1.9	1.9
IFC	13.3	12.3	9.6	11.6	8.9	9.9	10.6	10.7	10.6	11.1
MR	0.76	0.76	0.80	0.78	0.82	0.81	0.80	0.80	0.79	0.79
Significant Main Effects and Interactions*										
Nep Content	-		HM		HM		-		-	
LxN	SM		HM		HM		R		R	
SFC x N	SM		HM		HM		R		-	
Total	SM		HM		HM		HM X R		-	
VFM	SM		HM		HM		-		-	
IFC	SM		HM, HM X R		HM, R		-		R	
MR	SM		HM		HM, HM X R		-		HM, R	

*Means in this column are reported from the mixed model analysis across all tests.

Conclusions

An experiment designed to evaluate the influence of harvest method (picker or stripper with field cleaner), number of stick machines used in the seed cotton cleaning system (one or two), and the material flow rate of seed cotton through the seed cotton cleaning system on seed cotton foreign matter content, lint turnout, and fiber quality was conducted six times over the two year period 2009 to 2010. As expected, picker harvested cotton had less foreign matter in seed cotton samples collected after harvest (prior to ginning) than cotton harvested by a stripper equipped with a field cleaner. The stick machines used in the seed cotton cleaning system removed more foreign matter from picked cotton than from stripped cotton and also removed more foreign material from seed cotton fed through the system at lower mass flow rates. Seed cotton cleaning sequences utilizing two stick machines removed more foreign material from both picker and stripper harvested cottons than sequences using only one. However, the difference in total foreign matter removal between one and two stick machines was greater for stripped cotton than for picked. No differences in total stick machine seed cotton loss were observed by harvest method, number of stick machines, or seed cotton cleaning rate. Total seed cotton cleaning system efficiencies were higher for stripper harvested cotton and seed cotton cleaning systems using two stick machines but no difference was observed by seed cotton cleaning rate. Total foreign matter removed during ginning was higher for stripped cotton (due to the difference in initial foreign matter content by harvest method) but no difference was observed by the number of stick machines or seed cotton cleaning rate. Consequently, lint turnout after one lint cleaner was higher for picked cotton (34%) compared to stripped (38%), with no turnout differences observed by the other main factors tested. For this project, machinery down-stream of the seed cotton cleaning system (extractor feeder, gin stand, and lint cleaners) were able to compensate for reduced cleaning resulting from the use of only one stick machine and/or higher seed cotton cleaning rates. Analysis of the extractor feeder trash indicated that the extractor feeder alone was able to compensate for differences in total foreign matter removed during ginning affected through higher seed cotton cleaning rates. HVI and AFIS fiber quality parameters were primarily influenced by harvest method and favored picking. The use of two stick machines improved reflectance and yellowness parameters and reduced the amount of foreign matter contained in lint after one and two lint cleaners. For some tests, the use of two stick machines improved HVI and AFIS length parameters. Seed cotton cleaning rate had a minimal effect on fiber quality.

The cleaning efficiency, seed cotton loss, and fiber quality results for this project were observed for ginning tests conducted on well adjusted and maintained equipment processing cotton with moisture content in the range of 6 – 9%. These findings could be different given commercial ginning conditions utilizing worn or poorly adjusted equipment processing excessively dry cotton. Thus, the findings of this work support current recommendations for using two stick machines in seed cotton cleaning systems processing stripper harvested cotton and one stick machine for seed cotton cleaning systems processing picker harvested cotton.

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