ROLLER VS SAW – A PRELIMINARY ASSESSMENT OF THE BENEFITS OF ROLLER GINNING AUSTRALIAN COTTON

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Abstract

There is considerable interest within the Australian cotton industry to develop Long Staple Upland (LS) cotton varieties to obtain the high premiums paid for fine long and strong staple fiber used for the production of premium yarn counts. As Australia produces predominately Upland cotton it is mainly equipped with super high capacity saw gins, and only a small number of roller gins. The object of this work was to compare fiber quality and turnout of LS cotton harvested using a spindle picker and ginned using saw and roller ginning systems. Sixty one round modules from one test field were ginned at two saw gins and one roller gin. A total of 259 cotton lint bales were ginned and assessed in this study. The classing data from the High Volume Instrument showed that roller ginned fiber was more uniform, with less short fibers, longer and stronger than saw ginned fiber. Data from the AFIS instrument also showed that roller ginned fiber contained fewer neps and short fibers, but contained more trash and dust, resulting in higher visible foreign matter. However, it is currently unclear whether the improvements in fiber quality from roller ginning will significantly improve textile mill performance and if the improvements, in turn, will attract a premium for growers.

Introduction

Upland cotton is the most commonly grown cotton type in Australia, with only a small amount (≤1%) of Extra Long Staple (ELS) being grown. Most of the cotton is grown under irrigation, with a small percentage grown as rain fed (dryland). Cotton is 100% mechanically harvested (mostly by spindle harvesters with a small amount of rain fed cotton harvested by stripper harvesters). Upland cotton in Australia is ginned by 39 high capacity saw gins, while the ELS cotton, when produced, can be ginned at three roller gins equipped with Rotorbar or Rotary Knife. The bulk of Australian cotton is used in the production of 30-39 Ne yarns, with a growing amount used in the premium 40-59 Ne range. There is considerable interest within the Australian cotton industry to grow finer, longer and stronger fibres for the production into fine count yarns and increasing our proportion of this premium market.

The cost of cotton production in Australia is one of the highest in the world at almost three times the world average. High yields and quality cotton fiber ensure that the industry has remained competitive. The cost of production is a critical issue and since ginning on average contributes about 21% to the total cost of production (Chaudhry, 1998; Chaudhry, 2001; Chaudhry, 2004; Chaudhry, 2007; Chaudhry, 2010), it is thus no surprise that there is a focus in Australia on saw ginning.

However, the benefits of roller ginning are well understood. Roller ginning is gentler than saw ginning and thus better preserves the quality of the lint. Roller ginned cotton typically has a longer staple length, and contains fewer short fibres and neps, and thus can attract a premium of up to 12 USc/lb, compared to similar saw ginned cotton. All ELS cottons (≥13/8 inch) are ginned on roller gins, and it is estimated that currently 15 to 20% of LS and medium staple cottons (≥11/16 inch) produced worldwide are ginned on roller gins (Baker and Griffin, 1984; Chaudhry, 1997; Estur and Gergely, 2010; ICAC, 2011; Rutherford, 2008; Sharma, 2012). This has resulted in several producers in the US and Africa replacing their saw gins with roller gins for the ginning of medium to long staple Upland varieties (Armijo, 2012; Estur and Gergely, 2010; Gillum et al., 1994; Sharma, 2012). Despite these benefits, even high speed roller gins are slower than saw gins, and thus require more gin stands and floor space, resulting in higher ginning and investment costs. Variable and maintenance costs are higher due to less automation and they are also more labour intensive than saw ginning. Furthermore roller ginned cotton, contains more foreign matter, dust and seed coat fragments, as it is not as efficient in the removal of trash, and has a rougher appearance (Armijo, 2012; Armijo et al., 2013; Armijo and Gillum, 2007; Armijo and Gillum, 2010; Blaschke, 1955; Brown et al., 1959; Byler and Delhom, 2012; Dever et al., 1986; Estur and Gergely, 2010; Evenson, 1967; Furter and Douglas, 1991; Gillum and Armijo, 2000; Gillum et al., 1994; Griffin and Columbus, 1982; Harmancioglu and Ercan, 1981; Hughs and Gillum, 1991; Hunter, 1980; Johnson et al., 1994; Mangialardi and Anthony, 2005; Newton, 1964; Shete and Sundaram, 1974; Wahba, 1987; Wanjura et al., 2012).

This study was initiated to determine, quantify and compare the differences of fiber quality and turnout of Upland Australian cotton, harvested using a spindle picker and both ginned using saw and roller ginning systems.

Materials and Methods

Experiments were conducted to compare the fiber quality of cotton ginned by roller and saw ginning. Experiments were undertaken using one field during the 2011/ 2012 growing season (planted in 2011; defoliated, harvested and ginned in 2012) in St George (28° 2'3'S,148° 34'54'E) in Queensland, Australia. The weather experienced during the season was cold, overcast and wet resulting in an average yield of 8.5 bales/ha which was lower than expected.

Details of planting, variety, defoliation and ginning

The cotton variety used for the experiment was Sicala 340 BRF. The field was planted on the 12th October 2011 (Table 1). The field was subjected to standard management practices for irrigated Upland cotton in Australia. The field was first subjected to harvest aids by air with a mixture of leaf defoliant (0.1L ha^{-1} Dropp® liquid from Bayer Crop Science), boll opener (0.1 L/ha Prep® from Bayer Crop Science) and 0.5 L/ha Canopy® oil from Caltex. It was sprayed again by air with a mixture of leaf defoliant (0.07 L/ha Dropp®) boll opener (0.2 L/ha Prep® from Bayer Crop Science) and 0.5 L/ha Canopy® oil from Caltex.

The harvesting of the experimental field occurred over one day using a grower owned and operated John Deere (JD) 7760 round module harvester (Table 1). Harvesting took place during the day and seed cotton moisture was continually monitored by handheld moisture meters to ensure that harvested cotton did not have a surface moisture level greater than the recommended level of 12%. The harvester employed during the harvesting of the field was maintained and operated via normal industry practice and manufacturers recommendations. The harvester was operated at a ground speed of 6.4 kilometers per hour and round modules were dropped in the field and picked up by a mast-type tractor mounted implement that holds the module parallel to the tractor rear axle.

Table 1. Details of the location, variety used, size, planting, defoliation, harvest and ginning date

Field	Field size (ha)	Planting date	1st Harvest Aid date	2nd Harvest Aid date	Harvesting date	Ginning date
BLG1	83.24	12 Oct	25 Mar	05 Apr	12 Apr	3 May & 21 Sep

Modules were selected at random from the field and were to be ginned under standard commercial conditions at Brighann Ginning in Moree, New South Wales (NSW) and North Bourke in Bourke, NSW. The Brighann gin (Saw Gin 1) is a modern Lummus (Savannah, GA) super high capacity saw gin equipped with 4 x 170 saw gin stands followed by one Super Jet and two Sentinel lint cleaners, producing 60 bales per hour. The North Bourke saw gin (Saw Gin 2) is a modern Consolidated (Lubbock, TX) super high capacity saw gin equipped with 2 x 198 saw gin stands followed by one Super Jet and two Super 120 lint cleaners, producing 38 bales per hour. The North Bourke roller gin is equipped with seven Consolidated (Lubbock, TX) rotary knife roller gin stands, followed by an inclined cylinder cleaner, equipped with 7 spiked cylinders and one Super Jet cleaner, producing 14 bales per hour. Gin turnout was calculated by the gins as per their standard practice using module and ginned bale weights. Table 2 summarizes the details of modules and ginned bales of fiber produced from each gin.

Table 2. Number and weight of modules, number of bales of fiber produced and the gin turnout

Gin	Number of modules	Total weight of modules (kg)	Number of 227 kg bales of ginned fiber	Gin turnout (%)
Roller Gin	36	83,740	146	40.2
Saw Gin 1	23	56,783	102	41.1
Saw Gin 2	2	4,938	11	38.4

Fiber Testing
Fiber samples from each bale were subjected to manual visual classing 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). A HVI 1000 (Uster Technologies Inc, Knoxville, TN) was used to determine fiber upper half mean length (mm), bundle strength (g tex^{-1}) and micronaire (a combined measure of fiber fineness and maturity) by Auscott Limited Classing (Sydney, NSW) (ASTM International, 2012a,b). The above mentioned quality attributes are used by merchants in Australia to value and trade cotton bales. Fiber samples were also subjected to analysis by the Advanced Fiber Information System (AFIS) (Uster Technologies Inc, Knoxville, TN) to determine total neps, fiber neps and seed coat neps (total neps = fiber neps + seed coat neps), short fiber content and visible foreign matter (ASTM International, 2012c).

Data Analysis
Fiber quality data for each bale was used for statistical testing. To test for statistical differences between the three gin treatments, an ANOVA of the HVI & AFIS fiber data was conducted using Genstat 16.0 (Lawes Agricultural Trust, IACR Rothamsted, UK). Least significant difference (LSD) values (5%) were used to separate means.

Results and Discussion

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 3 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 3. Spinner's cotton fiber property requirements

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

Quality by HVI
A summary of the HVI results and the visual class for the three gin treatments are represented in Table 4.

Table 4. Average manual classing grade and average HVI results

Gin	Color grade	Leaf grade	Length inch	Strength g tex^{-1}	Micronaire
Roller Gin	21	2	1.27	31.6	4.56
Saw Gin 1	11	2	1.24	30.9	4.56
Saw Gin 2	11	2	1.22	30.8	4.46

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

The fiber produced by the roller gin was visually classified on average as color 21 (Strict Middling) with a leaf grade of 2. The fiber produced by the two saw gins were classified as color 11 (Good Middling) with a leaf grade of 2. Although the visual class for the fiber produced by the three gins was better than the Australian base grade of 31-3. As expected the color of the roller ginned cotton was slightly inferior to the color produced by the saw ginned cotton. For average HVI results, upper half mean length ranged from 1.27 to 1. 22 inch, bundle strength ranged from 30.8 to 31.6 g tex^{-1}, and micronaire ranged from 4.5 to 4.6 (Table 3). The strength results were 1-2 g tex^{-1} lower than expected (33 g tex^{-1}), but is in all likelihood due to the cooler season experienced during 2012 (CSD, 2012).

There were significant differences between roller and saw ginned fiber for length, uniformity, short fiber index (data not shown) and strength (Table 5). As expected there were significant differences between the fiber that was roller and saw ginned, with the roller ginned fiber on average 0.07 – 0.05 inch longer, with better uniformity and short fiber index. For micronaire, there were no significant differences between the roller and saw ginned fiber, although there were significant differences between the micronaire values, produced by the saw gins. This difference was relatively small and similar to the tolerance error of the instrument of +/- 0.1 (USDA, 2005), and within the preferred micronaire range of 3.9-4.5. Indeed, AFIS results for maturity and fineness (data not shown) showed that there were no significant differences between the three gin treatments.

Table 5. ANOVA results for HVI and AFIS data, with degree of significance between treatments

Gin Type	Length inch	Strength g tex^{-1}	Micronaire	Total neps g^{-1}	Fiber neps g^{-1}	Seed coat neps g^{-1}	SFC(w) %	VFM %
Roller Gin	1.27[a]	31.6[a]	4.56[a]	178[a]	148[a]	30[a]	7.4[a]	1.07[a]
Saw Gin 1	1.24[b]	30.9[b]	4.56[a]	223[b]	194[b]	29[a]	9.0[b]	0.88[b]
Saw Gin 2	1.22[b]	30.8[b]	4.46[b]	257[c]	232[c]	25[b]	9.8[c]	0.99[a]
P value	P<0.01	P<0.01	0.003	P<0.01	P<0.01	0.031	P<0.01	P<0.01

Values in the same column followed by different letters are significantly different at the 0.5 confidence level.

Quality by AFIS

There were significant differences between the three gin treatments in terms of total and fibrous neps. At 148 neps g^{-1} the roller ginned fiber had significantly fewer fibrous neps (54 to 84 neps g^{-1}) than saw ginned fiber, which is probably due to the fact that the roller ginned fiber was not subjected to saw batt lint cleaners after the gin stand as is the case with standard saw ginning. There was however significant differences in total and fibrous neps between the two saw gins. There were no significant differences between the fiber that was roller and saw ginned in terms of seed coat neps; although there were significant differences between the two saw gins. As expected, AFIS results showed that trash (>500µm), dust (<500µm) and visible foreign matter (VFM), all tended to be significantly higher for the fiber that was roller ginned, which could also have influenced the visual classing.

Gin Turnout

The gin turnout achieved for the roller ginned fiber was 40.2% and for the two saw gins 41.1 & 38.4% respectively. The turnout by the three gin treatments was 1- 4% lower than the expected turnout of 42%, measured in variety trials during 2012 (CSD, 2012), which was somewhat disappointing.

Summary

Upland cotton is the most commonly grown cotton type in Australia, and is mainly grown under irrigation, mechanically harvested and ginned by high capacity saw gins. There are also a small number of roller gins in Australia and although the benefits of roller ginning are understood, the production of standard and high speed roller gins are substantially less than saw gins, thus requiring more gin stands and floor space, resulting in higher ginning and investment costs. This is a major deterrent for Australia where the cost of cotton production is one of the highest in the world at almost three times the world average, with ginning on average contributing about 21% to the total cost of production.

There is considerable interest within the Australian cotton industry to develop LS cotton varieties to obtain the high premiums paid for fine long and strong staple fibre which is used for the production of yarns in the premium yarn count range. The object of this work was to compare fiber quality and turnout of LS cotton, harvested using a spindle picker and ginned using saw and roller ginning systems.

Sixty one round modules, from one test field were ginned at two saw gins and one roller gin. A total of 259 cotton lint bales were ginned and assessed in this study. The classing data from the High Volume Instrument showed that roller ginned fiber was more uniform, with less short fibers, longer and stronger than saw ginned fiber. Data from the AFIS instrument showed that roller ginned fiber contained fewer neps and short fiber, but contained more trash and dust, resulting in higher visible foreign matter. There was no real difference in the gin turnout between saw and roller ginned fiber. It is currently unclear whether the improvements in fiber quality of the roller ginned LS fiber, will result in premiums and how they will perform in the textile mill. Extensive commercial trials will be conducted in 2014 to answer these questions.

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Disclaimer

Mention of trade name, propriety product or specific equipment does not constitute a guarantee or warranty and does not imply approval of the product to the exclusion of others that may be available.

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