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ENGINEERING AND GINNING

Influence of Grid Bar Shape on Field Cleaner Performance – Field Testing

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ABSTRACT

A field study was conducted to evaluate the influence of grid bar cross sectional shape on cotton stripper field cleaner performance in terms of cleaning efficiency, seed cotton loss, and fiber and yarn quality. Three field cleaner configurations were tested on the same cotton stripper and included a production model John Deere 7460 field cleaner with 1) round cross section grid bars installed around both saws (FC1), 2) round grid bars installed around the top saw and experimental grid bars with a flat approach and angled relief installed around the bottom saw (FC2), and 3) experimental grid bars with a flat approach and 38.1 mm straight relief installed around both saws (FC3). Two additional harvest treatments were tested which included the same cotton stripper with the field cleaner bypassed (NFC) and a spindle picker harvester (picked). Four cotton cultivars were used in the study to investigate differences in field cleaner performance across varying crop conditions. Results indicate that FC1 and FC2 had equal cleaning efficiencies but seed cotton loss was higher for FC2. FC3 had the poorest cleaning efficiency but the lowest seed cotton loss of the field cleaner configurations tested. Differences in fiber and yarn properties were primarily observed between picker and stripper harvest methods. Minimal differences were observed between cotton stripper harvest treatments with or without the field cleaner for fiber and yarn quality parameters.

Field cleaners used on cotton strippers are extractor-type cleaners which remove foreign matter from harvested seed cotton before in-field storage and ginning. Foreign matter is removed by centrifugal force as seed cotton is pulled across a series of grid bars by a rotating saw cylinder. Burs, sticks, and other heavy foreign matter are removed from seed cotton with greater efficiency than leaf or fine trash in extractor cleaners as a result of the inertia-based cleaning method. Many factors influence the performance of extractors including machine design, cotton moisture level, processing rate, adjustments, speed and condition of the machine, the amount and nature of trash in the cotton, distribution of seed cotton across the machine, and the cotton cultivar (Baker et al., 1994). Field cleaners have been shown to improve lint turnout, leaf and color grades of ginned lint, and can help reduce the influence of immature fibers and neps on spun yarn for stripper harvested cotton (Baker and Brashears, 2000; Bennett et al., 1995; Brashears, 1991; Kulkarni et al., 2005). Field cleaners further improve the profitability of stripper-harvested cotton by reducing per bale ginning charges. For example, if ginning charges are \$0.0661/kg (\$3/cwt) of incoming seed cotton weight (module weight) and lint turnout for field cleaned and non-field cleaned stripper-harvested cotton are 30% and 25%, respectively, the producer will realize a savings in total ginning charges of about \$10 per bale (1 lint bale = 218 kg).

Research on the development of extractor cleaners has focused on identifying machine design and operating parameters that increase cleaning efficiency and reduce seed cotton loss. Kirk et al. (1970) tested the influence of saw speed, grid bar spacing (the distance between grid bars installed around the saw cylinder), saw to grid bar clearance, grid bar diameter, and feeding rate on the cleaning efficiency and seed cotton loss of an extractor cleaner. They found that grid bar spacing and grid bar diameter were the most important factors in predicting cleaning efficiency and seed cotton loss. Barker et al. (1969), Kirk et al. (1970), and Smith and Dumas (1982) showed that faster cleaning saw speeds improved foreign matter removal.

Wilkes et al. (1982) showed that replacing factory installed angle-iron grid bars with round grid bars improved foreign matter removal for field

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cleaners used on Allis Chalmers (Milwaukee, WI) cotton strippers. They found that acceptable levels of seed cotton loss could be achieved by spacing the round grid bars wider apart at the top of the reclaiming saw and narrower toward the bottom of the saw. Brashears (1986) showed that seed cotton loss could be reduced while maintaining foreign matter removal, by reversing the spacing recommendations made by Wilkes et al. (1982).

Recent research on lint cleaner grid bar cross sectional shape conducted by Armijo et al. (2011) demonstrated the ability of newly designed grid bars to remove seed coat fragments from ginned lint. Whitelock and Anthony (2003) and Ray (2006), evaluated the cleaning performance and seed cotton loss for cylinder cleaners using grid bars with round and square cross sections. However, the work by Whitelock and Anthony (2003), Ray (2006), and Armijo et al. (2011) did not investigate the influence of grid bar shape on the performance of extractor cleaners.

Wanjura et al. (2011) investigated the influence of grid bar cross section shape on foreign matter removal, seed cotton loss, and fiber quality during a laboratory screening test on a field cleaner from a John Deere model 7445 cotton stripper (Moline, IL). They found that several of the field cleaner configurations using experimental grid bar cross section shapes improved cleaning efficiency and reduced seed cotton loss compared to a conventional configuration that used round cross section grid bars. On the other hand, they observed that fiber quality was not affected by field cleaner configurations utilizing grid bars with experimental cross sectional geometry and concluded further investigation of the experimental grid bars under field conditions was warranted.

This investigation is a continuation of the work by Wanjura et al. (2011) and was conducted to investigate the influence of experimental grid bar cross section geometry on cotton stripper field cleaner performance operating under field conditions. The study was designed to quantify differences by harvesting treatment in terms of cleaning efficiency, seed cotton loss, and fiber and yarn quality.

MATERIALS AND METHODS

Harvesting. Three harvest treatments with different field cleaner configurations were tested on a John Deere model 7460 cotton stripper (Moline, IL). The field cleaner was 152 cm (60 in) wide and utilized 33.7 cm (13.25 in) diameter primary cleaning (top) and reclaiming (bottom) saws. The first configuration (FC1) was the original factory configuration consisting of round cross section grid bars installed around both saws (Figure 1). The second field cleaner configuration (FC2) consisted of conventional round cross section grid bars installed around the top saw and experimental grid bars with a flat approach and angled relief installed around the bottom saw (Figure 2). The screening test conducted by Wanjura et al. (2011), resulted in FC2 having the highest cleaning efficiency of the 28 machine configurations tested. It is hypothesized that grid bars with a flat approach are able to remove foreign matter from seed cotton more easily than the conventional round cross section grid bars because there is no portion of the grid bar that extends above the cleaning point, impeding the travel path of foreign matter separated from the seed cotton (the cleaning point is defined here as the point on the grid bar in closest radial distance to the saw cylinder surface). The angled relief increases the open space between successive grid bars allowing for increased foreign matter removal. The third field cleaner configuration (FC3) in the Wanjura et al. (2011) study consisted of grid bars with a flat approach and 38.1 mm (1.5 in) relief installed around both saws (Figure 3). The 38.1 mm straight relief reduces seed cotton loss by closing the open space between grid bars and holding cotton close to the saw over the length of the grid bar relief section. In the screening test conducted by Wanjura et al. (2011), FC3 exhibited the best balance between maximum cleaning efficiency and minimum seed cotton loss. The cleaning efficiency and seed cotton loss of the three field cleaner configurations measured during the laboratory screening test (Wanjura et al., 2011) are presented in Table 1.

The experimental grid bars used in FC2 and FC3 were constructed from 1.9 mm (14 ga) sheet metal formed on a press break to produce the desired grid bar cross sectional shape (4.76 mm bend radius). For each of the experimental grid bars used in FC2 and FC3, the flat approach section lies along a radial line of the saw. The angle between the approach and relief for the experimental grid bars used with FC2 and FC3 was 45 and 90 degrees, respectively (Figures 2 and 3). The same grid bar to grid bar spacing (distance between cleaning points) and saw to grid bar clearance values for FC1 were used for FC2 and FC3 and are shown in Table 2.

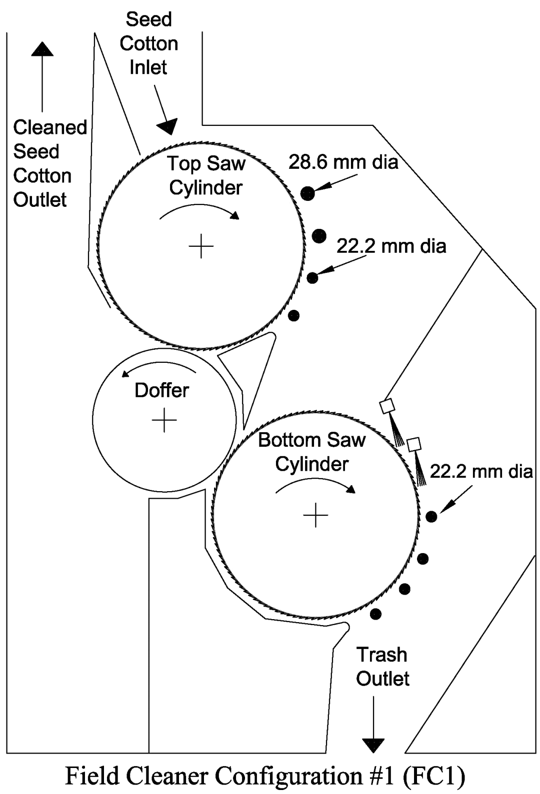

Figure 1. Schematic diagram of field cleaner configuration 1, factory configuration (FC1).

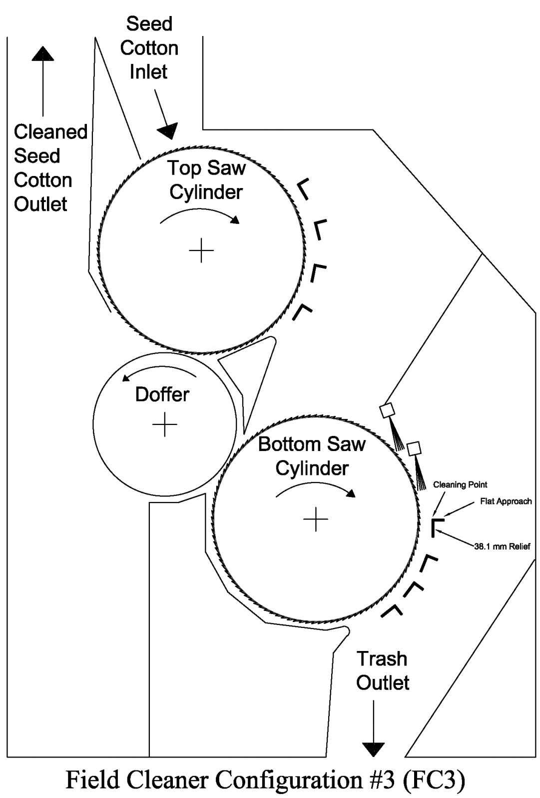

Figure 2. Schematic diagram of field cleaner configuration 2 (FC2).

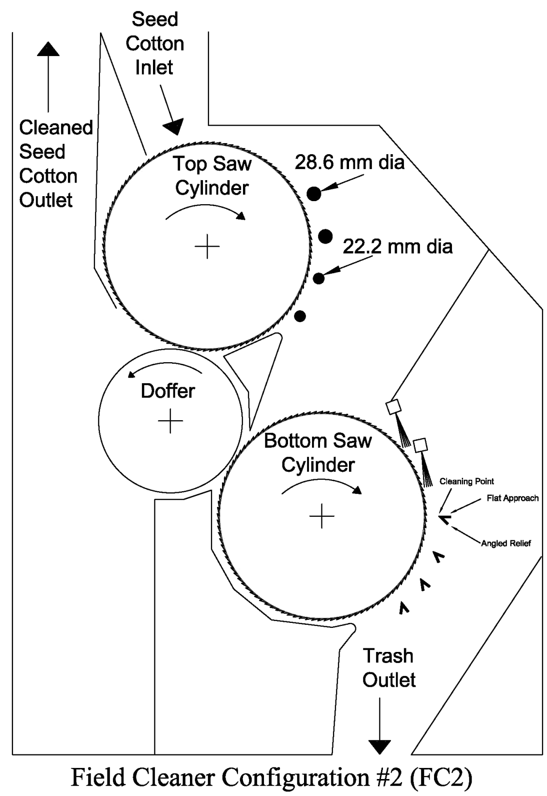

Figure 3. Schematic diagram of field cleaner configuration 3 (FC3).

Table 1. Cleaning efficiency and seed cotton loss for FC1, FC2, and FC3 measured in a laboratory screening test conducted by Wanjura et al. (2011).

Field Cleaner Configuration	Cleaning Efficiency (%)	Seed Cotton Loss (%)
FC1 (Factory Configuration)	30.9	0.36
FC2	44.3	0.76
FC3	37.7	0.05

The same John Deere 7460 cotton stripper used for FC1, FC2, and FC3 with the field cleaner bypassed (NFC) and a John Deere model 9996 cotton picker (Moline, IL) were included in the study to provide reference ginning and fiber quality data for machine harvested cotton that was not processed through a field cleaner.

The four cotton cultivars used in this test were planted 23 May 2008 on a center-pivot irrigated field near Lubbock, TX. The cultivars included DPL 143B2F (Monsanto, St. Louis, MO), AFD 5065B2F, FM 9063B2F and FM 9180B2F (Bayer CropScience, Research Triangle Park, NC). The cultivars spanned a range in crop maturity: FM 9180B2F and AFD 5065B2F early maturing, FM 9063B2F early/mid season maturity, and DPL 143B2F – mid season maturity. Based on seed company data and visual observations at harvest, the cultivars ranked in order of increasing storm-resistance were: DPL 143B2F (loosest boll type), FM 9063B2F, FM 9180B2F, and AFD 5065B2F (tightest boll type). Differences in yield and fiber quality were anticipated given the range in crop maturity and boll conformation by cultivar. Differences by cultivar were considered advantageous for evaluating harvesting treatments over varying crop conditions.

The field study was a randomized complete block design with 3 replications (blocks) of each cultivar with five cleaner configurations for a total of 60 runs. Four-row wide plots (102 cm row spacing) with an average area of 0.31 ha were harvested during each run at about 6.4 km/h (4 mi/h). Total seed cotton weight was measured for each run with a cotton weigh wagon equipped with load cells. Seed cotton yield was calculated using the total seed cotton weight and row length measured for each plot. Lint and seed yield were determined from seed cotton yield for each plot using lint and seed turnout values determined after ginning. Wet basis (w.b.) seed cotton moisture content (two samples per run) was measured at harvest using the procedure described by Shepherd (1972). Seed cotton fractionation samples for determining foreign matter content were collected before the harvested cotton entered the field cleaner for FC1, FC2, and FC3 runs (five per run) and again from the harvester basket (five per run) for all harvest treatments. The foreign matter removed by the field cleaner over a 30.5 m length of each plot was collected and weighed for FC1, FC2, and FC3. Total foreign matter removed by the field cleaner was calculated on an area basis and samples of the foreign material were collected, five per run, for fractionation analysis. Fractionation analysis was conducted on seed cotton and field cleaner foreign matter samples according to the method described by Shepherd (1972). Seed cotton loss due to field cleaning was calculated for FC1, FC2, and FC3 from fractionation results on samples collected from the foreign matter removed by the field cleaner. Total and component foreign matter cleaning efficiencies were calculated using fractionation results from seed cotton samples collected from the harvester basket and samples of the foreign matter removed by the field cleaner.

Ginning. A 100 kg seed cotton sample was collected after the seed cotton weight was measured for each plot. These samples were ginned at the USDA ARS Cotton Production and Processing Research Unit, Lubbock, TX, on commercial scale ginning equipment. The machinery sequence used to process each sample included: suction telescope, green boll separator, feed control, dryer #1 (no heat), #1 inclined cylinder cleaner, combination bur/stick machine, dryer #2 (no heat), #2 inclined cylinder cleaner, 3 saw stick machine, auger distributor, extractor feeder, 93 saw gin stand, lint cleaner #1, lint cleaner #2, battery condenser, and bale press. All seed cotton cleaning equipment prior to the auger distributor was 1.83 m wide. Seed cotton samples were collected at the extractor feeder apron for fractionation and seed cotton moisture content (w.b.) analyses (Shepherd, 1972). Seed weights and lint weights were measured after ginning and used to determine turnout values.

Table 2. Grid bar spacing and clearance values for all field cleaner configurations (FC1, FC2, and FC3).

	Grid Bar No.	Grid Bar Spacing (Distance to Next Grid Bar) [mm][z]	Saw To Grid Bar Clearance (mm)[z]	Grid Bar Diameter (mm)
Top Saw (630 rpm)	1	89	15.9	28.6
	2	89	15.9	28.6
	3	89	12.7	22.2
	4	89[y]	12.7	22.2
Bottom Saw (550 rpm)	1	76	12.7	22.2
	2	64	12.7	22.2
	3	64	12.7	22.2
	4	57[y]	12.7	22.2

[z] The same grid bar spacing distances and saw to grid bar clearances used for FC1 were used for FC2 and FC3. Grid bar spacing is the center to center distance for round grid bars or distance between cleaning points for experimental grid bars.

[y] Distance from last grid bar to cut-off plate.

Fiber and Yarn Testing. Lint samples from each run were collected after two stages of lint cleaning for high volume instrument (HVI) and advanced fiber information system (AFIS) fiber quality analyses at the USDA AMS Cotton Classing Office (Lubbock, TX) and Cotton Incorporated (Cary, NC), respectively. A substantial range in fiber length, length uniformity, strength, micronaire, and maturity was observed between cultivars and was spanned by DPL 143B2F and FM 9180B2F. Thus, lint from these two varieties was selected for spinning evaluations at the USDA ARS Cotton Quality Research Station in Clemson, SC. Lint lots of approximately 27 kg were used for spinning and treatment replications were maintained from the field through spinning.

Opening and cleaning of the lint was conducted with the following machine sequence: blending hopper (Fiber Controls, M&M Electric Service, Gastonia, NC), Axi-Flo opener/cleaner, GBRA blending hopper, RN cleaner, RST cleaner, and a DUSTEX fine dust cleaner (Trützschler, Mönchengladbach, Germany). All cotton was processed through a DK 803 card (Trützschler, Mönchengladbach, Germany) at 45.4 kg/h to produce 4.26 g/m sliver. Breaker drawing was performed on an RSB 951 drawing frame (Rieter, Winterthur, Switzerland) and produced 3.76 g/m sliver. Finish drawing was performed on an RSB 51 drawing frame (Rieter, Winterthur, Switzerland) and produced 3.90 g/m sliver. A Zinser 660 roving frame was used to produce 0.39 g/m roving prior to spinning on a Zinser 321 ring spinning frame (Oerlikon Schlafhorst, Übach-Palenberg, Germany). All cottons were spun into 14.76 tex yarn with a twist multiplier of 4.1.

Opening and cleaning waste was weighed and recorded for each run. Yarn samples were evaluated for count, strength, and elongation with a Statimat M (Textechno, Mönchengladbach, Germany). Yarn evenness was evaluated with an Uster Tester 5 and an Uster Classimat II (Uster Technologies, Knoxville, TN) was used to evaluate yarn faults.

Statistical Analysis. Analysis of response variables measured during harvest, ginning, and fiber and yarn testing were conducted by harvest treatment, cultivar, and the harvest treatment by cultivar interaction using the general linear model in SAS (SAS v. 9.2, SAS Institute, Cary, NC). Significant effects were identified using a 0.05 level of significance. Mean separation tests were conducted using Tukey's Honestly Significant Difference (HSD) test with a 0.05 level of significance. The size and nature of the harvesting equipment used in this study required the use of large field plots. Non-uniformity of crop yield and plant size across each plot may have contributed to the variance associated with measurements of cleaning efficiency, seed cotton loss, and fiber quality.

RESULTS

Seed cotton yield was different by harvest treatment and cultivar (Table 3). Seed cotton yield was highest for the stripper harvest with no field cleaner (NFC) treatment and lowest for the picked treatment with the three stripper harvest treatments using the field cleaner (FC1, FC2, and FC3) being intermediate. Since lint and seed yields were not different by harvest method, the differences observed by harvest treatment in seed cotton yield were due to differences in foreign matter content. Seed cotton yields for FC1, FC2, and FC3 were not different and were lower than the NFC seed cotton yield indicating that the field cleaner removed a significant portion of the foreign material harvested with the seed cotton.

The trend in lint yield by cultivar (Table 3) corresponded to crop maturity with early maturing cultivars (AFD 5065B2F and FM 9063B2F) producing higher lint yield than the longer season DPL 143B2F. Seed yield was considerably higher for AFD 5065B2F compared to the other three cultivars, which did not differ in terms of seed yield. Seed cotton moisture content (w.b.) at harvest differed by harvest treatment and cultivar but only ranged from 5.1 to 6.6%. The range in seed cotton moisture content at harvest was considered inadequate to affect differences in harvest efficiency and is within the recommended range (<12% w.b.) for protecting lint and seed quality during storage (Lalor et al., 1994).

Seed cotton loss was different among all stripper harvest treatments utilizing the field cleaner and was highest for FC2 and lowest for FC3 (Table 4). The same seed cotton loss trend for the factory and experimental field cleaner configurations was observed in the laboratory screening test conducted by Wanjura et al. (2011). Seed cotton loss for DPL 143B2F was about twice that of the other cultivars tested. Similar to the findings of Wanjura et al. (2011), total foreign matter removed by the field cleaner was higher for FC1 and FC2 than FC3. Total foreign matter removal was also different by cultivar and a significant harvest treatment by cultivar interaction was observed. As shown in Figure 4, the difference in total foreign matter removal among harvest treatments was similar for all cultivars except DPL 143B2F where FC1 removed substantially more total foreign matter than FC2 or FC3. Due to the extractor-cleaner design of the field cleaner, the cleaning efficiencies for bur and stick material were higher than fine trash (Table 4). FC1 and FC2 produced higher cleaning efficiencies for bur and total foreign matter compared to FC3. Stick removal efficiency for FC1 was about 17% higher than FC3, but stick removal efficiency for FC2 was not different than that of FC1 or FC3. Fine trash (i.e. leaf trash, pin trash, and motes) cleaning efficiency was not different by harvest treatment or cultivar. Cleaning efficiency for bur, stick, and total foreign material was different by cultivar. Although stick removal efficiency was not different between the FiberMax varieties or DPL 143B2F, total foreign matter cleaning efficiency was highest for FM 9180B2F because stick removal efficiency was approximately 10% greater.

Table 3. Yield and seed cotton moisture content values by harvest treatment and cultivar for the field test conducted in 2008.

Harvest Treatment (HT) [z]	Seed Cotton Yield (kg/ha)	Lint Yield (kg/ha)	Seed Yield (kg/ha)	Harvest Moisture Content (% WB)
FC 1	2669 b	832	1340	5.4 c b
FC 2	2748 b	829	1348	5.8 b
FC 3	2883 b	791	1254	5.5 c b
NFC	3310 a	810	1263	6.6 a
Picked	2254 c	800	1240	5.1 c
p > F	*<0.0001*	*0.6322*	*0.0500*	*<0.0001*
Cultivar				
AFD 5065 B2F	3190 a	886 a	1506 a	5.8 a b
DPL 143 B2F	2673 b	712 c	1178 b	5.9 a
FM 9063 B2F	2791 b	848 a b	1279 b	5.4 b
FM 9180 B2F	2437 c	803 b	1194 b	5.6 a b
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*0.0184*
HT x Cultivar Interaction (p > F)	0.9590	0.3180	0.4700	0.1600

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

Table 4. Seed cotton loss and total foreign matter removed by the field cleaner (kg/ha) and foreign matter cleaning efficiencies (%) by harvest treatment and cultivar.

Harvest Treatment (HT) [z]	Seed Cotton Loss (kg/ha)	Total Foreign Matter (kg/ha)	Burs (%)	Sticks and Stems (%)	Fine Trash (%)	Total FM (%)
FC 1	53.1 b	725 a	74.9 a	56.3 a	11.0	60.3 a
FC 2	76.9 a	706 a	77.6 a	47.5 ab	12.9	56.3 a
FC 3	17.7 c	443 b	42.5 b	39.0 b	13.4	35.1 b
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*0.0009*	*0.2314*	*<0.0001*
Cultivar						
AFD 5065 B2F	46.7 a	623 b	55.2 a	40.0 b	13.5	45.2 a
DPL 143 B2F	82.7 b	730 a	62.5 b	47.8 ab	9.8	49.1 a
FM 9063 B2F	38.0 a	624 b	69.2 c	45.6 ab	13.0	49.2 a
FM 9180 B2F	29.6 a	522 c	73.2 c	57.0 a	13.4	58.7 b
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*0.0090*	*0.1027*	*<0.0001*
HT x Cultivar Interaction (p > F)	0.6612	0.0044	0.1034	0.0890	0.9670	0.2822

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

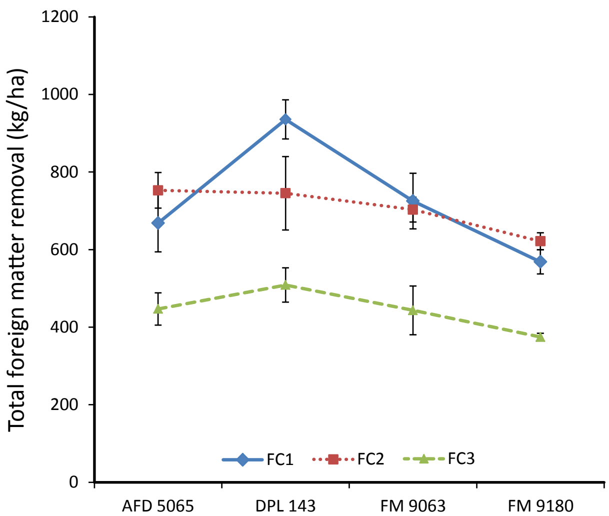

Figure 4. Total foreign matter removal by variety for FC1, FC2, and FC3 (bars represent +/- 1 standard deviation).

The same level of improvement in cleaning efficiency observed in the laboratory screening test (Wanjura et al., 2011) was not observed between the experimental field cleaner configurations (FC2 and FC3) and the conventional configuration (FC1). The test conducted by Wanjura et al. (2011) used a field cleaner from a John Deere model 7445 cotton stripper with five grid bars around the lower saw cylinder whereas the field cleaner used in this test was on a newer John Deere model 7460 cotton stripper which uses only four grid bars around the lower saw. The additional grid bar on the lower saw of the model 7445 cotton stripper field cleaner was replaced with an additional brush on the model 7460 field cleaner in an effort to help retain more seed cotton on the lower saw and reduce seed cotton loss. The modified design between field cleaner models may have caused some of the differences in the findings between this study and the one reported by Wanjura et al. (2011). Seed cotton feed rate, consistency of the feed rate, and distribution of material across the machine can also affect different levels of cleaning performance and seed cotton loss for extractor type cleaners. While the feed rate of seed cotton per unit of machine width into the field cleaner in the current study was about 20 kg/min-m (17.5 %) lower than that used by Wanjura et al. (2011), the consistency of the feed rate into the field cleaner operating under field conditions was likely much less consistent than that of the pneumatic feeding system used in the laboratory study. Inconsistency in feeding rate for a field cleaner operating under field conditions can be caused by any number of conditions including variable machine travel speed, areas of low yield, skips or variability in plant populations along the length of the row, and weeds or foreign obstacles.

Fractionation results for seed cotton samples collected after harvest and prior to ginning (from the harvester basket) are presented in Table 5. Differences by harvest method and cultivar were observed for all foreign matter fractions. Total foreign matter content was primarily influenced by the combination of bur and stick material when evaluated by harvest method. High bur and stick cleaning efficiencies observed for FC1 and FC2 resulted in lower bur, stick, and total foreign matter contents compared to FC3 and NFC. Picked cotton contained the lowest amount of foreign matter compared to all other harvest treatments. FM 9180B2F contained the least and DPL 143B2F the greatest amounts of total foreign matter. Significant harvest treatment by cultivar interactions were observed for bur, stick, total foreign matter, and seed cotton content.

After seed cotton cleaning at the gin, total foreign matter content of seed cotton fractionation samples was not different among FC1, FC2, and FC3 (Table 6). The gin's seed cotton cleaning system was able to compensate for differences in initial foreign matter content resulting from varying levels of field cleaner cleaning efficiency. Total foreign matter content remained highest for NFC and lowest for the picked harvest treatment. Differences in total foreign matter by cultivar at the extractor feeder apron reflected the same trends observed for the after harvest samples (Table 5). Cultivars with high initial trash content relative to the other cultivars contained high amounts of trash after seed cotton cleaning. Harvest treatment by cultivar interactions were significant for all foreign matter and seed cotton fractions measured at the extractor feeder apron.

The picked treatment had the highest and NFC had the lowest lint turnout values, after ginning and two stages of saw-type lint cleaning (Table 7). Among the stripper harvest treatments utilizing the field cleaner, lint turnout for FC3 was about 3% lower than FC1 and FC2, which were not different. Differences by cultivar in lint turnout were observed and followed trends in initial total foreign matter content. Seed weight per bale was not different by harvest treatment but differences were observed by cultivar. Seed weight for the FiberMax cultivars were lower than AFD 5065B2F and DPL 143B2F which were not different. Total foreign matter removed by the ginning system followed the same trends observed in the lint turnout data by harvest treatment and cultivar. Significant harvest treatment by cultivar interactions were observed for lint turnout and total foreign matter removed by the ginning system.

Analysis of seed cotton moisture content samples collected at the feeder apron (data not presented) indicated no difference by harvest treatment but differences were observed by cultivar. The range in seed cotton moisture content at the extractor feeder apron was low (5.5 to 6.2% w.b.) and was not considered adequate to affect differences in lint turnout or fiber properties.

Table 5. Fractionation results for seed cotton samples collected after harvest and prior to ginning.

Harvest Treatment (HT) z	Post Harvest Samples			
	Burs (%)	Sticks (%)	Fine Trash (%)	Total FM (%)
FC 1	6.5 b	3.5 b	6.9 b	16.9 b
FC 2	5.2 b	3.9 b	7.3 b	16.5 b
FC 3	13.6 c	5.6 c	7.5 b	27.4 c
NFC	17.2 d	6.8 c	6.9 b	33.5 d
Picked	1.8 a	0.7 a	4.2 a	6.7 a
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Cultivar				
AFD 5065 B2F	10.6 a	4.2 b	5.8 c	21.1 b
DPL 143 B2F	9.3 a	6.3 a	8.0 a	25.3 a
FM 9063 B2F	8.0 b	4.0 b	7.1 b	19.6 b
FM 9180 B2F	7.4 b	1.9 c	5.3 c	14.8 c
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
HT x Cultivar Interaction (p > F)	0.0019	0.0004	0.1427	0.0015

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

Table 6. Fractionation results for seed cotton samples collected at the extractor feeder apron prior to ginning.

Harvest Treatment (HT) [z]	Extractor Feeder Apron Samples			
	Burs (%)	Sticks (%)	Fine Trash (%)	Total FM (%)
FC 1	0.14 bc	0.68 b	1.43 b	2.24 b
FC 2	0.13 c	0.72 b	1.48 b	2.37 b
FC 3	0.26 ab	0.64 b	1.45 b	2.33 b
NFC	0.34 a	1.00 c	1.60 b	2.93 a
Picked	0.01 d	0.15 a	0.98 a	1.14 c
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Cultivar				
AFD 5065 B2F	0.26 a	0.88 a	1.2 a	2.3 b
DPL 143 B2F	0.30 a	1.01 a	2.1 b	3.4 a
FM 9063 B2F	0.13 b	0.57 b	1.2 a	1.9 b
FM 9180 B2F	0.03 c	0.07 c	1.1 a	1.2 c
p > F	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
HT x Cultivar Interaction (p > F)	0.0021	<0.0001	0.0034	<0.0001

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

Table 7. Lint turnout (%), seed weight (kg/bale), and total foreign matter (kg/bale) removed by the ginning system by harvest treatment and cultivar (1 bale = 218 kg).

Harvest Treatment (HT) [z]		Lint Turnout (%)	Seed Weight (kg/bale)	Total Foreign Matter Removed (kg/bale)
FC 1		31.4 b	351	132 b
FC 2		30.3 b	356	151 b
FC 3		27.6 c	346	235 c
NFC		24.4 d	344	352 d
Picked		35.7 a	337	57 a
	p > F	<0.0001	0.2450	<0.0001
Cultivar				
AFD 5065 B2F		28.1 c	370 b	198 b
DPL 143 B2F		27.2 c	363 b	256 a
FM 9063 B2F		30.8 b	329 a	170 b
FM 9180 B2F		33.4 a	326 a	118 c
	p > F	<0.0001	<0.0001	<0.0001
HT x Cultivar Interaction (p > F)		0.0212	*0.5383*	*<0.0001*

[z] **Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test (α = 0.05).**

HVI fiber analysis results indicated differences by harvest treatment for micronaire, length uniformity index, and leaf grade. Micronaire was 0.3 points higher for the picker-harvested treatment than for any of the stripper-harvested treatments, which were not different. The cotton picker is a selective harvester in that it can only harvest cotton from open bolls that generally contain mature fiber unlike the cotton stripper that harvests all seed cotton regardless of boll condition and fiber maturity. Uniformity index was 0.8% higher for the picked treatment compared to the FC3 harvest treatment. Uniformity index for FC1, FC2, and NFC were not different than any of the other harvesting treatments. The improvement in uniformity index for the picker harvested cotton is attributable to the selective harvest mechanism; however, it was expected that the NFC uniformity index would be the lowest of all harvest treatments but variability in the uniformity index data resulted in no differences among the stripper harvested treatments. Leaf grade (based on classer's leaf grade) after two stages of saw type lint cleaning was lowest for FC3 and highest for FC2. No clear trend by harvest treatment was apparent in the leaf grade data based on the harvest treatment cleaning efficiencies shown in Table 4. Leaf grade did not follow any of the seed cotton foreign matter content trends observed for seed cotton samples collected at the harvester basket (Table 5) or feeder apron (Table 6). No differences in loan value or lint value ($/ha) were observed by harvest treatment. However, lint value ranged from $952 to $1012 per ha between FC3 and FC1, respectively, due to the slight improvement in both lint yield and loan value for FC1.

Cultivar differences were observed for all HVI fiber property measurements. Micronaire was highest for FM 9180B2F and lowest for DPL 143B2F spanning a range of 1.16 units. Upper half mean length was longest for FM 9063B2F and shortest for AFD 5065B2F and DPL 143B2F. Length uniformity index was different for all four cultivars tested but was highest for FM 9180B2F and lowest for DPL 143B2F. Bundle strength was greatest for the FiberMax cultivars and weakest for AFD 5065B2F and DPL 143B2F. Loan value for DPL 143B2F was $0.18/kg lower than the other three cultivars, which were not different. Considering both lint yield and loan value, lint value was considerably lower for DPL 143B2F than the other three cultivars, which were not different.

Differences by harvest treatment were observed for all AFIS parameters shown in Table 9 except for visible foreign matter (VFM) and immature fiber content (IFC). Nep count (number of fiber entanglements per gram of lint) and fineness were not different among any of the stripper-harvested treatments but the picked treatment had the fewest neps and highest fineness value (fineness indicates fiber cross sectional area). Mean length by number (L(n)) was lower for FC3 compared to the FC2 and picked harvest treatments. Similarly, length by number coefficient of variation (L(n) CV) and short fiber content by number (SFC(n)) were higher for FC3 compared to the FC2 and picked harvest treatments. As expected, total foreign material (Total) was highest for NFC and lowest for the picked harvest treatment. Maturity ratio (MR) was statistically higher for the picked treatment compared to FC3, but the difference spanned a range of 0.02 and was not of practical significance. Differences were observed by cultivar for all AFIS parameters. Since the differences by cultivar for most HVI and AFIS fiber parameters were spanned by DPL 143B2F and FM 9180B2F, lint samples from these two varieties were spun into yarn to test for yarn quality differences by harvest method.

Table 8. HVI fiber properties by harvest treatment and cultivar.

Harvest Treatment (HT)[z]	MIC[y]	Length [mm]	UI [%]	Strength [kN-m/kg]	Rd [%]	Plus B [%]	Leaf Grade	Loan [$/kg]	Lint Value [$/ha]
FC1	3.51 a	29.17	80.1 ab	283.1	82.7	7.2	1.9 bc	1.21	1012
FC2	3.52 a	29.42	80.4 ab	283.2	82.3	7.0	2.7 a	1.20	997
FC3	3.45 a	29.00	79.9 b	281.6	82.8	7.1	1.4 c	1.20	952
NFC	3.48 a	29.27	80.3 ab	282.8	82.0	6.9	2.2 ab	1.19	973
Picked	3.80 b	29.46	80.7 a	284.9	81.4	7.0	2.3 ab	1.25	982
p > F	<0.0001	0.051	0.0179	0.675	0.107	0.3047	<0.0001	0.121	0.6659
Cultivar									
AFD 5065 B2F	3.59 b	28.75 c	80.6 c	267.6 b	82.2 a	7.0 b	2.2 ab	1.24 a	1097 a
DPL 143 B2F	2.90 c	28.43 c	77.3 d	263.1 b	80.9 b	8.1 a	2.5 a	1.07 b	766 b
FM 9063 B2F	3.64 b	30.26 a	81.3 b	300.4 a	83.1 a	6.6 bc	2.0 ab	1.25 a	1058 a
FM 9180 B2F	4.06 a	29.62 b	81.9 a	301.4 a	82.7 a	6.5 c	1.7 b	1.26 a	1012 a
p > F	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	0.002	<0.0001	<0.0001
HT x Cultivar Interaction (p > F)	0.0928	0.699	0.1346	0.2362	0.565	0.2621	0.5606	0.223	0.3614

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test (α = 0.05).

[y] MIC = micronaire, Length = upper half mean length, LUI = length uniformity index, Strength = bundle strength, Rd = reflectance, Plus B = yellowness, Loan = Commodity Credit Corporation 2008/09 Loan Value.

Table 9. AFIS fiber parameters by harvest treatment and cultivar.

Harvest Treatment (HT)[z]	Nep Count [cnt/g]	L(n)[y] [mm]	L(n) CV [%]	SFC (n) [%]	Total [cnt/g]	VFM [%]	Fineness [mTex]	IFC [%]	MR
FC1	626 a	17.695 bc	59.12 ab	35.76 ab	185 ab	0.62	165.00 b	5.81	0.90 ab
FC2	609 a	18.182 ab	58.17 bc	33.91 bc	212 ab	0.65	163.08 b	5.76	0.90 ab
FC3	640 a	17.251 c	60.67 a	37.26 a	180 ab	0.49	162.92 b	6.06	0.89 b
NFC	634 a	18.076 abc	58.50 abc	34.38 abc	239 a	0.77	161.75 b	5.93	0.89 ab
Picked	505 b	18.542 a	56.37 c	32.42 c	147 b	0.52	169.33 a	5.41	0.91 a
p > F	0.0002	0.0010	0.0004	0.0010	0.0311	0.1101	<0.0001	0.2850	0.0026
Cultivar									
AFD 5065 B2F	528 b	18.085 b	56.55 bc	33.19 b	178 b	0.60 ab	170.40 a	5.18 b	0.90 b
DPL 143 B2F	973 a	15.968 c	64.17 a	42.39 a	274 a	0.79 a	150.40 c	7.01 a	0.85 c
FM 9063 B2F	505 b	18.728 ab	57.89 b	32.61 b	187 b	0.61 ab	164.27 b	5.50 b	0.91 a
FM 9180 B2F	405 c	19.016 a	55.65 c	30.79 b	132 b	0.45 b	172.60 a	5.49 b	0.93 a
p > F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0126	<0.0001	<0.0001	<0.0001
HT x Cultivar Interaction (p > F)	0.1205	0.6646	0.8894	0.7037	0.9716	0.7776	0.0087	0.8253	0.2915

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test (α = 0.05).

[y] L(n) = mean length by number, L(n) CV = mean length by number coefficient of variation, SFC(n) = short fiber content by number, Total = total foreign material count, VFM = visible foreign matter, IFC = immature fiber content, MR = maturity ratio.

Opening and cleaning waste and total card waste were different by harvest treatment (Table 10). Waste during opening and cleaning was highest for the NFC and FC 2 treatments and lowest for picked. Waste at the card was again lowest for the picked harvest treatment, which was only significantly lower than FC1. Differences by cultivar were observed for opening and cleaning and total card waste. Yarn strength, elongation, and strength CV were not different among the harvest treatments tested. Yarn produced from FM 9180B2F fiber was stronger and had lower strength CV than DPL 143B2F yarn but elongation was not different by cultivar.

Evenness results on sliver and yarn samples with the UT5 are presented in Table 11. Mass CV after the card was not different by harvest treatment but mass CV after finish drawing was lower for the picked treatment compared to FC1. Yarn mass CV was not different by harvest treatment. Yarn nep count was only different between the picked and FC3 treatments with FC3 yarn containing about 150 more neps per km than yarn made from picked cotton. Thick and thin places as measured by the UT5 were not different by harvest treatment. Cultivar had a significant influence on all UT5 measurements.

Table 10. Opening and cleaning waste, card waste, and yarn tensile properties by harvest treatment and cultivar.

Harvest Treatment (HT)[z]	Opening & Cleaning Waste [%]	Total Card Waste [%]	Strength [g/tex]	Elongation [%]	Strength CV [%]
FC 1	1.21 ab	7.29 a	12.72	5.71	11.97
FC 2	1.39 a	6.50 ab	13.42	5.99	12.24
FC 3	1.37 ab	6.98 ab	13.33	5.95	11.80
NFC	1.39 a	6.73 ab	13.58	6.11	12.13
Picked	1.01 b	6.22 b	13.42	6.03	11.60
p > F	0.0113	0.0397	0.3672	0.1990	0.2305
Cultivar					
FM 9180	0.91 a	5.56 a	14.31 a	5.94	10.82 a
DPL 143	1.61 b	7.75 b	12.42 b	6.00	13.01 b
p > F	<0.0001	<0.0001	<0.0001	0.3713	<0.0001
HT x Cultivar (p > F)	0.3227	0.0921	0.9759	0.7448	0.0207

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

Table 11. Sliver and yarn evenness results from UT5 analysis.

Harvest Treatment (HT)[z]	Card Sliver Mass CV [%]	Finish Drawing Mass CV [%]	Yarn Mass CV [%]	Nep Count [cnt/km]	Thick Places [cnt/km]	Thin Places [cnt/km]
FC 1	3.00	4.16 a	17.65	347 ab	489	73
FC 2	3.08	3.88 ab	17.46	330 ab	466	64
FC 3	3.22	4.09 ab	18.04	450 a	561	93
NFC	3.04	4.09 ab	17.65	347 ab	488	73
Picked	3.10	3.81 b	17.28	301 b	432	49
p > F	0.0638	0.0285	0.1274	0.0201	0.0946	0.0826
Cultivar						
FM 9180	3.13 a	3.55 a	16.63 a	216 a	329 a	24 a
DPL 143	3.05 b	4.40 b	18.50 b	478 b	629 b	112 b
p > F	0.0329	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
HT x Cultivar (p > F)	0.3911	0.2060	0.5101	0.4506	0.4337	0.2015

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

Classimat II analysis results on yarn samples are presented in Table 12. Yarn produced from picked cotton contained significantly fewer minor faults per km than FC2, FC3, or NFC yarn. Fewer long thin faults per km were observed for picked cotton compared to all stripper-harvested treatments. No differences in major faults or long thick places were observed by harvest method. Yarn produced from DPL 143B2F contained more major faults, minor faults, and long thin places than yarn produced from FM 9180B2F but long thick places were not different by cultivar.

Based on the results of this study, neither of the field cleaner configurations utilizing experimental grid bars provided superior performance over the factory configuration in terms of cleaning efficiency, lint yield, lint value, fiber quality, or yarn quality.

CONCLUSIONS

The primary function of a cotton stripper mounted field cleaner is to remove foreign matter from harvested seed cotton with a minimal level of seed cotton loss. Favorable market conditions characterized by high lint prices place an additional emphasis on minimizing seed cotton losses. The findings of this work indicate that a field cleaner configured as specified for FC2 can have cleaning efficiencies equal to FC1. Seed cotton loss was increased for FC2 compared to FC1 but no lint yield, fiber quality, or yarn quality differences were observed. Cleaning efficiency for FC3 was substantially lower than that of FC1 or FC2 but FC3 had lower seed cotton loss than FC1 or FC2.

Field cleaning had a minimal influence on fiber quality. No differences were observed between FC1 and NFC for any of the HVI or AFIS parameters reported. With the exception of higher average leaf grade for FC2, no differences were observed between FC2 and FC1 for the HVI and AFIS parameters reported. FC3 reduced AFIS length parameters compared to FC2.

Spinning data indicated that the stripper harvest treatments had higher waste levels during opening and cleaning and at the card than the picked treatment. No differences in yarn strength, elongation, or strength CV were observed by harvest treatment. Yarn nep count was highest for FC3 and lowest for the picked treatment. Yarn evenness testing revealed no differences by harvest method. The number of yarn faults in terms of minor faults and long thins was lowest for the picked treatment compared to the stripper harvested treatments which were not different.

Based on the findings of this study, neither of the experimental field cleaner configurations improved cleaning efficiency, lint yield, lint value, fiber quality, or yarn quality compared to the original factory configuration.

This study demonstrates the potential influence of the cross sectional geometry of field cleaner grid bars on cleaning performance, seed cotton loss, and fiber and yarn quality. Additional work on this subject should focus on evaluating field cleaner per-

Table 12. Yarn fault results from Classimat II analysis.

Harvest Treatment (HT)[z]		Major Faults [cnt/km]	Minor Faults [cnt/km]	Long Thicks [cnt/km]	Long Thins [cnt/km]
FC 1		13.12	941.05 ab	23.79	1683.34 a
FC 2		10.75	1065.54 a	28.43	1849.85 a
FC 3		12.25	1423.45 a	29.53	2502.62 a
NFC		13.31	1068.64 a	24.79	2104.29 a
Picked		9.48	574.51 b	28.80	1195.68 b
	$p > F$	0.7488	0.0049	0.8665	0.0001
Cultivar					
FM 9180		8.33 a	279.63 a	25.66	604.77 a
DPL 143		14.76 b	1678.46 b	28.67	3020.25 b
	$p > F$	0.0050	<0.0001	0.9085	<0.0001
HT x Cultivar (p > F)		0.7948	0.0132	0.2355	0.0002

[z] Means by harvest treatment or cultivar within a column followed by the same letter are not different according to Tukey's HSD test ($\alpha = 0.05$).

formance and seed cotton loss under crop conditions with higher yields, higher plant moisture content, lower crop/fiber maturity, and conditions favoring the generation of bark contamination. Further work could also investigate the potential for grid bar cross section shape to influence the cleaning performance and seed cotton loss for extractor type cleaners used in the ginning process.

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. USDA is an equal opportunity provider and employer.

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