CRDC Project: Variety Trials 2004

Project reference No: CTFT 10

Report on Variety Trials for 2004

Marinus H. J. van der Sluijs and Stuart G. Gordon
CSIRO Textile and Fibre Technology, Geelong

Summary

This pilot study involved the processing of five bales of cotton, representing three varieties i.e. Sicala 350B, Sicala 60BR and Sicot 289BR, into ringspun carded and combed yarns to determine their textile processing performance. The results indicate that the yarns and fabrics produced from Sicala 350B were better then those produced from Sicala 60BR and superior to those produced from Sicot 289BR. The study did highlight that agronomic and ginning variables should be controlled as they have a large impact on each variety's fibre properties and processing performance.

Introduction

There is no doubt that the Australian cotton industry has seen phenomenal growth over the past 30 years, growing from a small lower-quality crop, to a large high-yielding, premium crop with export earnings in excess of $1.5B/annum. Australian cotton is viewed worldwide as a quality fibre and is purchased for spinning high quality fine count yarns.

CSIRO plant breeders have made a major contribution to the Australian Cotton Industry by successfully breeding high quality and yielding varieties. New varieties are selected on the basis of plant vigour, yield, disease resistance and fibre quality. One criterion missing from selection trials has been the textile processing ability of new varieties. The importance of knowing how well a variety of cotton will process is highlighted by recent negative comments facing Australian fibre quality with regards to nep, short fibre and high micronaire values, and by the increased competition in the high-medium export quality market coming from the USA.

To this end CSIRO Plant Industry (CPI), Cotton Seed Distributors (CSD) and the Cotton Research and Development Corporation (CRDC) identified three new varieties (Table I) ready to be introduced to the commercial market at CRDC's request. Bales of these varieties, grown at different locations, were processed into yarn and fabric at CSIRO Textile and Fibre Technology (CTFT)

in order to test their commercial processing ability and to obtain market support information.

With the international shift in focus to high quality fibre exports it is appropriate to extend the testing of new Australian varieties to textile processing trials under controlled conditions in order to determine directly the yarn and fabric quality that can be expected from them.

In these trials fibre from three 'new' varieties was spun into fine count carded and combed yarn and converted into knitted fabric. In part this project also has the objective of identifying a standard protocol for testing the processing performance and textile quality of 'new' varieties.

Methodology

Cotton lint

The choice of varieties, ginning and bales for the project was done outside of this project. This choice led to limitations on the interpretation of the data as described more fully below. Bales of each variety (Table I) were supplied to CTFT by CSD. The three varieties were grown during the 2004 season under 'commercial' growing conditions and ginned in commercial gins near each growing location.

Table I - Varieties processed and sites where grown.

Variety	Site
Sicala 60BR	Emerald
Sicot 289BR	Emerald
Sicala 350B	Condamine
Sicala 60BR	Dalby
Sicot 289BR	Dalby

Fibre Testing

Testing of fibre (and sliver) samples was extended considerably beyond normal commercial tests on a single bale sample by High Volume Instrumentation (HVI). Replicate samples from each bale were sent to the Schlafhorst Texlab in Mönchengladbach, Germany for tests to determine HVI properties, nep, trash and short fibre content by the Advanced Fibre Information System (AFIS) and trash and dust by the Micro-Dust and Trash Analyser (MDTA). The HVI and AFIS results represent averages of thirty replicate samples drawn from each bale, while the MDTA represent an

average of six replicates. Samples were drawn from three locations within the bale; top, middle and bottom.

Textile Processing
The bales of cotton were processed using machines set to industry standard settings and production speeds. To minimise the cost of the project it was agreed that all the machine settings and speeds were to be kept constant through out the trial and were not optimised for individual varieties, despite knowledge of each variety's fibre properties. In retrospect this approach discriminated against some of the varieties tested here and it is recommended that machine settings be optimised according to the measured fibre properties as this would be the accepted practice in a high-quality spinning mill.

Figure 1 summarises the steps taken at CTFT to convert raw fibre into yarn.

Spinning trials were conducted using the ring spinning system, which continues to be the most dominant spinning system world wide and is the spinning system used predominately to spin Australian cotton into yarn. Fibre from each bale supplied was processed into two fine count carded and combed yarns, i.e. Ne 42 (14 tex) and Ne 35 (17 tex) using a twist factor (αm) of 120, (which can be considered to be an average value for twist insertion). Yarns were wound, cleared and waxed onto 1 kg packages. For each yarn count, spinning performance and yarn quality was measured.

The Ne 35 yarns (i.e. 5 carded and 5 combed yarns) were knitted on a HSRF Moorgate 12 gauge circular rib machine producing a 1x1 Rib fabric using a machine tightness factor of 14.6 cm/tex to produce a fabric weight of 228g/m^2. Fabric samples were bleached and dyed using a Mathis laboratory dyeing machine. Fabrics were scoured before bleaching and dyeing. The fabric was dyed using Cibacron Red LS-6G. The recipe appears in Appendix 1

.Yarn Testing
Yarns were tested at CTFT's National Association of Testing Authorities (NATA) accredited laboratory. Yarn was tested for evenness, hairiness and imperfections using an Uster Technologies 4-SX evenness tester and for tensile properties using the Uster Technologies Tensorapid 3 and Tensojet 3.

Fabric Testing
Greige (undyed) fabrics were tested at CTFT for fabric mass, air permeability and bursting strength.

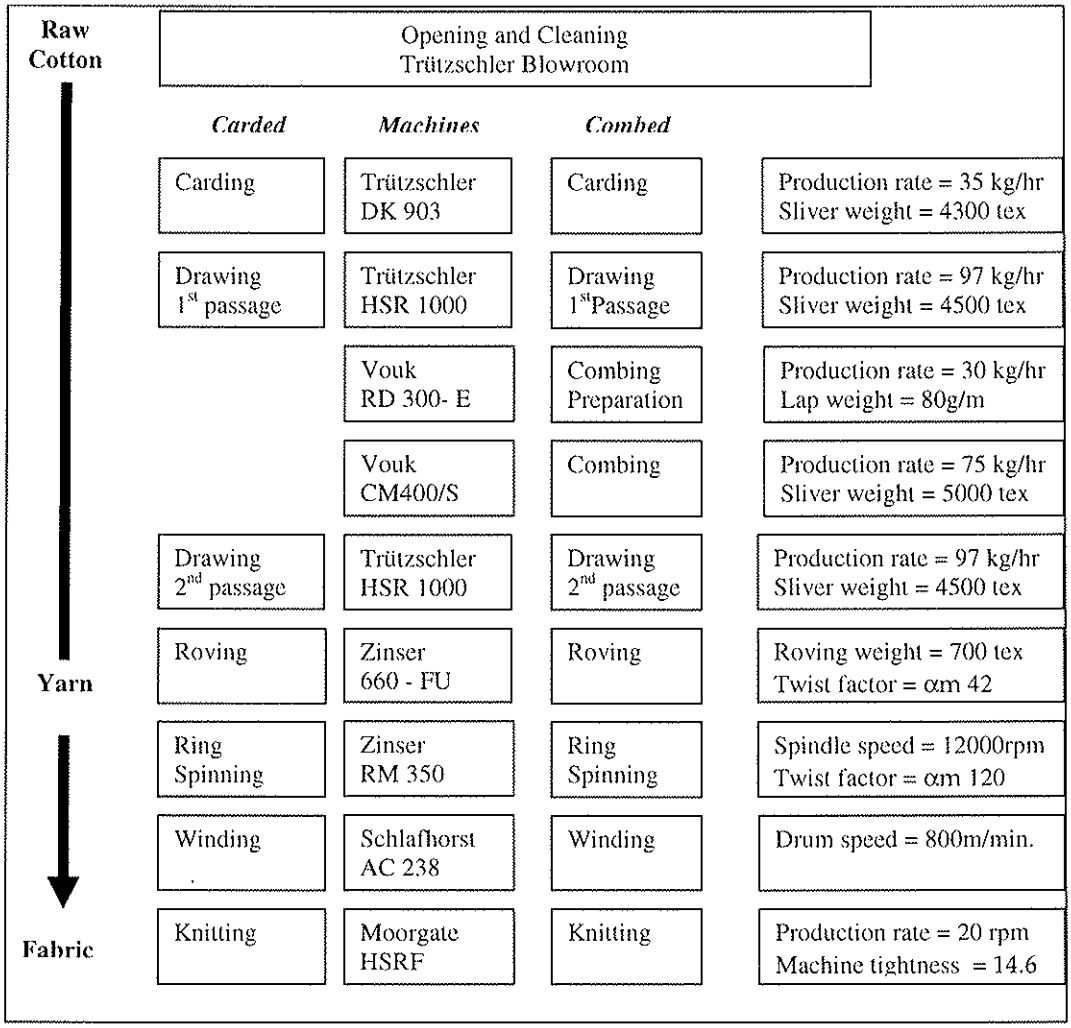

Figure 1 – Textile Processing Route

Results and Discussion

Fibre Quality

The fibre properties for the five bales are listed in Tables II to IV.

For ring spinning the most important fibre properties to achieve yarn quality standards and processing performance are considered to be staple length, strength and fineness. In addition, length uniformity, elongation, neps, short fibre content, trash and dust, maturity, dye ability, stickiness and contamination are also important.

Comparison of the fibre properties from each bale to the preferred values required by spinners, surveyed by CTFT [1] are listed in Table V. The comparison shows that in all cases the fibre properties of the Sicala 350B grown at Condamine exceeded the parameters required by spinners. The varieties grown at Dalby largely met spinner's requirements with the exception of the Sicala 60BR micronaire test value (4.58) and the Sicot 289BR length (28.14 mm) and micronaire (4.86) test values.

The two varieties grown in Emerald were both shorter than the spinners preferred length but still acceptable within the base staple length of 35 staple (at 28.27 mm for the Sicala 60BR & 28.38 mm for the Sicot) at the time. Both were also lower in strength (at 28.01 cN/tex for the Sicala 60BR & 28.43 cN/tex for the Sicot 289BR). Research experience [2] has shown that the same variety can have different fibre properties when grown at different locations due to the effects of local climates and soils. The shorter and weaker fibre in the Emerald cotton is attributed to the higher temperatures and possible heat and moisture stress experienced in Emerald during 2004/05.

The nep content and the short fibre index and trash content of all the bales were well within the preferred range. However, it is impossible to attribute the reasons for this as growing conditions and ginning processes were not controlled in this study.

Table VI lists the amount of trash, including short fibre and nep, extracted from the major cleaning and carding points for each variety. The data in this table should be compared against the trash (particle size > 500 micron) and dust (particle size > 15 micron) results from the bale in Table IV. The Sicala 350B and the Sicala 60BR grown at Dalby produced the least amount of waste in the mill, reflecting, in the case of the Sicala 350B, the low amount of trash in the bale and a good cleaning ability. In the case of the Sicala 60BR grown at Dalby, which contained the greatest amount of trash in the bale, a very good cleaning ability is evident.

No instrumentation is available to measure 'cleaning ability' which is dependent upon the source of trash, amount and size of trash particles as well as fibre surface properties such as specific surface area i.e., micronaire, stickiness and wax content.
The most waste was produced by the varieties grown at Emerald particularly the Sicot 289BR, which also had the highest SFI and the highest dust content. The relatively higher SFI and nep levels and dust content in the Sicot 289BR then perhaps reflects a harsher treatment of this fibre in the gin, and consequently the lower cleaning ability.

Table II– HVI 900[1] results of the five bales*

Variety	Location	Tenacity cN/tex	Elongation %	Length mm	Uniformity Index %	SFI %	Micronaire (µg/inch)
Sicala 60BR	Emerald	28.01	6.8	28.27	83.0	4.6	4.44
Sicot 289BR	Emerald	28.43	6.2	28.38	82.4	5.8	4.27
Sicala 350B	Condamine	29.04	7.0	31.72	85.2	3.3	4.16

Sicala 60BR	Dalby	29.42	6.3	29.33	82.9	4.6	4.58
Sicot 289BR	Dalby	28.98	6.9	28.14	82.4	5.3	4.86

[1]*Calibrated using HVI ICC calibration cotton.*

[*] *Average of 30 replicate bale samples*

Table III – AFIS results of the five bales[*]

Variety	Location	Neps Cnt/g	Nep Size %
Sicala 60BR	Emerald	198	770
Sicot 289BR	Emerald	218	762
Sicala 350B	Condamine	222	756
Sicala 60BR	Dalby	182	762
Sicot 289BR	Dalby	181	750

[*]*Average of 30 replicate bale samples*

Table IV – MDTA 3 results of the five bales[*]

Variety	Location	Trash %	Dust %
Sicala 60 BR	Emerald	1.361	0.042
Sicot 289 BR	Emerald	1.440	0.096
Sicala 350 B	Condamine	1.401	0.062
Sicala 60 BR	Dalby	1.814	0.057
Sicot 289 BR	Dalby	1.429	0.049

[*] *Average of 6 replicate bale samples*

Table V – Spinner's cotton fibre property requirements

Fibre Properties	Preferred Value
Micronaire	3.8 - 4.2
Length	>28.7 mm (1.13")
Uniformity	> 81%
SFI	< 8%
Strength	> 29 cN/tex
Neps	< 250 neps/g

Table VI – Percent Trash Extracted in the Blow Room and Carding

Variety	Location	Blow Room %	Carding %	Total %
Sicala 60 BR	Emerald	1.29	1.13	2.42
Sicot 289 BR	Emerald	1.79	0.86	2.65
Sicala 350 B	Condamine	1.13	0.57	1.70
Sicala 60 BR	Dalby	1.19	0.72	1.91
Sicot 289 BR	Dalby	1.48	0.70	2.18

Further indication that the Sicala 350B and the Sicala 60BR grown at Dalby were premium fibres is the fact that less noil was extracted during combing even though the comber was mechanically set to extract 17 – 20% noil. Table VII lists the amount of noil extracted at the comber for each growth. Noil is expressed as percentage of the weight of fibre processed. The results for the two varieties reflecting the good length and length uniformity, low short fibre, nep and strength of the fibre.

Table VII – Percent Noil Extracted in Combing

Variety	Location	Noil %
Sicala 60BR	Emerald	19
Sicot 289BR	Emerald	19
Sicala 350B	Condamine	14
Sicala 60BR	Dalby	15
Sicot 289BR	Dalby	18

Yarn quality

The yarn results achieved for the Ne 35 and Ne 42 carded and combed yarns are listed in Tables VIII and IX.

As expected the most even carded yarns were produced from the Dalby Sicala 60BR and Sicala 350B reflecting the fine, long and strong fibre. The evenness and hairiness values for these varieties are similar, with Sicala 60BR obtaining

better results for total imperfections, i.e. the number of thin and thick places and neps. These were followed in order of quality by the Dalby Sicot 289BR and the Sicot 289BR and Sicala 60BR varieties grown in Emerald.

Sicala 350B produced by far the strongest carded yarns being 2 to 3 cN/tex stronger than yarns spun from the other varieties reflecting its better length, fineness and strength. The Sicala 350B also had the lowest variation in yarn strength and the highest elongation. In terms of strength, the Sicala 350B was followed by the varieties grown in Dalby and then those grown in Emerald. The poorer results of the Dalby Sicot 289BR and the two varieties from Emerald are associated with the higher CV% of tenacity, which coincides with the higher number of thin places found in these yarns. These results in turn reflect the poorer fibre properties of these varieties.

Table VIII Carded yarn results for the five bales

Instrument & Measurement	Sicala 60BR Emerald		Sicot 289BR Emerald		Sicala 350B Condamine		Sicala 60BR Dalby		Sicot 289BR Dalby	
	42Ne	35Ne	42Ne	35Ne	42Ne	35Ne	42Ne	35Ne	42Ne	35Ne
Uster Technologies 4-SX										
Evenness										
Mean linear irregularity U %	16.12	15.45	16.37	15.59	14.96	14.26	14.88	13.94	16.03	15.20
Coefficient of variation CV %	20.72	19.79	21.09	20.01	19.27	18.29	19.11	17.82	20.57	19.45
Thin places - 50 % /1000	186	133	191	123	63	43	80	35	185	111
Thick places + 50 % /1000	1282	999	1362	1040	957	722	258	578	1192	907
Neps + 200 /1000	1594	1144	1880	1277	1538	1116	1086	627	1346	897
Hairiness										
Hairiness H	5.91	6.50	6.18	6.70	5.47	5.90	5.78	6.25	6.0	6.49
Standard Deviation S_h	1.70	1.78	1.78	1.84	1.58	1.64	1.67	1.72	1.74	1.83
Uster Technologies Tensorapid										
Strength										
Breaking Tenacity cN/tex	12.77	12.35	12.53	12.21	16.42	15.85	14.87	14.71	12.83	12.27
CV % Tenacity	10.95	10.54	10.83	11.35	11.12	10.02	10.06	10.27	10.54	12.32
Breaking Elongation. %	4.16	4.27	3.94	3.89	4.59	4.68	4.21	4.43	4.06	4.40
CV % Elongation	12.36	9.47	9.96	9.23	10.12	7.94	9.84	8.76	10.43	10.60
Uster Technologies Tensojet 3										
Strength										
Breaking Tenacity cN/tex	14.44	14.41	14.95	14.71	18.29	18.32	17.60	16.69	15.09	14.64
CV % Tenacity	11.79	11.48	12.46	12.37	10.48	10.35	10.83	10.72	12.20	12.09
Breaking Elongation %	3.68	3.86	3.75	3.81	4.26	4.43	4.02	3.81	3.80	4.08
CV % Elongation	11.45	9.76	10.89	9.35	9.26	9.54	10.17	9.82	11.22	10.97

As per the case with carded yarns the combed yarns followed a similar pattern. The most even combed yarns were produced from the Dalby Sicala 60BR followed by Sicala 350B. The evenness and hairiness values for these varieties are similar but the total imperfections, i.e. the number of thin and thick places and neps for Sicala 350B is somewhat higher compared to the other varieties. This might be explained by the fact that machine settings i.e., comber and drawframe settings, were not optimised for processing the longer

Sicala 350B fibre. These varieties were then followed by the Dalby Sicot 289BR and the varieties grown in Emerald.

Sicala 350B produced by far the strongest combed yarns (3 to 4 cN/tex stronger) with the lowest variation in strength and the highest elongation, and again reflecting the superior properties of this variety grown at Condamine. The other varieties generally followed in a similar order as per the carded yarns.

Table IX Combed yarn results for the five bales

Instrument & Measurement	Sicala 60BR Emerald		Sicot 289BR Emerald		Sicala 350B Condamine		Sicala 60BR Dalby		Sicot 289BR Dalby	
	42Ne	35Ne	42Ne	35Ne	42Ne	35Ne	42Ne	35Ne	42Ne	35Ne
Uster Technologies 4-SX										
Evenness										
Mean linear irregularity U %	12.73	12.22	12.42	12.03	12.45	11.77	12.25	11.61	12.49	12.13
Coefficient of variation CV %	16.25	15.52	15.91	15.34	15.92	15.00	15.59	14.73	15.91	15.39
Thin places - 50 % /1000	22	8	13	7	10	5	12	6	18	11
Thick places + 50 % /1000	337	198	314	212	342	208	50	137	267	190
Neps + 200 /1000	521	281	554	363	622	398	350	183	355	225
Hairiness										
Hairiness H	5.50	5.98	5.51	6.08	5.04	5.53	5.35	5.85	5.47	5.97
Standard Deviation S_h	1.70	1.53	1.46	1.55	1.33	1.40	1.42	1.50	1.45	1.5
Uster Technologies Tensorapid										
Strength										
Breaking Tenacity cN/tex	14.45	14.53	14.19	14.50	17.26	18.58	14.78	15.04	14.44	14.50
CV % Tenacity	9.47	9.00	9.78	9.80	8.57	8.37	9.43	8.81	10.93	9.61
Breaking Elongation. %	4.39	4.86	4.01	4.51	4.76	5.52	3.79	4.03	4.24	4.70
CV % Elongation	9.45	7.02	9.47	8.22	7.25	6.28	9.51	11.11	10.05	8.69
Uster Technologies Tensojet 3										
Strength										
Breaking Tenacity cN/tex	16.93	16.81	17.35	17.20	20.27	20.53	17.18	17.80	16.69	16.65
CV % Tenacity	10.20	9.83	10.90	10.09	9.18	8.37	11.00	10.25	10.80	10.56
Breaking Elongation %	4.24	4.45	3.94	4.22	4.60	4.95	3.58	3.79	4.05	4.23
CV % Elongation	9.68	8.47	10.8	8.77	8.71	7.17	10.28	10.71	10.08	9.46

A comparison of the yarn test results to the current Uster Statistics of 2001 [3] shows that, with the exception of thick places and neps, the quality of the yarn produced (both carded and combed) from Sicala 350B and Sicala 60BR from Dalby were considered on par with the average quality i.e., the 50 percentile line, for yarn produced world wide. *Note that comparisons of yarn quality with Uster Statistics are not rigorous as the Statistics make no allowance for the amount of twist inserted or the route taken to prepare fibre for spinning. Improvements to quality can be made, as mentioned already, by optimising drawframe and comber settings.*

The yarn strength for all varieties tested was more than adequate for processing the yarn into knitted fabric (where a minimum of 11 cN/tex is

required). The strength of yarns produced from Sicala 350B is considered to be above the average quality produced world wide, which is a major advantage for yarns destined for quality apparel end-uses.

Spinning End Breaks

Another important measure of cotton lint quality is its processing performance. The recording of end breakages is an important issue as it indicates whether production levels and quality standards can be achieved.

The processing performance of the carded yarns produced from Sicala 350B and the Dalby Sicala 60BR (see Table X) were excellent with end break rates per 1000 spindle hours (/1000 SpH) recorded at 30 breaks/1000 SpH for carded yarns produced from these varieties. The end break rates for the Dalby and Emerald Sicot 289BR were slightly higher, with the end break rates for the Emerald Sicala 60BR being too high (> 40 breaks/1000 SpH and possibly due to the higher CV % of tenacity and low elongation) and unacceptable to a commercial spinning mill. The processing performance of the combed yarns produced from all the varieties were excellent with end break rates per 1000 spindle hours (/1000 SpH), for the combed yarns at 20 breaks/1000 SpH.

Table X– End break rates per 1000 spindle hours

Variety	Location	Carded		Combed	
		42Ne	35Ne	42Ne	35Ne
Sicala 60BR	Emerald	96	45	22	15
Sicot 289BR	Emerald	41	35	22	15
Sicala 350B	Condamine	28	32	20	21
Sicala 60BR	Dalby	32	26	11	10
Sicot 289BR	Dalby	36	30	18	16

Fabric Quality

Knitted fabrics were produced from the Ne 35 (17 tex) carded and combed yarns and subject to standard bursting pressure and air permeability tests (Table XI). Fabric burst pressure results, which is an indication of fabric strength, typically follow yarn tenacity results. As expected the fabrics knitted from Sicala 350B and Sicala 60BR grown in Dalby have the highest bursting results (up to 200 KPa higher) followed by fabrics constructed from the varieties grown in Emerald and followed by Sicot 289BR from Dalby.

The air permeability test, which is a measure of the rate of air flow passing perpendicular through a known area of fabric under a prescribed air pressure

differential, gives an indication of comfort. The results generally follow in a similar order as per the bursting strength results with the fabric with high bursting strength results generally letting through less air flow.

Table XI – Rib (Griege) Fabric test results

Fabric Property	Sicala 60BR Emerald		Sicot 289BR Emerald		Sicala 350B Condamine		Sicala 60BR Dalby		Sicot 289BR Dalby	
Carded/Combed	35Ne	35Ne	35Ne	35Ne	35Ne	35Ne	35Ne	35Ne	35Ne	35Ne
Bursting Pressure (KPa)	560	681	548	663	708	799	722	800	514	588
Air Permeability cm^3/cm^2sec	139	135	120	133	135	139	127	130	144	144

Conclusion

The aim of variety trials is to determine the textile processing performance of varieties that CSIRO plant breeders have selected for commercialisation. The results of these processing trials will enable varieties to be selected not only to serve the grower at the farm gate and gin door but will also to satisfy the needs of their ultimate customers, the spinner and retail consumer.

The variety trials for 2004 consisted of Sicala 350B (grown in Condimine) and the Sicala 60BR and Sicot 289BR varieties (grown in Dalby and Emerald). The fibre properties obtained for Sicala 350B and to a slightly lesser degree Sicala 60BR, grown in Dalby, were superior to those achieved for Sicala 60BR grown in Emerald and Sicot 289BR grown in Emerald and in Dalby. The superior fibre properties of Sicala 350B and the Dalby Sicala 60BR resulted in yarns with good evenness and hairiness results, excellent yarn strength, good processing performance and good fabric strength. The fibre properties obtained for Sicala 60BR and Sicot 289BR grown in Emerald had poorer fibre length and strength which resulted in yarns with poorer evenness, hairiness, strength and poor processing performance, and low fabric strength.

This variety trials project is a pilot project the results and protocol of which can be used to build on in future trials. Information from these trials would be further enhanced by controlling the agronomic and ginning processes, which also have a significant impact on fibre quality and textile performance. These variables will be controlled to a greater extent in the new CCC CRC Linking Farming Systems to Fibre Quality and Textile Performance project. Further information on the fibre properties could also have been gleaned had the project followed the original proposal and conducted more in depth spin limit trials. Further testing on fabric such as to determine lustre, dye ability and white speck should also be incorporated in future variety trials.

This information is important to the plant breeders and the Australian cotton industry as it provides further data on the overall performance of varieties before they are commercially released. This will contribute to the sustainability, competitiveness and growth of the Australian cotton industry which faces increased competition.

Recommendations

I. Production and environmental variables be controlled in future investigations of a variety's textile performance.
2. Machine settings optimised according to measured fibre properties.
3. Adjust machinery until CV % of evenness is at minimum.

References

1. 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.
2. Constable, GA, Llewellyn, D, Reid, PE and Stiller. Breeding fibre for the future. Proceedings of the 11th Australian Cotton Conference. pp 35-40. Brisbane 13-15 August 2002. ACGRA.
3. Uster Statistics 2001, December 2001

Acknowledgements

The author gratefully acknowledges the financial support of CSIRO Textile and Fibre Technology and the Cotton Research and Development Corporation. The support of Dr. Geoff Naylor, Dr. Greg Constable and the assistance of Stephen Ash, Mark Freijah, Fred Horne, Jan Hair, Anne Parnell and Peter Herwig in processing the bales of cotton through the various production stages are also gratefully acknowledged.

Appendix 1

Bleaching and Dyeing for Variety Trials 2004

Machine
All work was carried out in a Mathis laboratory dyeing machine at a speed of 25 RPM and a liquor ratio of 10:1.

Scour Method
Bath set at room temperature with

Albatex FFC	0.25 g/l
Texal HZ	2.0g/l
Irgasol CO new	1.0g/l
Caustic Soda	2.5 g/l

Heated to 100°C at 3°C/min and held for 30 minutes cooled to 80°C and drained.

Rinsed for 10 minutes at 50°C, drained.
Rinsed cold for 10 minutes
Rinsed in 0.5 g/l Acetic acid at 50°C for 15 minutes, drained.
Rinsed cold for 10 minutes, drained.

Bleach Method
Bath set at room temperature with

Baysolex EXD-N	1.0g/l
Stabiliser 9188	0.5g/l
Blankophor BA Blue liq.	0.6g/l
Hydrogen Peroxide (30%)	6.0g/l
Caustic soda pellets	1.6g/l

Ran for 10 minutes at 30°C, temperature raised to 103°C at 2°C/min. and held for 30 minutes.

Cooled to 60°C and drained.

Rinsed twice at room temperature.

Dyeing Method
Bath set at 30°C with
Albatex FFC 0.25 g/L
Lyoprint RG granules 3.0 g/L
Sodium Sulphate 20 g/ L
Acetic acid pH 6.0
Ran for 10 minutes, dye added and held for a further 10 minutes.
Heated to 90°C at 1°C/ minute and held for 30 minutes
Cooled to 70°C
Sodium Carbonate 12 g/L
Added in 3 equal additions 5 minutes apart
Ran for 45 minutes at 70°C
Drained
Rinsed at 55°C for 10 minutes, drained.
Rinsed cold for 10 minutes in
Acetic acid 1.0 g/L
Drained.
Rinsed cold, drained.
Soap Off:-
Bath set with
Delinol VB-LU 1 g/L
Heated to 90°C and ran for 15 minutes Cooled to 60°C and drained.
Rinsed at room temperature twice.

Dye
Cibacron Red LS-6G 4%

Discussion
All fabrics were scoured prior to bleaching or dyeing. The fabrics were treated in pairs (i.e. Carded and combed fabric of a variety) in same bath. All bleached samples were of a similar whiteness and the dyed samples appeared even and of a similar depth of shade but no measurement of colour difference were taken.