COMPARISON OF FIBER QUALITY HARVESTED WITH ROUND AND CONVENTIONAL MODULES

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Abstract

The introduction to the Australian cotton industry of the John Deere 7760 harvester, with on-board module building capacity, has led to the harvester being taken up very quickly. In 2011/12 these harvesters picked approximately 75-80% of the Australian crop, which is the largest percentage of any crop harvested by the John Deere 7760 worldwide. There have been reports from Australian classing facilities that the quality of cotton harvested by the John Deere 7760 is inferior to that harvested by conventional basket harvesters in terms of grade. To assess these claims four fields planted with the two most popular Upland varieties grown in Australia were harvested in the Southern and Central cotton growing areas of Australia utilizing both the new on-board module and conventional basket harvesters. Alternative rows of the test fields were harvested using the two different methods and then ginned concurrently at the same gin. A total of 1811 cotton lint bales were harvested and assessed in this study. There was no difference in gin turnout between fields or harvest treatments. Classing data from High Volume Instruments, the classer's grade, and data from the AFIS instrument showed no practical differences in the quality of the cotton lint bales produced from round or conventional modules.

Introduction

The John Deere (JD) 7760 harvester (Moline, Ill., USA), which has been described as a hybrid of a cotton harvester and an oversized round hay baler, has on-board module building capacity that produces round modules. These modules are covered with a polyethylene film that both protects the seed cotton and provides compressive force to maintain the module density. The modules have a diameter of 2.44 m and a width of 2.39 m and, depending on moisture content, can weigh between 2,000-2,600 kg, producing on average four bales of lint/module. In contrast, the conventional module builder used in Australia with a harvester with a basket system builds modules that are 2.4 m x 3.0 m x 12 m and that can weigh between 12-16,000 kg, producing an average of 24 bales.

The JD 7760 harvester has been taken up very quickly by the Australian cotton industry since its introduction in 2008. The main reasons for the Australian cotton industry embracing this new technology are that these machines can harvest cotton virtually non-stop, which makes it very productive; they require less labor to produce harvested cotton for the gin; and they require less capital, as the JD 7760 does not require the auxiliary equipment to build the module.

It is estimated that 80 JD 7760 harvesters were operational during the 2010/11 cotton season and these harvested around 44% of the 4.2 million bale crop. This number increased to over 200 during the 2011/12 cotton season and 75-80% of the estimated 5.4 million bale crop was harvested with the JD 7760. This is the largest percentage of any crop harvested by the JD 7760 harvester worldwide, with indications that there will be even more of these harvesters operational in Australia during the forthcoming cotton season.

Despite the obvious advantages of the JD 7760, there are some concerns regarding soil compaction and the potential effect on yield (Braunack et al., 2011). Contrary to studies conducted in the USA on fiber quality (Byler et al., 2009; Byler et al., 2010; Thibodeaux et al., 2009), there have been suggestions that the quality of the cotton lint harvested by the JD 7760 harvester is more variable in color than fiber harvested by the conventional basket machines. Figure 1 highlights the variability in color between consecutive bale samples attributed to the JD 7760 harvesters as experienced by a classing facility during the 2011/12 season.

Figure 1. Variability of Classing Grade for bales from a gin module made up of six round modules.

Aside from the variability in color in these samples, the cotton from the JD 7760 was also trashier with leaf/trash grades of 4 and lower, when compared to cotton from conventional modules.

Some suggested reasons for the differences are:

- There is limited in-field blending with round modules.
- The JD 7760 harvester is able to start earlier in the morning and harvest longer into the night where moisture (dew) is present. Moisture at harvesting may have a significant effect on leaf/trash content.
- Lack of air flow during formation of round module as compared to the basket harvester may contribute to more leaf / trash content.

This study was initiated to determine, quantify, and compare the differences, if any, between cotton lint harvested from round (JD 7760) and conventional harvesters.

Materials and Methods

To account for environmental variables the module/picker trials were conducted in the Gwydir Valley (North Central NSW) and the Lachlan Valley (South West NSW) growing areas. In order that direct comparisons could be made, rows of the test fields were harvested alternatively by the JD 7760 and then a conventional basket harvester, both harvesters being spindle pickers. This resulted in the JD 7760 harvesting seed cotton from the first six rows, then skipping four rows and harvesting the next six rows until the field has been completed. The conventional basket harvester, a four row harvester, would then harvest the rows that were not harvested by the JD 7760.

The test fields were planted with Sicot 74BRF and Sicot 71BRF (both Bollgard II Roundup Ready Flex®), which are currently the two most popular Upland varieties used in Australia (CSD, 2012). The fields were harvested at the same time of day, with moisture continually recorded to ensure that it stayed below 12% during harvesting. The completed round modules were dropped in the field and then picked up and staged together by a mast-type tractor-mounted implement that holds the module with the axis parallel to the tractor rear axle. The modules produced, both conventional and round, were staged in the sequence they were harvested to allow for direct comparison through the gin and classing and to highlight issues such as in-field variation or leaf defoliation.

The modules were placed, to allow easy access for the equipment and trucks, on a smooth, even, and firm compact surface that allows water to drain away. Round modules were staged in a "sausage" (end to end) method with a gap between modules to ensure water could run off down the ends. Round and conventional modules were ginned at the same gin within a similar timeframe to ensure no weathering effects would be applied to part of the sample modules.

The subsequent bales were classed (both visually and objectively by High Volume Instrument) at an industry-certified classing facility with samples forwarded to CSIRO MSE for further testing.

Details of Planting, Variety, Defoliation and Ginning

The trial in the Gwydir Valley was conducted on two fields in the Boomi district:

- Field A was 51 hectares of Sicot 74BRF planted on 17 October 2011. This field was defoliated on 12 April 2012 and defoliated again on 20 April 2012.
- Field B was 63 hectares of Sicot 71BRF planted on 18 October 2011. This field was defoliated on 29 March 2012 and defoliated again on 09 April 2012.

Field A was harvested on the 17th and 18th of April 2012 and Field B on the 19th and 20th of April 2012. The JD 7760 and the JD 9967 (basket) harvesters (Moline, Ill., USA) used during this trial were grower owned and operated. Seed cotton harvested by the JD 9967 was dumped directly into the module builder when the basket was full.

The modules were ginned under standard commercial conditions at a modern high capacity Lummus (Savannah, Ga., USA) gin equipped with five 170 gin stands, with each gin stand followed by Super Jet cleaners and two Sentinel Lint cleaners, producing 50 bales/hour. The modules were ginned sequentially with the modules from Field A ginned on the 8th of May 2012 and the modules from Field B ginned on the 8th and 9th of May 2012.

The trial in the Lachlan Valley was conducted on two fields with Sicot 74BRF in the Hillston area:

- Field C was 42 hectares planted on 8 October 2011. This field was defoliated on 15 April 2012 and defoliated again on 11 May 2012.
- Field D was 22 hectares planted on 8 October 2011. This field was defoliated on 25 April 2012 and defoliated again on 11 May 2012.

Field C was harvested on the 22nd and 23rd of May 2012, with Field D harvested on the 23rd and 24th of May 2012. The Case IH 2555 and Case IH 2155 basket harvesters (Racine, Wisc., USA) and JD 7760 used during this trial were contractor owned and operated. Seed cotton harvested by the Case IH 2555 and 2155 was dumped into tractor-drawn boll buggies that unloaded the seed cotton into the module builders. As cotton was planted with a 12 m planter, the JD 7760 harvested seed cotton from the first twelve rows, skipped twelve rows, and harvested the next twelve rows until the field was completed.

The modules were ginned under standard commercial conditions at a modern high capacity Continental Eagle gin (Prattville, Ala., USA) equipped with three 181 gin stands, with each gin stand followed by Super Jet cleaners and two 24D Lint cleaners, producing 38 bales/hour. The modules were ginned sequentially with the modules from Field C ginned on the 16th of August 2012 and modules from Field D ginned on the 17th of August 2012.

Table 1 gives a breakdown of the number of modules and the resultant number of bales from the four fields.

Table 1. Breakdown of modules and bales from the Boomi and Hillston Trials.

Field	Module Type	Number of Modules	Replicates (Blocks)	Module Weight (kg)	Number of bales	Gin Turnout (%)
A	Round	66	8	161,640	291	43.9
A	Conventional	8	8	106,860	197	43.2
B	Round	85	11	208,280	349	40.4
B	Conventional	11	11	141,420	237	40.0
C	Round	58	10	130,540	241	41.7
C	Conventional	10	10	129,480	240	41.9
D	Round	30	5	68,220	130	43.5
D	Conventional	5	5	65,720	126	43.6

Figure 2. Staging and harvesting of modules at Boomi.

Figure 2 depicts the staging and harvesting of the round and conventional modules. Due to the design of the study conducted in Field A and B there were more cotton lint bales produced from round modules as opposed to conventional modules due to the fact that the JD 7760 is a six row harvester and the JD 9967 harvesters were four row pickers. This was overcome in the trial in Field C and D where seed cotton from twelve rows was harvested alternately.

Fiber Testing

Fiber samples were conditioned under the standard conditions of 20°C +/-2°C and 65% +/-3% relative humidity for 24 hours as per ISO 139. Samples from the Boomi trial were tested on an Uster Technologies Inc. (Knoxville, Tenn., USA) 1000 High Volume Instrument (HVI) and the samples from Hillston were tested on an Uster Technologies Inc. (Knoxville, Tenn., USA) HVI 900. Irrespective of the HVI model all the samples were tested as per ASTM D5867, for Micronaire, staple length, length uniformity, staple strength and color. All the samples were also visually classed by a cotton classer to assess the color (color grade), visible trash (leaf grade) and preparation (degree of smoothness or roughness of the cotton sample) according to the current grades established by the United States Department of Agriculture (USDA).

Due to sample size and time constraints only a small number of samples from Field A and B were tested by an Uster Technologies Inc. (Knoxville, USA) Advanced Fiber Information System (AFIS PRO) instrument. Preliminary information on the number of neps and seed-coat neps (SCN), short fiber content % by weight (SFC w%), as well as trash and dust content is reported here.

Data Analysis

Data was analysed as a randomised complete block design. The fields were divided into blocks with the fiber properties of each block averaged. An ANOVA of the HVI fiber data was conducted using Genstat 13.1 (Lawes Agricultural Trust, IACR, Rothamsted, UK). The level of significance is reported for significant ANOVA ($p<0.05$).

Results and Discussion

Quality by HVI

The fiber data from the trials were compared to standards identified by spinners as to their preferred minimum values for fiber properties specified on sales contracts for Australian cotton (van der Sluijs and Johnson, 2011). Table 2 summarizes the minimum fiber values for Micronaire, length, length uniformity, strength and grade as required by spinning companies to spin high quality yarn consistently.

Table 2. Spinners' cotton fiber property requirements (Australian base).

Fiber Properties	Preferred Value
Micronaire	3.9 - 4.5
Length	≥1.13 inches
Uniformity	≥ 82%
Strength	≥ 29 g/tex

A summary of the HVI results for the four fields are represented in Table 3.

Table 3. Average HVI data for Fields A, B, C and D.

Field		Length inches	Uniformity %	Strength cN/tex	Micronaire µg/inch	Color Rd	Color +b
A	Round	1.216	84	31.1	4.67	84.0	7.6
	Conventional	1.219	84	33.2	4.68	83.2	7.7
	p value	0.320	0.239	<.001	0.833	0.002	0.626
	Significance	N.S.	N.S.	***	N.S.	**	N.S.
B	Round	1.198	83	29.8	4.27	83.4	7.8
	Conventional	1.203	83	30.1	4.46	82.6	7.6
	p value	0.148	0.005	0.585	<.001	0.005	0.002
	Significance	N.S.	**	N.S.	***	**	**
C	Round	1.202	80	29.6	3.72	82.2	6.6
	Conventional	1.193	81	28.3	3.73	82.0	6.8
	p value	0.186	<.001	<.001	0.827	0.449	0.013
	Significance	N.S.	***	***	N.S.	N.S.	*
D	Round	1.193	81	29.5	3.84	83.4	6.5
	Conventional	1.202	81	30.2	3.92	82.5	6.6
	p value	0.321	0.078	0.078	0.306	0.065	<.001
	Significance	N.S.	N.S.	N.S.	N.S	N.S	***

*0.01<p<0.05, **0.001<p<0.01, ***p<0.001. NS denotes non-significant ANOVA (p>0.05)

By any measure, the quality of the fiber produced from these four fields can be considered as good quality, with most of the cotton lint produced above the Australian base grade.

The average length in all cases was ≥1.13 inch and there were no significant differences between the cotton lint produced from round or conventional modules. The average uniformity of length for Field A and B was ≥82 and although there were significant differences between the cotton lint produced in Field B from the round and conventional modules, these are not practically significant as they would have no real effect on processing performance and yarn quality. The average uniformity of length for Field C and D was <82 and although there were significant differences between the cotton lint produced in Field C from the round and conventional modules, these are not practically significant.

The average Micronaire was within the 3.5-4.9 range and there were no significant differences between the cotton lint produced from round or conventional modules, with the exception of Field B where there was a significant difference. The average Micronaire for the cotton lint produced from the round modules was 4.27 as compared to 4.46 for cotton lint produced from the conventional modules.

The average strength of the cotton lint for Field A, B and D and the round modules from Field C was ≥29 cN/tex, while the cotton lint for Field C produced from the conventional modules was <29 cN/tex. There were no significant differences in the strength for the cotton lint produced from Field B and D; however there were significant differences in the strength for the cotton lint produced from Field A and C. In Field B, the cotton lint from round modules was 2.1 cN/tex stronger than the cotton lint produced from conventional modules. In Field D, the cotton lint from round modules was 1.3 cN/tex stronger than the cotton lint produced from conventional modules.

Although the color grade of Australian cotton is still based on the cotton classer's visual assessment of color with USDA grade boxes, we compared the Reflectance (Rd) and Yellowness (+b) values to the color chart which are uploaded in all HVI instruments. In the case of Field A & B the cotton was classed as Strict Middling, and in the case of Field C & D the cotton was classed as Middling. Although there are some significant differences in the Rd and + b values these would have no real practical significance as the color grades were not affected.

As there are no clear trends in the differences in length uniformity, strength, Micronaire and color it is assumed that this could be due to the natural variability of the cotton fiber and is within the accepted tolerance limits. However the quality of the fiber produced from these 4 fields, in terms of contracted fiber properties, can be considered as high quality with most of the cotton lint produced above the Australian base grade (Table 2).

Quality by Classing Grade

The assigned grades as visually classed by a cotton classer for Field A and B varied between 21-2 and 21-3, irrespective of harvesting method. Thus all the cotton from Field A and B can be considered Strict Middling cotton, which is above (i.e. better than) the current Australian base grade of 31-3 (Middling) and would lead to a premium paid to the grower for this cotton. The assigned grades for Field C and D were 21-2, irrespective of harvesting method. Thus all the cotton from Field C and D can also be considered Strict Middling cotton, which would also lead to a premium paid to the grower for this cotton.

Quality by AFIS

For fiber properties not specified on sales contracts, such as nep content, percent short fiber, trash (trash particles >500µm) and dust content (dust particles <500µm), we used the 50th percentile of the current Uster® Statistics for benchmarking the fiber properties (Uster, 2007). The Uster® Statistics has been published by Uster Technologies Incorporated for close on sixty years and is widely used in the textile industry as a quality reference which allows for the classification and benchmarking of fibers and yarns produced worldwide.

Table 4 below gives a summary of the AFIS PRO results for Field A and B as well as the current statistics for neps and seed coat neps (SCN), percent short fiber by weight (SFC(w)), and trash and dust content as determined by the AFIS instrument.

Table 4. AFIS PRO for Field A and B and Uster Statistic.

		AFIS PRO				
Field		**Total Neps/gram**	**SCN/ gram**	**SFC(w) %**	**Dust/ gram**	**Trash/ gram**
A	**Round**	236	21	6.5	176	38
	Conventional	233	22	7.5	162	31
	Difference	3	1	1.0	14	7
B	**Round**	274	21	6.9	204	38
	Conventional	276	21	7.0	244	45
	Difference	2	0	0.1	40	7
Uster Stat®	**50%**	270	22	7.8	600	100

The quality of the fiber produced from these two fields in terms of the properties measured by the AFIS PRO can be considered as good quality, with very little difference between the harvesting methods and most of the cotton lint produced better than the 50th percentile of the current Uster® Statistics.

The average nep content for Field A was < 270 neps/gram and the average nep content for Field B was > 270 neps/gram which is slightly above the 50 percentile of the current Uster® Statistics. The average seed coat nep content was ≤ 22 neps/gram for both fields. The short fiber content for both fields was < 7.8% and the trash and dust content were well below the 50 percentile value of 100 and 600/gram respectively.

Gin Turnout

As mentioned previously, there were two cotton varieties used in these trials, Sicot 74BRF and Sicot 71BRF. When one looks at the turnout achieved (Table 1) in the trial conducted at Boomi one will note that the average gin turnout for the Sicot 74BRF (Field A) was 43.4% and the average turn out for the Sicot 71BRF (Field B) was 40.2%. Irrespective of the harvesting method, Sicot 74BRF had 3.4% higher gin turnout than Sicot 71 BRF, which was expected, although the turnout for both varieties was slightly lower than predicted (CSD, 2012). When one looks at the turnout achieved (Table 2) for the trial conducted in Hillston with Sicot 74 BRF one will note that the average gin turnout for Field C was 41.8% and the average gin turnout for Field D was 43.6%. This variability in the gin turnout between the two fields was field-related and not related to the harvesting method.

Summary

The JD 7760 harvester has been taken up very quickly by the Australian cotton industry because of its productivity. There were over 200 of these harvesters operational during the 2011/12 cotton season, harvesting around 75-80% of the Australian crop, which is the largest percentage of any crop harvested by the JD 7760 harvester worldwide.

There have been some suggestions that the quality of the cotton lint harvested by the JD 7760 harvester during the 2011/12 season was more variable and trashier than fiber harvested by the traditional basket machines which produce the conventional modules. In order to compare the quality from the two harvesting systems, single field trials utilizing both harvesting methods were undertaken.

Test fields in two regions were planted with two of the most popular Upland varieties grown in Australia and harvested with both the round and conventional basket harvesters. Alternate rows of the test fields were harvested at the same time of day, with moisture continually recorded to ensure that it stayed below 12% during harvest. The conventional and round modules were staged in the sequence that they were produced to allow for direct comparison and to highlight issues such as in-field variation or leaf defoliation. Round and conventional modules were ginned at the same gin within a similar timeframe to ensure no weathering effects applied to part of the sample modules.

This trial showed there were no practical differences in gin turnout or the quality of cotton lint. However, to ensure this desired outcome it is highly recommended that (1) seed cotton should not be harvested when moisture is above 12%; (2) round modules are staged and transported to the gin and processed in the sequence they are produced; (3) modules should be placed on a smooth, even, and firm compact surface leaving a gap between modules to allow for water runoff and (4) the condition of module covers is monitored.

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Disclaimer

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