Management for premium cotton fibre

Robert Long[1] and Michael Bange[2]

[1]CSIRO, Manufacturing, P.O. Box 21,Belmont VIC 3216, Robert.long@csiro.au
[2]CSIRO, Agriculture, LMB 59, Narrabri, NSW 2390, Michael.bange@csiro.au

Abstract
Cotton fibre quality is affected by a large number of interacting factors; cultivar, seasonal conditions, crop and harvest management, and ginning. These can all determine whether or not the spinner's requirements are met. With the advent of premium fibre varieties, there may be a need to have tailored management regimes so growers attract the maximum return for production to offset lower lint yields. A large scale field experiment was conducted in Narrabri to establish the value of specific pre- and post- harvest management practices to deliver high quality cotton. The experiment used the cultivars Sicala 340BRF (a premium fibre type) and Sicot 74BRF (popular industry cultivar) grown with two management regimes ('standard' and 'wise' management). The wise management treatment involved targeted irrigations at flowering, a later defoliation (avoiding use of boll opening chemical) and using late season growth regulator to ensure that crop maturity avoided inclement weather. Following harvest, cotton was also subjected to zero and two lint cleaning passages to remove foreign material at ginning. As expected the premium fibre cultivar yielded less and produced fibre of better quality. Under the wise infield management system fibre was longer and was lower in the incidence of fibre entanglements (neps). Extra lint cleaning passages lowered trash content improving quality, however reduced yield and fibre length, and increased neps. While this research demonstrates that there are combinations of pre- and post- harvest management practices that can influence quality without affecting yield, further research is required to establish the relative economic and agronomic benefits of adopting these practices to enhance fibre quality alone.

Key words
Cotton, fibre, quality, management, post-harvest

Introduction
Australian cotton is already purchased for a premium as it meets spinner's requirements on the basis of quality and consistency. Fibre quality is affected by a large number of interacting factors: variety, climate, in-season management, harvesting and post-harvest ginning practices. While some of these factors cannot be controlled, there are many that can. Fortunately the majority of crop management factors which increase/optimise yield will also increase/optimise fibre quality. Indeed with the advent of specific premium fibre varieties there may be a need to have tailored management regimes to ensure that these varieties produce premium quality cotton. Through better understanding of the nature of fibre and the factors that affect its quality, improved cultivars, management for each region's climate, and processing to minimise damage to fibre are all opportunities to improve the quality of fibre delivered to mills.

Since the fibre is primarily cellulose, any influence on plant photosynthesis and production of carbohydrate will have a similar influence on fibre growth. Cell expansion during growth is strongly driven by turgor, so plant water relations (irrigation) will also affect fibre elongation in the period immediately following flowering. Early crop defoliation or leaf removal can cause substantial reductions in fibre micronaire due to the cessation in carbohydrate supply for fibre thickening. Few agronomic or climatic conditions have been shown to consistently affect fibre strength. Any management which delays crop maturity can lead to reduced micronaire and more neps (Bange et al. 2010), as well as lower grades from discolouration and increases in leaf material (Bednarz et al. 2002), all due to exposure of a greater proportion of a crop to unfavourable conditions such as cooler or cloudy weather.

The post harvest ginning process transforms the cotton into a marketable commodity by removing the lint from the seed and removing foreign material. Ginners are faced with often conflicting objectives: the need to maximize gin outturn to increase lint yield for growers; to minimize impact on fibre quality to meet the needs of the spinners; and optimizing gin throughput and operating efficiencies. As the ginning process will impact on fibre quality (Anthony, 1999), any operation in the gin should be bypassed in an attempt to preserve quality if the cotton does not need specific treatment, a particular process that is a focus of fibre preservation is the use of a different number of lint cleaners (Long et al. 2010).

This paper presents yield and fibre quality results of large scale farming systems experiments will compare ± premium varieties, ± modified agronomy (including changes in irrigation, crop cessation and defoliation management) and ginning ± lint cleaning. Improving the understanding of the links between production, harvest, ginning and textile processing will facilitate better crop management recommendations to ensure Australian cotton exceeds market expectations.

Methods

Cultural Details

A large scale field experiment was conducted at Narrabri NSW Australia to assess practices tailored to deliver better fibre quality. Cultivars Sicot 74BRF and Sicala 340BRF (both CSIRO, Australia) were planted 13 Oct. 2010 and grown with high input management and insect control. Sicot 74BRF is a popular high yielding cultivar, while Sicala 340BRF is a lower yielding (by approx. 6 %) cultivar that has better fibre properties (3% longer and stronger fibres, respectively, and lower micronaire 4.4%) (CSD, 2014). A split plot design with four replicates and 583 m long by 4 m wide (4 rows) plots were used. The main plots were two management treatments ('wise' and 'standard') and sub plots were cultivars. There was an eight row buffer between main plots.

The wise treatment was intended to enhance fibre quality, while the standard treatment used current industry practice. The differences in the wise treatment compared with the standard treatment were as follows: 1. An extra irrigation was applied during flowering to assist in fibre elongation; 2. The growth regulator mepiquat choride was applied (22 Feb 2011) around the time of the estimated average last effective flower date (27 Feb) to assist the crop maturing at the appropriate time to avoid inclement weather at the end of the season; and, 3. Avoiding the early use of harvest aids at the end of the season that cause bolls to open prematurely, thus increasing the risk of lower micronaire cotton and higher nep counts.

At the end of the season (11 Jun 2011) the middle two rows of each plot were harvested using a spindle picker. All harvested seed cotton from each plot was collected and ginned at CSIRO's post harvest cotton research facility in Belmont, Geelong. Seed-cotton from each plot was then subjected to either zero or two lint cleaning passages. Lint cleaning is an additional process undertaken at ginning that aims to further remove trash from cotton.

Measurements and statistics

Once ginning had been completed an estimate of plot lint yields were calculated. During the ginning process lint was sub-sampled (approximately 15 x 20g lots) for each plot and lint cleaning treatment. These samples were then recombined and thoroughly mixed and re-sampled twice, and so ensuring a sampling precision greater than that used commercially for the High Volume Instrument (HVI) testing of fibre. Lint samples were subjected to quality assessment using a HVI 1000 instrument to measure upper half mean length (mm), strength (cN tex^{-1}), and micronaire (no units). Samples were also subjected to testing via an Advanced Fibre Information System (AFIS PRO) instrument to measure total neps (count g^{-1}) and total trash (count g^{-1}). Data was analysed using ANOVA and a split-split plot design, where lint cleaning treatments was the sub-sub plot.

Results and discussion

For yield, Sicot 74BRF yielded 7% more fibre compared with the premium cultivar Sicala 340BR, which was in line with other yield results for these cultivars (Table 1). There was an interaction between infield management practice and ginning treatment. The wise treatment 2LC had a greater reduction in yield (6.9%) compared with lint cleaning using the standard treatment (5.3%). As expected, lint cleaning greatly reduced yield because a large amount of trash was removed that did not contribute to the weight of baled fibre. For example, lint cleaning reduced AFIS trash by 47% for Sicot 74BRF and by 54% for Sicala 340BRF. The lint cleaning process is also the most mechanically intensive in the cotton post-harvest processing and this was evident by a reduction in fibre length (1.2%) and a 27% increase in total neps. As hypothesised the infield management treatment did not affect yield, but did affect some fibre quality attributes.

Table 1. Effect of cultivar (Sicala 340BRF, Sicot 74BRF), management treatment (wise and standard), and ginning treatment (OLC – no lint cleaning, 2LC – two lint cleaners applied at ginning) on cotton yield and fibre quality traits. Only significant main effects and highest order interactions are shown.

Variable	Ginning Treatment	Sicala 340BRF		Sicot 74BRF	
		Standard	Wise	Standard	Wise
Lint Yield (kg/ha)	0LC	2078	2193	2185	2390
	2LC	1968	2042	2079	2236
LSD (0.05)	Cultivar (C)		68**		
	Ginning Treatment (G)		14***		
	Management (M) x G		234**		
Fibre Length (mm)	0LC				
	2LC	32.37	32.79	31.54	31.92
LSD (0.05)		31.97	32.52	31.03	31.58
	Management		0.19**		
	Cultivar		0.25***		
	Ginning Treatment		0.19***		
Fibre Strength (grams tex^{-1})	0LC	34.94	35.59	32.71	33.23
	2LC	34.19	35.18	32.39	33.56
LSD (0.05)	Cultivar		0.15***		
Micronaire (no units)	0LC	4.30	4.29	4.54	4.49
	2LC	4.21	4.21	4.49	4.41
LSD (0.05)	Cultivar		0.06***		
	Ginning Treatment		0.05**		
Neps (count g^{-1})	0LC	203	196	183	181
	2LC	294	268	256	234
LSD (0.05)	Management		10*		
	Cultivar		15**		
	Ginning Treatment		13***		
Trash (count g^{-1})	0LC	1615	1702	1126	1209
	2LC	723	806	580	651
LSD (0.05)	Cultivar		85***		
	Ginning Treatments		76***		
	C x G		104***		

* Significant at the 0.05 level;** Significant at the 0.01 level;*** Significant at the 0.001 level

The wise management treatment significantly improved fibre length due to additional irrigation during the fibre elongation phase. Fibre elongation is associated with internal plant turgor pressure (Constable and Bange 2007) and this additional irrigation would have assisted in avoiding any stress that may have been encountered during this phase. This effect did not however translate into changes in yield.
As expected the premium cultivar Sicala 340BRF had longer fibres (2.8% longer) than Sicot 74BRF.

Micronaire was not influenced by infield management, which can be attributed to there being little effect of the defoliation treatment (no boll openers) on plants that had probably matured adequately before the application of the treatment. This ensured that fibres had adequate secondary cell wall cellulose deposition (fibre maturity) which influences micronaire (Bange et al. 2010). There were no significant differences between management treatments for micronaire. The significantly lower micronaire result for Sicala 340BRF is attributed to that cultivar being finer or having average fibre perimeter dimensions less than Sicot 74BRF. Lint cleaning affected micronaire because trash in a fibre sample contributes to the resistance of air during the micronaire measurement.

For neps, the longer and finer premium cultivar Sicala 340BRF had a greater propensity to buckle and knot and had 10.8% more total neps compared to the shorter and coarser Sicot 74BRF cultivar. Fibre maturity is also an attribute often reported as being related to neps because thinner cell walls make for fibre that has a greater propensity to break and entangle (Anthony et al. 1988). Here the infield management treatment did not change fibre micronaire (a measure of fibre maturity). In comparison the wise treatment reduced neps by 6% while simultaneously improving fibre length. The reduction in neps is attributed to the wise treatment also having better length uniformity (consistency of length) and less short fibre (% of fibres shorter than 12.7mm) (data not shown). Shorter and less uniform fibre populations are known to exhibit disproportionately more processing problems including neps. Fibre strength is also related to neps, but in this case there was no infield management effect on strength, although as predicted, Sicala 340BRF fibre was stronger than Sicot 74BRF fibre by 2 cN tex^{-1}.

Conclusion

In these studies there were consistent effects with current knowledge of premium fibre cultivars on yield and fibre quality. In-field management practices studied here did not affect yield but did improve fibre quality. An extra irrigation was required to improve fibre length but this did not improve yield. The economic and agronomic benefit of this practice still needs to be assessed against the improved fibre quality attained.

Additional lint cleaning passages after harvest did not improve either yield or quality. Consequently it is preferable to avoid lint cleaning passages. However, the impact of additional trash on cotton quality is still being assessed. Further research is being undertaken to evaluate these infield and post harvest treatments in other seasons, as well as the impact of these practices on final textile quality.

References

Anthony WS. (1999) Postharvest management of fiber quality. In: AS Basra (Ed.), Cotton Fibers Developmental Biology, Quality Improvement and Textile Processing, The Haworth Press, Binghamton NY. pp. 293-333.

Anthony WS, Meredith WR, and Williford J.R. (1988) Neps in ginned lint: The effect of varieties, harvesting, and ginning practices. Textile Research Journal. 58, 633-639.

Bange MP, Long RL, Constable GA, and Gordon SG. (2010) Minimizing Immature Fibre and Neps in Upland Cotton. Agronomy Journal. 102, 781-789.

Bednarz CW, Shurley DW, and Anthony WS. (2002) Losses in yield, quality, and profitability of cotton from improper harvest timing. Agronomy Journal. 94, 1004-1011.

Constable GA and Bange MP. (2007) Producing and preserving fibre quality: from the seed to the bale. In Proc. 4th World Cotton Conf. 10-14 Sep. 2007, Lubbock USA.

CSD (2014) ‘2014 variety trial results.’ (Cotton Seed Distributors: Wee Waa, NSW).

Long RL, Bange MP, Gordon SG, van der Sluijs MHJ, Naylor GRS, and Constable GA. (2010) Fibre Quality and Textile Performance of Some Australian Cotton Genotypes. Crop Science. 50, 1509-1518.