Report on Commercial Processing Trials of Sicala 350 B Long Staple Upland Cotton at Vardhman Textiles Limited

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Background

Spinning trials conducted at CSIRO Materials Science and Engineering (CMSE) has highlighted the superior fibre properties of a new Long Staple (LS) Upland variety called Sicala 350 B, produced by breeders at CSIRO Plant Industry. Initial trials conducted in 2004 showed that Sicala 350 B fibre produces superior Ne 42 (14 tex) and Ne 35 (17 tex) ring-spun carded and combed yarn, and subsequently fabric (single jersey) knitted from it. Performance was measured in terms of process efficiency and quality relative to yarn and fabric produced from standard Upland cotton. Subsequent spin limit trials conducted in 2005 showed that Sicala 350 B could be used to process high quality fine count carded and combed ring-spun yarns in the range of Ne 60 to 70 (8 to 10 tex). The Premium Blends project in 2007 further highlighted the fact that a 70/30 blend of Pima/Sicala 350 B did not cause a practical deterioration in yarn quality and processing efficiency when compared with yarn spun from 100% Pima. The primary advantage for the spinner using Sicala 350 B fibre is a substantial savings in raw material costs[1].

Aim

Although this information was well received the question remained whether these results could be replicated in industry.
The aim of this spinning trial was to determine:

1. Whether the results obtained in the CMSE Cotton Mill can be achieved by commercial fine count spinners.
2. Determine whether there are advantages or disadvantages of using Sicala 350 B in terms of fabric formation and quality.

Commercial Spinning Mills

Members of the Australian Cotton Shippers Association (ACSA) provided a number of potential spinning mills where the above commercial trials could be conduced. These included:

- Vardhmann - India
- Esquel - Hong Kong

[1] van der Sluijs M.H.J (2008) *The Market for Australian Long Staple Upland Cotton,* Proceedings 29th Bremen International Cotton Conference, Bremen

- Nishinbo - Japan
- Thai Textile Industries - Thailand
- Central Textiles - Indonesia

Initial contact was made with Vardhman Textiles Limited at the ACSA conference in late 2007 and it was agreed that the first commercial spinning trials will be conducted in India at Vardhman in the presence of a CSIRO researcher.

Vardhman's head office is in Ludhiana in the province of Punjab and is one of the largest textile groups in India with numerous processing mills in different parts of India. They have an installed ring spinning capacity of 770 000 spindles and are currently installing a further plant with 60 000 spindles with further expansion plans for the future. Vardhman produce a large range of staple fibres with cotton accounting for 85% of their production in 100% and in blends. Vardhman have had a long association with Australian cotton and have been purchasing our cotton since 2001 although not much was purchased over the past 2 years.

These commercial trials were conducted at Auro Spinning Mills (ASM) in Baddi in the province of Himachal Pradesh in Northern India during the second and third week of March 2009. ASM was established in 1991 and now comprises five spinning mills that produce 36 to 40 tons of yarn a day on around 80 000 ring spindles. ASM and employ around 6000 people.

The product range is vast with the mills producing normal ring spun yarns, compact yarns, slub yarns, core spun yarns, Siro spun yarns in single and twisted yarns in the count range of 10 to 120 Ne (60 to 5 tex) yarns. The open end spinning in 6 to 30 Ne (100 to 20 tex) yarns in a large range of 100% and blended yarns.

The spinning machinery installed is a mixture of European and Indian machines and seem to be well maintained and in good running order. The mills are very clean and housekeeping is good.

There is a large Quality Assurance Department on site that is staffed with 28 people, who conduct routine tests according to a laid down schedule.
The laboratory is equipped with the standard instruments one would expect to find in a modern high quality spinning mill. For example, Uster Evenness tester 3, Tensorapid 3, Classimat 3 as well as a Spinlab 900 High Volume Instrument (HVI) and AFIS PRO.

On the same site there is also:

- Two weaving plants that have over 500 weaving machines producing mainly Poplin fabric. Sixty percent of the yarns produced by ASM are for these two plants. The rest is sold on local and export market.
- Yarn dyeing plant
- Sewing thread plant
- Manual contamination removal plant. Contamination is a very big issue for ASM and bales that are purchased from countries that have reputation for high contamination (India, Pakistan etc.) are manually cleaned.

Materials

One 40 foot container containing 100 bales of Sicala 350 B was shipped to Vardhman Textiles Limited by Queensland Cotton. Bales in the shipment were divided into three lots (see Tables 1, 2 and 3 in Appendix 1) on the basis of fibre properties, grower and year. Lot One had 68 bales, Lot Two had 11 bales and Lot Three had 21 bales. All bales were covered in cotton bale wrappings. Lot One were High density bales and Lots Two and Three were universal density bales.

Fibre Testing

All bales in the shipment were extensively tested before they were shipped to India. Before testing bale samples were passively conditioned under standard conditions of 20°C ±2°C and 65% ±3% relative humidity for at least 18 hours.

Two replicates were tested per bale using an Uster Technologies 900 HVI at Queensland Cotton's classing facility to determine the Micronaire, staple length, length uniformity, staple strength, elongation and colour (Rd & +b). Three replicates were tested per bale using the Cottonscan instrument to determine fibre fineness. Combined with the HVI Micronaire value, the average fibre maturity was calculated using Lord's empirical relationship between Micronaire, maturity ratio and fineness.

Nep, seed-coat neps (SCN), short fibre content by weight (SFCw), trash and dust were also tested at CMSE on an Uster Technologies Advanced Fibre Information System (AFIS PRO). Five replicates were tested per sample.

Fibre and Yarn testing during Textile Processing

In order to obtain an accurate indication of the fibre properties of the cotton being processed fibre samples were collected by ASM staff from every bale in the laydown, and then at points in the blowroom and at each process through to roving. Samples were tested on HVI (Micronaire, length and strength) and AFIS (neps, Short fibre content). Sliver evenness from the carding, drawing, combing as well as roving processes was also monitored. Sliver evenness of card sliver is not normally tested at ASM due to the fact that the cards are equipped with a long term Autoleveller and that the sliver goes through a large number of doublings.

Along with fibre tests the following yarn tests were conducted; yarn count, tenacity, evenness, number of imperfections, hairiness and twist. Unfortunately accurate ends down figures were not measured.

Textile Processing

The trials were conducted in the Sample Line factory which is an entire processing facility dedicated to product development and the production of samples.

It was initially proposed (See Appendix 1) that the spinning trials involve introducing bales of Sicala 350 B gradually into mill laydowns that currently use ELS-type cotton, until it reaches a proportion of up to 30%, without significantly changing the laydown's average fibre properties, and examining the affect on yarn and fabric quality. After discussions at Vardhman it was agreed that before the Sicala 350 B is considered for any blends it needs to be evaluated on its own merits. It was thus decided that 100% Sicala 350 B would be processed. Two lots were examined in this study.

100% Sicala 350 B, saw ginned, high density bales from Lot One.
100% Sicala 350 B, saw ginned, universal density bales from Lot Three.

Five bales or 1135 kg's of fibre from each lot was opened of which approximately half was processed into yarn using machines set to industry standard settings. Production speeds were kept constant throughout the trial but machine settings e.g. draft setting distances, were optimised for individual blends as is accepted practice in high-quality spinning mills. The bales chosen were considered to be representative of the two lots. See Table 1 and 2 for the bales that were selected with the original classing data and results from ASM.

Table 1 - Lot One bales and fibre properties

	HVI	AFIS					
Bale Number	Length mm	Length Uniformity	Strength g/tex	Micronaire µg/inch	Neps/ gram	SCN/ gram	SFC/ (n)
5421674[a]	31.2	83.4	34.0	4.5	268	36	23.1
5421676	31.0	83.8	34.2	4.6	226	24	20.5
5421678	31.0	83.8	34.2	4.6	178	22	19.3
5421681	31.0	83.8	34.2	4.6	226	29	20.5
5421693	31.0	83.9	34.2	4.6	181	16	20.8
5421674[b]	31.2	83.0	30.1	4.6	164	20	23.6
5421676	33.3	79.2	32.9	4.7	157	4	24.8
5421678	31.2	82.9	34.1	4.6	204	5	23.7
5421681	31.3	81.8	32.8	4.5	187	6	22.8

5421693	30.7	82.9	31,2	4.7	145	9	22.7

[1] QC classing results

[2] ASM results

Table 2 - Lot Three bales and fibre properties

	HVI	AFIS					
Bale Number	Length mm	Length Uniformity	Strength g/tex	Micronaire µg/inch	Neps/ gram	SCN/ gram	SFC/ (n)
2465965[a]	32.3	82.7	32.7	3.6	318	22	23.1
2465969	32.8	84.0	33.5	3.6	318	19	20.5
2465971	32.3	82.7	32.7	3.6	300	24	19.3
2465974	32.3	82.7	32.7	3.6	332	19	20.5
2465979	32.3	82.7	32.7	3.6	289	16	20.8
2465965[b]	32.1	82.4	30.9	3.8	275	0	29.1
2465969	32.9	84.9	34.8	3.6	294	10	31.9
2465971	30.9	81.5	30.8	3.6	302	4	26.4
2465974	32.2	82.7	32.2	3.6	285	6	26.8
2465979	32.3	82.9	34.9	3.7	240	2	31.9

[a] QC classing results

[b] ASM results

Samples from the two lots were also tested on the Micro Dust and Trash Analyser (MDTA), which showed that the trash for Lot One was 2.6 % and for Lot Three the trash was 3.2 %. One would expect values below 2.0 % which suggests that the cotton contains more trash than normal. This is further highlighted by the trash results from the AFIS PRO (Appendix 1) which can be considered to be average, i.e. on the 50 percentile line when compared with current Uster Statistics[2]. This would mean that more waste will need to be extracted in the blowroom and combers, which reduces the realization percentage.

The five bales for Lot One and Three were opened for at least 24 hours before processing to allow the bales to condition at the standard temperature and relative humidity conditions. In order to achieve a good blend the five bales were broken into three and laid in the bale laydowns as shown in Figure 1 and 2.

5421674	5421678	5421693	5421676	5421681
5421676	5421681	5421674	5421678	5421693
5421678	5421693	5421676	5421681	5421674

Figure 1 Bale Laydown for Lot One

[2] Uster Statistics 2007 CD ROM from http://www.uster.com

2465971	2465965	2465974	2465969	2465979
2465969	2465979	2465971	2465965	2465974
2465965	2465974	2465969	2465979	2465971

Figure 2 Bale Laydown for Lot Three

As Lot One consists of high micronaire cotton it was decided to first produce a 50 Ne (12 tex) combed hosiery and weaving yarn as well as a compact weaving yarn. As the results proved to be acceptable a 60 Ne (12 tex) compact weaving yarn was attempted. Lot Three consists of low micronaire cotton and it was decided to produce a 60 Ne (10 tex) combed hosiery and weaving yarn as well as a compact weaving yarn. As the results proved to be good a 70 Ne (8.4 tex) compact weaving yarn was attempted.

The twist factor (αe) for the hosiery yarns is 3.7 and the twist factor for the weaving yarns is 4.2. The twist factor for the compact ring spun yarns is 4.0.The twist factor for the 60 Ne compact for Lot One and the 70 Ne compact for Lot Three is 4.3.

For the trials the opening, cleaning, carding, drawing, combing, roving and spinning processes were conducted with the equipment set initially to Vardhman's standard specifications, which were optimised to achieve the required quality. Figure 3 and 4 summarises the processing steps, production speeds and other production related details used to convert each lot into yarn.

Both lots were processed on the same machines. Sliver was produced on three carding machines, one comber, one drawframe and one speedframe. All the ringspun yarn was produced on one ringframe and all the compact yarns were produced on one compact ringframe.

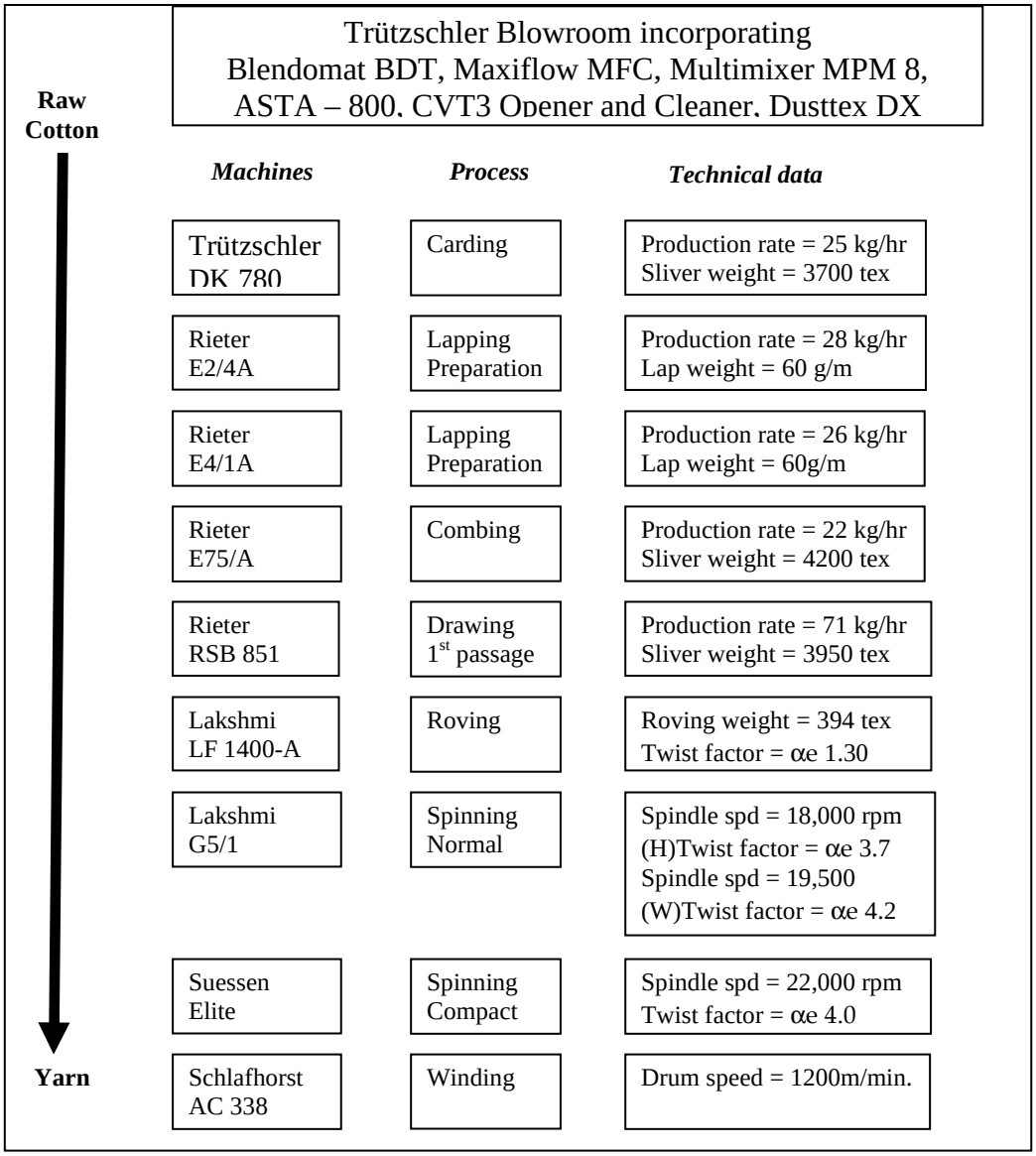

Figure 3 – Textile Processing Route for Lot One

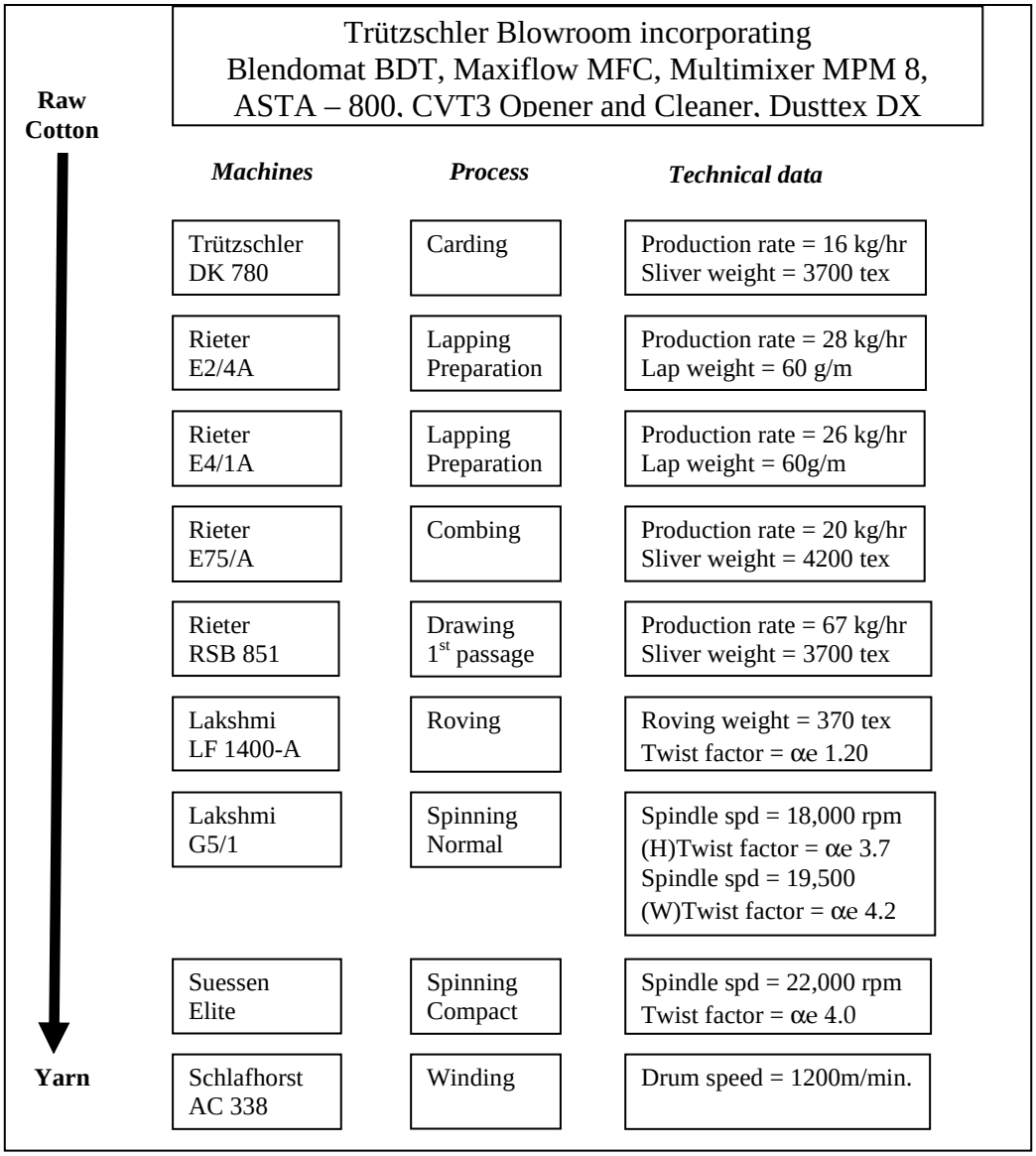

Figure 4 Textile Processing Route for Lot Three

Results and Discussion

- **Lot One**

Lot One processed well through the preparation stages easily meeting and even exceeding in all cases the tough standards (Table 3 and 6) imposed on the fibre by the laboratory. Table 3 gives the results for the lot at the various processing stages as measured by AFIS PRO. Although length, strength and micronaire are considered to be important what was apparent was that nep content (which should be < 200 neps/gram) and short fibre content (which should be < 22 SFC (n)) and contamination are just as important for Vardhman.

Table 3 - Lot 1 Results for AFIS PRO

Process	Neps	SCN	SFC
	Cnt/g	Cnt/g	(n)
Maxiflow	217	6	23.2
Multimixer	232	5	24.5
Cleanomat	243	9	23.7
Dustex	318	6	23.0
Card Feed	337	6	24.4
Card Sliver Specification	**60 - 65**	**0 - 1**	**28 - 30**
Card sliver (5)	41	0	24.1
Card sliver (6)	46	0	23.9
Card sliver (7)	47	0	24.5
Sliver lap	47	0	22.9
Ribbon lap	30	0	21.4
Combed Sliver Specification	**12 - 15**	**0**	**11**
Combed sliver	13	0	9.9
Drawframe Passage	14	0	9.3
Roving	17	0	10.0

Five replicates were tested per sample

Table 4 gives the evenness results for the lot at the various processing stages. There are no standards for carded and combed sliver as ASM do not test the evenness values at this stage. Although the evenness results of the drawframe sliver was slightly out of specification the production was given the go ahead as the evenness results for the roving were better than the standard.

Table 4 - Lot One Evenness Results

Process	Standard U%	Actual U%	Standard CV% (1m)	Actual CV% (1m)
Card	*	3.22	*	2.45
Comber	*	3.19	*	1.83
Drawframe	2.0	2.19	0.5	0.59
Roving	3.5	2.53	2.0	1.61

* No Standard Available.

Normally the amount of noil to be extracted ranges between 18% and 20%. In the case of Lot One the amount of noil extracted at the comber to meet the required specifications was 18.4%.

The yarn results are given in Table 5

Table 5 - Test Results for Yarns for Lot One

Instrument & Measurement	50 Ne Hosiery Normal	50 Ne Weaving Normal	50 Ne Weaving Compact	60 Ne Weaving Compact
Uster Technologies 3				
Evenness[1]				
Coefficient of variation CV %	12.59	12.76	12.98	13.04
Thin places - 50 % /1000	1	1	2	2
Thick places + 50 % /1000	10	12	23	21
Neps + 200 % /1000	23	30	34	37
Hairiness				
Hairiness H	4.77	4.38	3.35	3.57
Standard Deviation S_h	1.03	0.95	0.78	0.78
Uster Technologies Tensorapid 3				
Strength[2]				
Breaking Tenacity cN/tex	16.95	18.67	20.95	21.13
CV % Tenacity	8.79	5.83	8.85	9.56
Breaking Elongation %	4.42	4.49	4.42	4.97
CV % Elongation	8.26	8.10	8.85	8.92

[1] *Average of 10 tests* [2]*Average of 100 tests*

The evenness results for the normal 50 Ne (12 tex) weaving and hosiery ringspun yarns are comparable to quality achieved by other qualities and are thus acceptable to Auro Spinning Mills. The hairiness values were a bit higher than the values achieved by other qualities and it is felt that the yarn strength is slightly below

expectation and needed to be 1 to 1.5 cN/tex higher. It is however felt that this can be overcome by increasing the noil percentage at combing (which will lead to more waste) and increasing twist levels (which will lead to a reduction in production) and blending the fibre with other cottons.

A comparison of the yarn results with current Uster Statistics shows that, the evenness and imperfections (thin, thick places and neps) are excellent, i.e. between the 25 and 5 percentile lines of all yarns produced world-wide. Yarns within these percentiles are considered high quality. However, as observed by Vardhman the strength and hairiness values can be considered to be average i.e. at the 50 percentile line.

Another important measure of cotton lint quality is processing performance. The recording of end breakages in spinning is an important measure of processing performance because it indicates whether production levels and quality standards can be achieved. Unfortunately ends down are not formally checked at Auro Spinning Mills but feedback from the operators and mill manager suggest that there were no end breaks during the two doffs that were spun of each quality.

As the yarns processed well, the 60 Ne compact weaving yarn was also produced using a twist factor (αe) of 4.3. The evenness results for the 60 Ne (10 tex) compact weaving yarn was very similar to the results achieved for this yarn produced from Lot Three (Table 7). However the yarn was 3.0 cN/tex stronger and the hairiness was slightly lower.

Obviously a fibre with a lower micronaire will also assist as this will increase the number of fibres in the cross section and will improve the yarn quality substantially[3].

- **Lot Three**

As opposed to Lot One, Lot Three posed some problems in the preparation stage. The initial results showed that the nep and Short Fibre Content was out of specification even though the carding machines were running at 9kg/hr less. This was in all likelihood due to the fact that the nep content in the cotton lint was on average 100 to 120 neps/gram more than the nep content of Lot One. This highlights the fact that more than 250 neps/gram in cotton lint for fine count spinners can pose a problem[4] ; with Vardhman insisting that < 200 neps/gram is a more realistic figure.

[3] van der Sluijs M.H.J., Gordon ,S.G. and R.L. Long , A Spinners Perspective on Fibre Fineness and Maturity Part 1: Current Practice based on Micronaire, Australian Cotton Grower Feb – Mar. 2008

[4] Gordon, S. G., van der Sluijs, M. H. J. and Prins, M. W., 'Quality Issues for Australian Cotton from a Mill Perspective', Australian Cotton CRC, July 2004

In order to achieve the required nep and short fibre content results, the carding machines were thoroughly cleaned, the flats sharpened and flat settings tightened which led to an improvement in the results and achieved the required specification. It must be noted that the settings set are extremely tight and can only be done where machines are well maintained and in good mechanical order.

See Table 6 for Lot Three AFIS PRO results.

Table 6 - Lot Three results for AFIS PRO

Process	Neps	SCN	SFC
	Cnt/g	Cnt/g	(n)
Maxiflow	346	4	25.7
Multimixer	365	5	29.1
Cleanomat	551	5	27.0
Dustex	524	4	27.3
Card feed	509	4	25.6
Card Sliver Specification	**60 - 65**	**0**	**28 – 30**
Card sliver (5)	58	0	25.2
Card sliver (6)	53	0	26.3
Card sliver (7)	62	0	26.1
Sliver lap	74	1	28.5
Ribbon lap	57	0	26.5
Combed Sliver Specification	**12 - 15**	**0**	**11**
Combed sliver	12	0	10.8
Drawframe Passage	17	0	10.5
Roving	24	0	10.2

Five replicates were tested per sample

Table 7 gives the evenness results for the lot at the various processing stages. There are no standards for combed sliver as Auro Spinning Mills do not test the evenness values at this stage. As can be seen from the results the evenness specifications were not only met but exceeded in all cases.

As mentioned previously the amount of noil to be extracted ranges between 18% and 20%. In the case of Lot Three the amount of noil extracted at the comber to meet the required specifications was 20.5%, which was 2 % higher than Lot One.

Table 7 Lot Three Results for Evenness

Process	Standard U%	Actual U%	Standard CV% (1m)	Actual CV% (1m)
Card	*	3.58	*	3.40
Comber	*	2.99	*	1.86
Drawframe	2.0	1.86	0.5	0.67
Roving	3.5	3.24	2.0	2.19

* No Standard Available

The yarn results are given in Table 8

Table 8 - Test Results for Yarn for Lot Three

Instrument & Measurement	60 Ne Hosiery Normal	60 Ne Weaving Normal	60 Ne Weaving Compact	70 Ne Weaving Compact
Uster Technologies 4-SX				
Evenness[1]				
Coefficient of variation CV %	13.96	13.98	13.04	14.62
Thin places - 50 % /1000	13	20	25	25
Thick places + 50 % /1000	27	24	32	56
Neps + 200 % /1000	35	31	40	62
Hairiness				
Hairiness H	4.07	3.82	2.74	2.60
Standard Deviation S_h	0.88	0.58	0.85	0.59
Uster Technologies Tensorapid 3				
Strength[2]				
Breaking Tenacity cN/tex	16.92	18.03	21.41	20.52
CV % Tenacity	9.65	11.40	9.39	8.94
Breaking Elongation %	4.18	4.46	3.85	4.45
CV % Elongation	11.17	12.20	13.12	11.68

[1] *Average of 10 tests* [2]*Average of 100 tests*

As is the case with Lot One, the evenness results for the normal 60 Ne (12 tex) weaving and hosiery ringspun yarns are comparable to quality achieved by other qualities and are thus acceptable to Auro Spinning Mills. The hairiness values were a bit higher than the values achieved by other qualities and it is felt that the yarn strength is slightly below expectation and needed to be 1 to 1.5 cN/tex higher.

A comparison of the yarn results with current Uster Statistics shows that, the evenness and imperfections (thin, thick places and neps) are excellent, i.e. between

the 25 and 5 percentile lines of all yarns produced world-wide. Yarns within these percentiles are considered high quality. However, the strength and hairiness values can be considered to be average i.e. at the 50 percentile line.

Again as per Lot One the ends down were not formally checked for this lot but feedback from the operators and mill manager suggest that there were no end breaks during the two doffs that were spun of each quality.

As the yarns processed well the 70 Ne (8.4 tex) compact weaving yarn was also produced using a twist factor (αe) of 4.3

Further Work

Yarn for knitting has been sent to Ludhiana for knitting trials and yarns for weaving have been forwarded to Auro Weaving Mills for weaving trials. Once these fabrics are returned they will be forwarded to the author

Sliver from the two lots will also be used in dyeability trials to determine dye uptake and also to determine suitability of blending with other cottons.

As only 15 kg's of yarn was produced for each yarn count there is still a large amount of roving left as well as the 90 bales left from Lot One, Two and Three. Vardhman will conduct further trials on a larger scale both in 100% and in blends with ELS type cottons and have promised to forward the results to the author.

Conclusion

The aim of this study was to determine whether the results that were obtained at the CMSE Cotton Mill could be duplicated in a commercial spinning trial. The results from this investigation show that Sicala 350 B can indeed be spun successfully in high quality fine count yarns and it has been mentioned by Varhmann that it can easily replace Ultima[5] and should be able to be blended with ELS cottons to produce 80 Ne yarns.

There are however some issues raised by Vardhman which will need to be considered;
The Micronaire values must be below 4.2 to ensure that the number of fibres in the cross section is sufficient to produce yarns with the required yarn strength,
The nep content must be below 200 neps/gram and
The Short Fibre Content by Number, as measured by the AFIS must be below 22%.

[5] SJV Upland cotton which is roller ginned

If the fabric also proves to be acceptable the commercial aspects will need to be agreed upon.

Acknowledgements

The author gratefully acknowledges the financial support of CSIRO Materials Science and Engineering and Cotton Research and Development Corporation. He would also like to thank, the Australian Cotton Shippers Association for their assistance and Vardhman Limited for allowing the trials to be conducted at Auro Spinning Mills. The assistance of Mr. T.C. Gupta and Mr. P. Singal and all the other personnel from Auro Spinning Mills that were involved during the processing of the bales of cotton through the mill is also gratefully acknowledged.

APPENDIX 1

Large Scale Processing Trials of Australian Long Staple Upland cotton to determine suitability of blending with Extra Long Staple cotton

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November 2008

Background

Spinning trials at CSIRO have highlighted the superior fibre properties of a new Long Staple (LS) Upland variety called Sicala 350 B, produced by breeders at CSIRO Plant Industry. Trials have shown that Sicala 350 B fibre produces superior Ne 42 (14 tex) and Ne 35 (17 tex) ring-spun carded and combed yarn, and subsequently fabric (single jersey) knitted from it. Performance was measured in terms of process efficiency and quality relative to yarn and fabric produced from Upland cotton. Subsequent spin limit trials conducted showed that Sicala 350B could be used to process high quality fine count carded and combed ring-spun yarns in the range of Ne 60 to 70 (8 to 10 tex). Other trials highlighted the fact that a 70/30 blend of Pima/Sicala 350 B did not cause a practical deterioration in yarn quality and processing efficiency when compared with yarn spun from 100% Pima. The primary advantage for the spinner using Sicala 350 B fibre is a substantial savings in raw material costs.

Aim

The aim of this spinning trial is to determine:

3. Whether the above results obtained in the CMSE Cotton Mill can be achieved by a commercial fine count spinner.
4. The advantages or disadvantages of using Sicala 350 B in terms of fabric formation and quality.

Materials

One 40 foot container containing 100 bales of Sicala 350 B has been shipped to Vardhman Textiles Limited by Queensland Cotton. Bales in the shipment can be divided into 3 lots (see Tables I, II and III) on the basis of fibre properties, grower and year. Lot one has 68 bales, Lot two has 11 bales and Lot three has 21 bales.

Fibre Testing

All bales in the shipment have been extensively tested. Before testing bale samples were passively conditioned under standard conditions of 20°C ±2°C and 65% ±3% relative humidity for at least 18 hours.

Micronaire, staple length, length uniformity, staple strength, elongation and colour (Rd & +b) were tested at Queensland Cotton's classing facility in Brisbane. Two replicates were tested per bale using an Uster Technologies 900 High Volume Instrument (HVI), which was calibrated using HVI ICC Upland Cotton.
Fibre fineness was measured using the Cottonscan instrument developed by CSIRO. This instrument determines fibre fineness (linear density) by measuring the length of fibre in an accurately weighed specimen of fibre snippets. Three replicates were tested per sample. Combined with the HVI Micronaire value, the average fibre maturity was calculated using Lord's empirical relationship between Micronaire, maturity ratio and fineness.

Nep, seed-coat neps (SCN), short fibre content by weight (SFCw), trash and dust were also tested at CSIRO on an Uster Technologies Advanced Fibre Information System (AFIS PRO). Five replicates were tested per sample.

The fibre properties are listed in Tables I, II and III.

Spinning Trial

The proposed spinning trials involve introducing bales of Sicala 350 B gradually into mill laydowns that currently use ELS-type cotton, without significantly changing the laydown's average fibre properties, and examining the affect of yarn and fabric quality. Initially, it is proposed that the Sicala 350 B be introduced until it reaches a proportion of up to 30% in a nominally ELS cotton laydown. Higher percentages of Sicala 350 B in the laydown could be tested once the quality of yarn blends up to 30% have been measured. CSIRO notes in their own trials substituting up to 30% Sicala 350 B in a Pima laydown did not practically affect the quality of fine count yarns. (*It is currently unclear how many bales Vardhman use in their bale laydowns, but once this is known the number of bales per laydown and the laydown itself will be agreed upon*).

For the trials the opening, cleaning, carding, drawing, combing and roving processes will be conducted with equipment set initially to Vardhman's specifications, which are expected to be those typically used in the wider industry. Settings will then be optimised according to fibre quality if required as is accepted practice in high-quality spinning mills. Details of all the machines used, their settings and setting changes will be recorded.

It is proposed that the Sicala 350 B blend be spun into ring and compact spun fine count Ne 60 and 70 (10 to 8 tex) carded and combed yarns. Yarn tenacity will be monitored to ensure fibre quality and initial twist levels are satisfactory. If there is room in the trial schedule a range of twist factors and finer yarn counts will be tried in order to extend the viable range of yarns that can be spun from a Sicala 350B

blend. Once spun all yarns will be cleared using standard clearer settings, and if destined for knitting the yarn will be waxed.

Fibre and Yarn Testing

In order to obtain an accurate indication of the fibre properties of the cotton being processed fibre samples need to be collected from every bale in the laydown, and then at points in the blowroom and at each process through to roving. Samples will be tested on HVI (Micronaire, length, strength, colour and trash), AFIS (neps, length, trash and dust), Cottonscan (linear density, maturity) and SiroMat (maturity, maturity distribution and linear density) instruments. Sliver evenness from the carding, drawing, combing as well as roving processes will also be monitored.

Yarn tests provide the ultimate feed-back on relative fibre quality. Along with fibre tests the following yarn tests are proposed; yarn count, tenacity, evenness, number of imperfections, hairiness and twist. Where possible the yarn-ends down figures will be measured for each yarn processed.

CSIRO Participation

Our experience indicates that it is vital that a CSIRO researcher interacts closely with the mill during the planning phase of the trial and that the CSIRO researcher is also present whilst the trial is conducted.

Table I – Lot 1

	HVI							AFIS					Cottonscan	Calculated
Bale Number	Length inch	Length mm	Length Uniformity	Strength g/tex	Micronaire	Colour Rd	Colour b+	Neps/ gram	SCN/ gram	SFC/ (w)	Dust/ gram	Trash/ gram	Fineness mtex	Maturity
5421669	1.22	31.0	83.8	34.2	4.6	80.6	8.9	207	31	8.1	232	38	195	0.90
5421670	1.22	31.0	83.8	34.2	4.6	80.6	8.9	223	30	7.6	177	30	191	0.90
5421671	1.22	31.0	83.4	33.9	4.6	80.7	8.5	202	31	7.0	273	40	186	0.88
5421672	1.22	31.0	83.8	34.2	4.6	80.6	8.9	205	21	6.9	200	37	190	0.94
5421673	1.22	31.0	83.8	34.2	4.6	80.6	8.9	216	22	7.6	197	37	192	0.90
5421674	1.23	31.2	83.4	34.0	4.5	81.6	9.0	268	36	8.3	240	49	190	0.90
5421675	1.22	31.0	83.8	34.2	4.6	80.6	8.9	199	29	7.2	214	35	187	0.91
5421676	1.22	31.0	83.8	34.2	4.6	80.6	8.9	226	24	7.2	249	41	192	0.83
5421677	1.23	31.2	84.2	34.3	4.5	80.7	9.2	199	22	6.9	203	35	200	0.90
5421678	1.22	31.0	83.8	34.2	4.6	80.6	8.9	178	22	6.7	172	29	201	0.88
5421679	1.22	31.0	83.8	34.2	4.6	80.6	8.9	206	29	8.3	238	40	194	0.84
5421680	1.23	31.2	83.8	34.7	4.6	79.7	8.8	205	28	7.5	193	42	185	0.97
5421681	1.22	31.0	83.8	34.2	4.6	80.6	8.9	226	29	7.1	237	47	190	0.91
5421682	1.22	31.0	83.8	34.2	4.6	80.6	8.9	188	24	7.3	254	38	193	0.85
5421683	1.22	31.0	84.1	34.1	4.6	81.3	9.3	236	32	6.6	277	47	188	0.92
5421684	1.22	31.0	83.8	34.2	4.6	80.6	8.9	189	24	7.4	214	40	202	0.87
5421685	1.22	31.0	83.8	34.2	4.6	80.6	8.9	210	22	7.4	241	41	194	0.86
5421686	1.23	31.2	84.3	34.4	4.6	81.6	8.9	210	30	6.8	266	39	199	0.88
5421687	1.22	31.0	83.8	34.2	4.6	80.6	8.9	222	24	6.6	170	32	194	0.88
5421688	1.22	31.0	83.8	34.2	4.6	80.6	8.9	227	29	8.1	290	42	201	0.92
5421689	1.21	30.7	83.7	34.2	4.6	79.6	8.9	192	22	6.8	242	36	198	0.94
5421690	1.22	31.0	83.8	34.2	4.6	80.6	8.9	171	16	7.1	249	36	198	0.88
5421691	1.22	31.0	83.8	34.2	4.6	80.6	8.9	216	25	7.5	219	36	191	0.84
5421692	1.21	30.7	83.8	34.5	4.6	80.8	8.9	202	27	6.5	226	47	195	0.87
5421693	1.22	31.0	83.9	34.2	4.6	80.7	9.1	181	16	6.9	218	33	199	0.91
5421694	1.23	31.2	83.8	34.4	4.7	81.4	9.0	204	24	6.9	230	30	191	0.92
5421695	1.21	30.7	82.9	33.1	4.6	83.3	8.8	184	25	6.3	185	38	209	0.91
5421696	1.21	30.7	83.0	33.1	4.6	83.3	8.8	218	29	7.1	210	45	193	0.90
5421697	1.21	30.7	82.9	33.1	4.6	83.3	8.8	195	21	6.5	205	36	198	0.92
5421698	1.21	30.7	82.9	33.1	4.6	83.3	8.8	198	31	6.8	192	38	191	0.87

5421699	1.20	30.5	83.5	31.8	4.6	83.4	8.8	180	26	6.4	228	34	189	0.87
5421700	1.21	30.7	82.9	33.1	4.6	83.3	8.8	198	25	7.3	204	39	197	0.90
5421701	1.21	30.7	82.9	33.1	4.6	83.3	8.8	162	18	6.4	233	30	197	0.89
5421702	1.21	30.7	82.6	33.5	4.6	83.2	8.9	177	20	6.9	270	34	195	0.89
5421703	1.21	30.7	82.9	33.1	4.6	83.3	8.8	242	35	6.4	248	44	192	0.90
5421704	1.21	30.7	82.9	33.1	4.6	83.3	8.8	200	31	7.2	221	39	195	0.87
5421705	1.21	30.7	83.1	33.1	4.6	83.4	8.6	198	26	6.3	240	38	200	0.93
5421706	1.21	30.7	82.9	33.1	4.6	83.3	8.8	170	20	6.2	191	28	198	0.87
5421707	1.21	30.7	82.9	33.1	4.6	83.3	8.8	222	43	6.7	230	35	195	0.85
5421708	1.20	30.5	82.9	33.4	4.6	83.3	8.9	144	14	6.4	202	37	182	0.94
5421709	1.21	30.7	82.9	33.1	4.6	83.3	8.8	196	26	6.6	203	35	195	0.89
5421710	1.21	30.7	82.9	33.1	4.6	83.3	8.8	200	24	6.5	252	35	187	0.89
5421711	1.23	31.2	82.9	34.2	4.6	83.3	8.7	188	24	6.7	296	46	193	0.85
5421712	1.21	30.7	82.9	33.1	4.6	83.3	8.8	239	39	7.4	244	37	184	0.84
5421713	1.21	30.7	82.9	33.1	4.6	83.3	8.8	188	28	6.8	173	38	198	0.89
5421714	1.21	30.7	82.5	33.0	4.6	83.0	9.1	195	26	6.3	218	37	186	0.91
5421715	1.21	30.7	82.9	33.1	4.6	83.3	8.8	174	21	6.4	200	35	195	0.88
5421716	1.21	30.7	82.9	33.1	4.6	83.3	8.8	206	21	8.4	218	29	200	0.90
5421717	1.21	30.7	82.0	31.9	4.6	83.9	9.3	187	22	6.7	230	34	199	0.90
5421718	1.21	30.7	82.1	32.6	4.6	83.9	9.3	186	28	7.2	185	29	198	0.84
5421719	1.21	30.7	82.1	32.6	4.6	83.9	9.3	221	31	7.2	173	38	192	0.91
5421720	1.22	31.0	82.0	32.6	4.6	83.9	9.1	185	20	6.4	184	32	200	0.88
5421721	1.21	30.7	82.1	32.6	4.6	83.9	9.3	217	27	7.0	244	37	198	0.87
5421722	1.21	30.7	82.1	32.6	4.6	83.9	9.3	192	26	6.8	242	31	197	0.85
5421723	1.22	31.0	81.0	32.8	4.6	83.7	9.3	222	30	7.5	258	40	198	0.93
5421724	1.21	30.7	82.1	32.6	4.6	83.9	9.3	226	37	8.0	222	43	196	0.93
5421725	1.21	30.7	82.1	32.6	4.6	83.9	9.3	219	27	6.2	258	38	190	0.90
5421726	1.20	30.5	81.2	32.7	4.5	83.6	9.2	220	33	6.5	188	32	187	0.92
5421727	1.21	30.7	82.1	32.6	4.6	83.9	9.3	196	28	6.9	208	34	200	0.91
5421728	1.21	30.7	82.1	32.6	4.6	83.9	9.3	221	32	7.2	244	42	193	0.86
5421729	1.20	30.5	82.8	33.2	4.5	83.9	9.4	197	29	7.3	208	41	188	0.88
5421730	1.21	30.7	82.1	32.6	4.6	83.9	9.3	228	28	7.4	236	36	193	0.96
5421731	1.21	30.7	82.1	32.6	4.6	83.9	9.3	222	26	6.6	234	41	193	0.87
5421732	1.21	30.7	81.8	32.6	4.6	84.1	9.1	200	22	6.7	196	31	208	0.93
5421733	1.21	30.7	82.1	32.6	4.6	83.9	9.3	186	18	6.7	198	32	187	0.89

5421734	1.21	30.7	82.1	32.6	4.6	83.9	9.3	224	27	7.0	225	35	203	0.94
5421735	1.22	31.0	82.7	33.2	4.5	83.6	9.3	237	36	6.2	138	29	198	0.92
5421736	1.20	30.5	81.7	32.3	4.6	84.2	9.5	198	24	6.5	204	36	200	0.85

Table II – Lot 2

	HVI							AFIS					Cottonscan	Calculated
Bale Number	Length inch	Length mm	Length Uniformity	Strength g/tex	Micronaire	Colour Rd	Colour b+	Neps/ gram	SCN/ gram	SFC/ (w)	Dust/ gram	Trash/ gram	Fineness mtex	Maturity
2465939	1.26	32.0	82.6	31.5	3.6	80.5	7.6	303	15	8.5	414	65	183	0.70
2465940	1.26	32.0	82.5	31.5	3.6	81.6	7.5	267	11	8.3	544	63	183	0.70
2465941	1.26	32.0	82.5	31.5	3.6	81.6	7.5	269	19	7.8	407	55	183	0.70
2465942	1.26	32.0	82.1	31.8	3.6	80.7	7.4	335	16	11.1	270	40	194	0.66
2465943	1.26	32.0	82.5	31.5	3.6	81.6	7.5	312	22	8.2	439	74	183	0.70
2465944	1.26	32.0	82.5	31.5	3.6	81.6	7.5	279	20	8.8	458	65	188	0.68
2465945	1.26	32.0	82.5	32.7	3.6	81.9	7.5	288	22	8.3	401	52	182	0.71
2465946	1.26	32.0	82.5	31.5	3.6	81.6	7.5	318	20	9.3	374	53	191	0.67
2465947	1.26	32.0	82.5	31.5	3.6	81.6	7.5	277	19	7.9	412	60	185	0.69
2465948	1.26	32.0	82.4	29.8	3.6	81.6	7.5	278	16	7.9	448	72	185	0.69
2465963	1.26	32.0	81.9	31.1	3.6	82.2	7.5	279	18	7.7	398	50	187	0.69

Table III – Lot 3

Bale Number	HVI							AFIS					Cottonscan	Calculated
	Length inch	Length mm	Length Uniformity	Strength g/tex	Micronaire	Colour Rd	Colour b+	Neps/ gram	SCN/ gram	SFC/ (w)	Dust/ gram	Trash/ gram	Fineness mtex	Maturity
2465964	1.27	32.3	82.7	32.7	3.6	82.2	7.5	285	20	8.0	453	61	187	0.69
2465965	1.27	32.3	82.7	32.7	3.6	82.2	7.5	318	22	9.3	410	62	184	0.70
2465966	1.27	32.3	82.7	32.7	3.6	82.2	7.4	284	18	8.0	464	67	185	0.69
2465967	1.27	32.3	82.7	32.7	3.6	82.2	7.5	299	16	8.1	446	58	183	0.70
2465968	1.27	32.3	82.7	32.7	3.6	82.2	7.5	310	19	8.6	386	57	185	0.69
2465969	1.29	32.8	84.0	33.5	3.6	82.2	7.5	318	19	7.7	452	51	186	0.69
2465970	1.27	32.3	82.7	32.7	3.6	82.2	7.5	296	20	7.9	406	58	179	0.72
2465971	1.27	32.3	82.7	32.7	3.6	82.2	7.5	300	24	7.9	398	55	184	0.70
2465972	1.28	32.5	83.2	32.0	3.6	82.4	7.5	281	22	8.6	421	46	187	0.69
2465973	1.27	32.3	82.7	32.7	3.6	82.2	7.5	288	20	8.4	425	58	185	0.69
2465974	1.27	32.3	82.7	32.7	3.6	82.2	7.5	332	19	8.5	448	47	179	0.72
2465975	1.25	31.8	80.5	33.4	3.6	82.2	7.5	302	22	8.6	373	53	185	0.69
2465976	1.27	32.3	82.7	32.7	3.6	82.2	7.5	307	14	8.8	470	67	184	0.70
2465977	1.27	32.3	82.7	32.7	3.6	82.2	7.5	279	12	8.3	445	69	182	0.71
2465978	1.25	31.8	83.0	33.4	3.6	82.0	7.5	306	21	9.5	470	64	183	0.70
2465979	1.27	32.3	82.7	32.7	3.6	82.2	7.5	289	16	8.4	513	60	185	0.70
2465980	1.27	32.3	82.7	32.7	3.6	82.2	7.5	284	12	8.2	465	62	181	0.71
2465981	1.28	32.5	83.3	32.6	3.6	81.9	7.6	270	19	8.3	394	53	191	0.67
2465982	1.27	32.3	82.7	32.7	3.6	82.2	7.5	316	20	8.5	476	67	180	0.71
2465983	1.27	32.3	82.7	32.7	3.6	82.2	7.5	272	23	11.5	248	29	193	0.66
2465984	1.27	32.3	82.7	32.7	3.6	82.5	7.6	294	26	11.2	274	38	207	0.62