Linking farming systems to fibre quality and textile performance

By Robert Long, Mike Bange, Stuart Gordon, Marinus van der Sluijs and Greg Constable*

Australian cotton fibre is exported into a dynamic and competitive market and there is a need to ensure an ever-improving product to meet demand from spinners. Neps (fibre knots), short fibre (fibres shorter than 0.5 inches) and high micronaire are issues of concern for spinners of Australian cotton.

This means that fibre quality is just as important for maintaining the viability of the industry as cotton yield. Crop management and environment can significantly affect fibre quality. In addition, many processes occurring after the crop is harvested (such as ginning) can also cause a decline in fibre quality.

To fully reap the benefits of improved genetics and agronomic management options to improve fibre quality, there is a need to extend research efforts beyond the farm gate to cotton processing to ensure cotton produced in the field meets or exceeds market expectations in terms of quality. A new project initiated by the CSIRO, Cotton Catchment Communities CRC, and CRDC aims to strengthen cotton research efforts to understand the links between breeding, agronomic management and post harvest fibre quality, and to extend this knowledge to the industry to improve the overall quality of Australian cotton.

Information on fibre quality and processing performance is vital to breeders and agronomists so that they can determine which varieties and farm practices are most beneficial in producing a quality product. Information on the textile performance of new varieties can be used strategically in marketing.

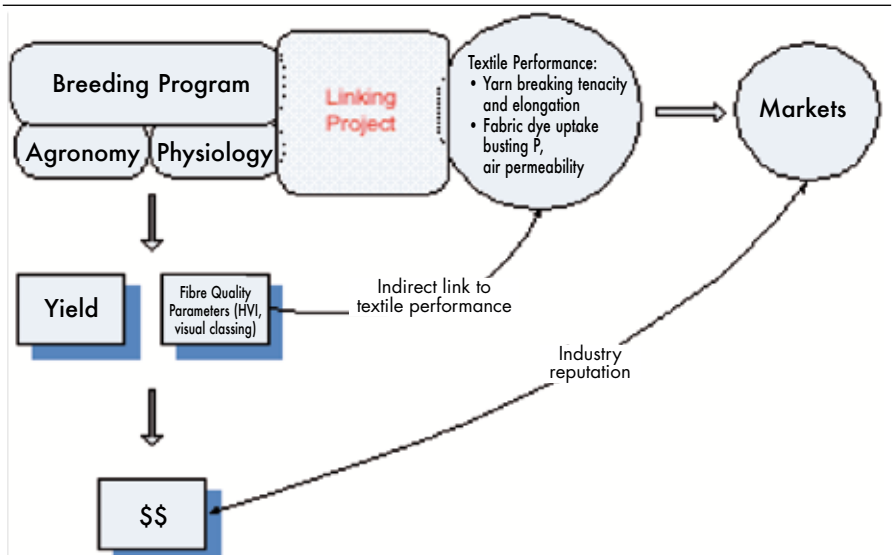
An additional scientific benefit is the development of consistent textile test protocols and a significant database that can be used to test new varieties and crop management strategies (Figure 1). The project will further support the use of other fibre quality parameters important in predicting or elevating textile performance — such as fineness, maturity, inter-fibre friction, fibre elongation, and cellulose and wax chemical properties that affect dyeing and chemical processing of fibre.

This article introduces a part of this project aimed at specifically comparing the performance of new elite cotton varieties with existing varieties to highlight improved fibre quality for cotton processing.

AT A GLANCE

- A new project has been initiated to identify linkages between on-farm crop management practices and the impact on fibre quality from a textile production perspective.
- Field studies in the 2005–06 season explored current and new elite cotton varieties grown under similar management, which were then processed into yarn and fabric using the same processes.
- New varieties from CSIRO's breeding program had improved yield, HVI quality, and are showing superior textile performance attributes.

FIGURE 1: A new project was initiated by the CSIRO, the cotton CRC and the CRDC to more cohesively link the research effort in the field with that in the textile mill



Variety selection

Five varieties were selected for the experiment, including three currently released varieties — Sicot 71BR, Sicala 350B and Pima CPX42. Sicala 350B and Pima were selected because of their superior fibre quality traits including long staple length and fineness which should contribute to improved textile production. Pima is especially long and fine compared to the upland varieties and typically is lower in micronaire (Table 1). Two unreleased upland varieties were also introduced — a Bollgard II (CHQX12B) and a conventional variety (CHQX377). Both also have superior fibre quality traits, while having good yield potential.

The experiment was conducted at the Australian Cotton Research Institute at Narrabri. The

five varieties were sown at the same time and grown with full irrigation, and pests were managed using requirements for the conventional varieties. Cotton was machine harvested with a universal single row spindle harvester. Upland varieties were saw ginned at Cotton Seed Distributors (CSD) in Wee Waa. A small sub-sample of Pima cotton was roller ginned using a laboratory roller gin at the ACRI.

Variety performance

Of the released varieties, Sicot 71BR yielded one bale per hectare more than Sicala 350B and was double the yield of Pima CPX42. The new Bollgard II variety, CHQX12B, was the highest yielding variety, producing more than Sicot 71BR, while the new conventional variety (CHQX377) yielded similar to Sicala 350B (Figure 2).

Both the new varieties have longer fibre length than Sicot 71BR, while the new conventional variety boasts similar fibre fineness to Sicala 350B. Interestingly, the conventional variety has similar micronaire to Sicot 71BR, and yet is as fine as Sicala 350B. This result demonstrates the downfall of the micronaire measure — CHQX377 and Sicot 71BR have similar micronaire yet are different in both fineness and maturity (Table 1).

TABLE 1: Length, micronaire (HVI), maturity (SiroMat) and fineness (CottonScan) for experimental varieties

	Length (inches)	Mic	Maturity ratio	Fineness (mtex)
Sicot 71BR	1.26	4.5	0.97	229
Sicala 350B	1.32	3.9	0.91	206
CHQX12B	1.29	4.1	0.94	220
CHQX377	1.27	4.4	0.91	205
PIMA CPX 42	1.46	3.6	0.73	168

All varieties exceeded spinner's minimum requirements for strength (>29 g/tex) with new varieties trending stronger than released upland varieties. Pima CPX42 produced the strongest fibres, but these fibres displayed inferior elongation properties compared to the upland varieties (Figure 3). Elongation is the percent elongation of a fibre bundle before it breaks.

Properties that affect the degree of nep formation include fibre maturity and fineness (micronaire is a product of these two attributes), low strength, length, high and low wax content and resistance to bending and twisting. The nep levels reported here are all below 250 count/g, which is indicative of the lack of lint cleaning in the ginning we employed.

Despite this, an interesting and encouraging result was that the new upland varieties trended lower in potential to nep compared to Sicot 71BR and Sicala 350B, even though they exhibited longer staple length than the industry standard Sicot 71BR (Figure 4).

The higher amount of nep for Pima CPX42 is most probably due to its long staple length, although the lower maturity for Pima (0.73) may have also contributed. Different management (allowing more time for fibre secondary wall development) may have produced more mature and thus more robust fibres with less potential to nep. We concede that for the experiment in the 2006–07 season, Pima CPX42 will require a different management strategy to the upland varieties.

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FIGURE 2: Yield for varieties grown together in Narrabri

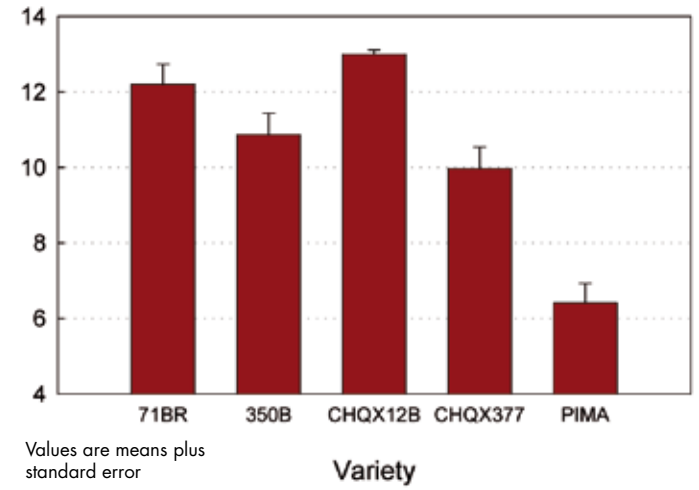
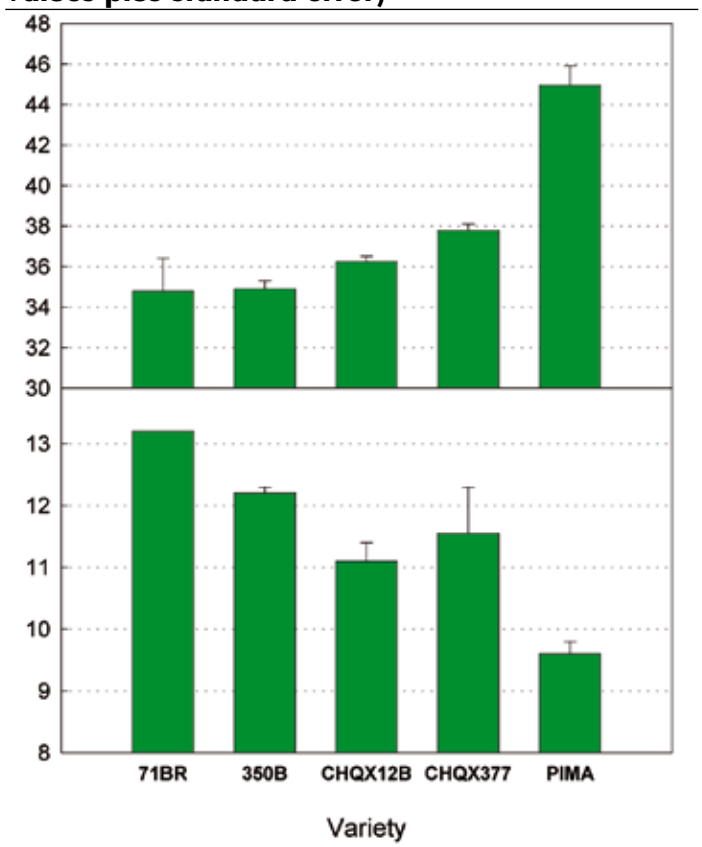


FIGURE 3: HVI elongation and strength (mean values plus standard error)



Variety performance in the mill

Logistical limitations prevented the large scale roller ginning of Pima CPX42 (and thus large scale mill processing). For upland varieties, cotton lint was subjected to full scale mill processing in two batches. One batch was carded, while the other was carded and then combed.

The carding process is the first step in yarn manufacture, and removes trash and some neps, and aligns and condenses fibres into the first sliver. Combing is an additional step that can be implemented after carding whereby carded sliver is delivered through a set of fine combs which removes additional neps, trash and short fibre (this waste is collectively called noil).

Following carding and/or combing, sliver was drawn, converted to twisted roving, and ring-spun 20 tex yarns were produced. Tex is a universal measure of sliver and yarn linear density, with one kilometre of a 20 tex yarn weighing 20 grams. A 20 tex yarn is a typical medium count range yarn.

Preliminary yarn quality results indicated that combed yarns outperformed carded only yarns (Figure 5). This was expected because of less noil in the combed sliver. It should be noted that combing is a more expensive production path because of the additional processing stages, which produce more waste. Combed yarns are only made from high quality cotton — more than 65 per cent of Australian cotton is used to make combed yarns.

For the current upland varieties, the premium Sicala 350B outperformed Sicot 71BR in terms of tenacity, reflecting Sicala 350B's longer staple length. Importantly the new Bollgard II variety (CHQX12B) had similar yarn performance to Sicala 350B, and yet this variety yielded as much or more than Sicot 71BR! The lower yielding new conventional variety tended to outperform other upland cottons.

The testing of yarn and fabric from this experiment is still on-going. In a future article we will report in greater detail the yarn and textile performance attributes of these varieties.

FIGURE 4: Nep content measured on the Uster AFIS PRO (mean values plus standard error)

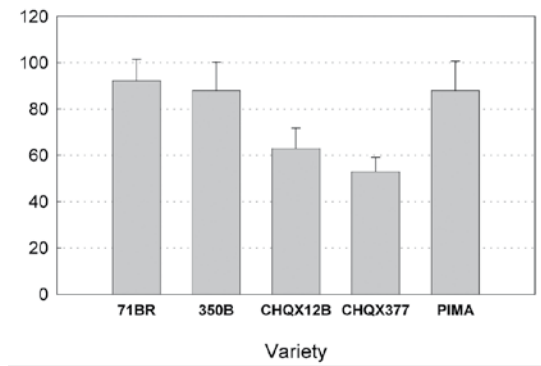
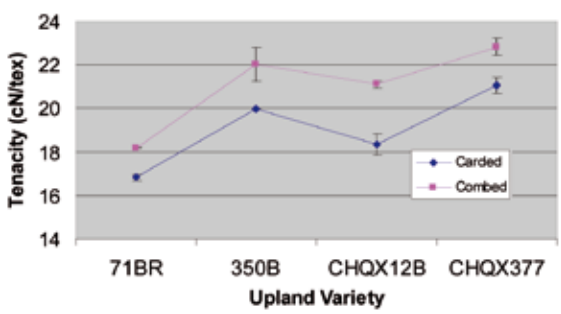


FIGURE 5: Mean tenacity values plus and minus standard error for 20 tex ring spun carded and carded/combed yarns for the four upland varieties



Tenacity is the force in centinewtons to break a piece of yarn, normalised back to the linear density (tex) of that yarn

Future implications

The full scale field trial will be repeated in the 2007–08 season with one additional new unreleased upland variety to be included. Pima cotton will also be roller ginned before full-scale processing in the mill.

To allow more efficient means of conducting these comparisons, another component of the project currently in progress, is investigating the use of miniature spinning technology. This will allow small amounts of lint to be made into yarn and fabric (42 grams of lint) compared to 50 kg of lint needed for full scale spinning in CSIRO's Geelong mill. This will allow more varieties and a wider range of tests to be conducted. The experiments described in this article are being used to help validate the miniature spinning equipment.

The fibre to fabric program is also exploring other avenues to link farm management practices with fibre quality and textile performance. For example, we are currently processing yarn and fabric from lint harvested from field experiments examining defoliation timing treatments. This work will help to address the issues relating to the effects of immature cotton on yarn and textile quality, such as neps and associated white spec in fabric.

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Please note that in 2007, the CSIRO will again run its 'Field to Fabric' course in Geelong. This three day course covers all aspects of cotton production, including agronomy, ginning and spinning, and comprehensive tours of CSIRO's full scale cotton spinning mill. For further information about this course please contact Rene van der Sluijs: rene.vandersluijs@csiro.au or phone 03 5246 4000

***CSIRO Textile and Fibre Technology and Plant Industry, and the Cotton Catchment Communities CRC**