

Crop Physiology – Producing a Better Fibre

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Summary

Fibre quality is an important consideration for Australian cotton farm profitability and industry credibility in the world marketplace. Recent significant issues relating to fibre quality in the industry include maintaining fibre length, prevalence of high micronaire, and the perception of high levels of neps. Fibre development responds directly to the environment, crop management and stresses. Understanding clearly the reasons why these fibre quality issues persist, and why they differ for regions, seasons and for different crop management practices can aid in developing management guidelines. This paper presents a brief summary of: the physiology of fibre development and impacts of agronomy and environmental influences that change the growth of the fibre; consequences of different fibre properties that are changed in the field and the consequences for textile production; some general recommendations for agronomic management for preserving fibre quality; and a discussion of current dedicated research to further this knowledge and deliver it to benefit the industry.

Introduction

Australian cotton fibre is exported into a dynamic and competitive market and we need to ensure an ever-improving product to meet the demand from spinners. Recent significant issues relating to fibre quality in the industry include maintaining fibre length, prevalence of high micronaire, and the perception of high levels of neps in Australian cotton. These issues directly affect the economic return to growers (Figure 1) as well as our overall market reputation.

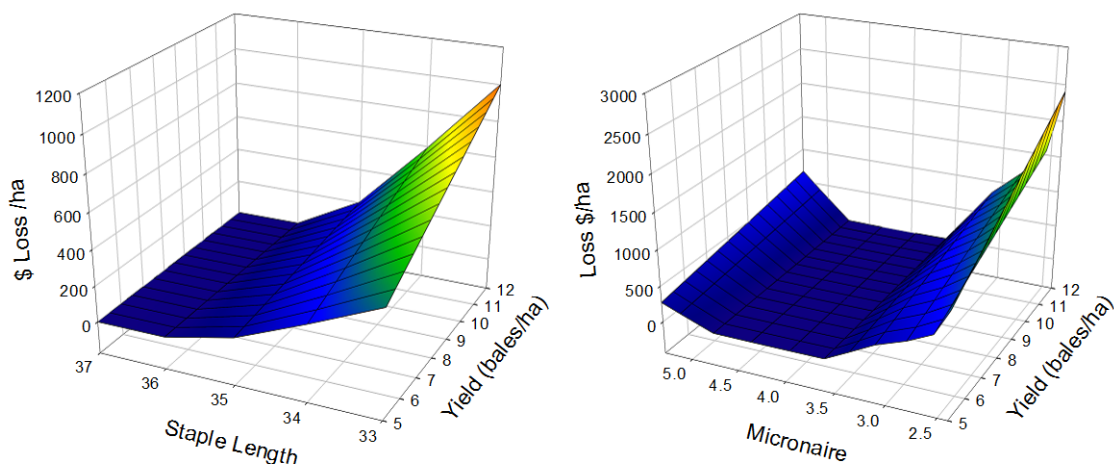


Figure 1: Calculated \$ loss/ha (based on average discounts across merchants in 2006) associated with discounts for fibre length and micronaire at different yield levels.

Fibre development responds directly to the environment, crop management and stresses. While variety plays a large role in fibre quality, understanding clearly the reasons why performance of varieties differ for regions, seasons and for different crop management practices can aid in developing management guidelines.

This paper aims to briefly discuss:

- Physiology of fibre development; the agronomic management and environmental influences that change the growth of the fibre;
- Measured fibre quality traits that are affected in the field and the consequences for textile production;
- General recommendations for agronomic management for preserving fibre quality.
- Current dedicated research into the understanding of the impacts of agronomy and environment on fibre quality and integration of this knowledge for delivery to industry.

Fibre development

Each cotton fibre on a seed develops from a single cell on the outer surface of the seed. From this point onwards the development of a cotton fibre can be simply described in two phases:

Phase 1: Immediately after flowering, the development of the fibre starts. From this period until around day twenty days after flowering the length of the fibre is being determined. During this period, water stress is the critical attribute that will determine how long the fibre is. This is the primary reason that dryland crops, which can have periods of water stress, often have reduced length.

Phase 2: Fibre thickening doesn't start to occur until around 28 days after flowering and involves daily deposition of layers of cellulose on the inner surface of the fibre wall. From this period onwards temperature and stress are the main components affecting fibre thickness, although boll load has an influence because of competition for assimilates in the plant. Fibre from bolls lower down on the main stem has higher micronaire due to development in optimum growing conditions with minimal stress, allowing good fibre wall thickening.

Management and Environmental effects on Fibre Quality

The main attributes of fibre quality influenced by environment, crop management and stresses that are important for Australian growers to consider that meet market expectations and influence price are:

Fibre length – affects yarn strength, yarn evenness, and the efficiency of the spinning process. Fibre length in the field is largely determined by variety, but exposure to severe water stress, high and low temperatures and nutrient deficiencies can shorten length.

Micronaire – a measure of fibre fineness and maturity. Finer fibres means that there are more fibres in the cross section of a yarn when it is spun and the yarn is stronger. The degree of fibre maturity impacts dye absorbency and retention. Fibre fineness is determined at fibre initiation on a seed. Fibre maturity is the proportion of fibre cross section occupied by cellulose and is influenced by impacts on photosynthesis and demand for resources by the developing bolls.

Neps – entanglements of fibres that are often associated with immature fibres. Neps spoil the appearance of cotton yarns and fabric.

Stickiness – residues on cotton fibre can lower spinning performance by causing build-up on textile machinery. Significant levels of stickiness can be caused by secretions from Aphids and silverleaf whitefly.

Colour Grade and Leaf Grade – colour grade of cotton fibre can affect the ability of the fibre to absorb and hold dyes. Colour of the fibre in the field is affected by field weathering (rainfall), early termination of bolls caused by frost, insect damage to bolls, deterioration of fibre caused by fungi, and contamination with the fibre (eg. green leaf particles). The presence of leaf in harvested cotton is waste and there is a cost in removing it. Those particles that cannot be removed detract from the quality. Variety can influence the amount of leaf in harvested cotton, but the efficiency of conditioning (boll opening and defoliation) the crop for harvest and the timeliness of the harvest operation are significant.

Seed Coat Fragments - are parts of the cotton seed coat that have been torn off or shattered during ginning and may contribute to the formation of a nep (seed coat neps). Increases in seed cotton fragments following ginning can be associated with low moisture content in the seed causing the seed to be brittle, or late season stresses that cause seeds to be smaller or lighter.

Smart Decisions for Fibre Quality in the Field

In reality it is always a balancing act between what is desirable and what is achievable given the need to finish a crop off and get it picked. There would appear to be no evidence suggesting that high yielding crops, if managed correctly, cannot have excellent fibre quality. On the contrary it is likely that high yielding crops, because of excellent management, will by default also have good quality. Many factors interact in a cropping system. Adoption of appropriate and efficient integrated pest management (IPM), irrigation, crop nutrition, disease, and weed management practices in the same way they contribute to improving yield will also contribute to improved fibre quality.

Direct and indirect effects on fibre growth and cumulative stresses are important to recognise and diagnose so they can be corrected. Stress at one point in a season may have indirect consequences on fibre quality at other stages in the season (e.g. by changing the boll setting pattern).

Specific management decisions that can have significant impact on fibre quality are now discussed.

Choose the right variety for your region and cropping situation

It is important to match variety to each circumstance to optimise yield and fibre quality by considering:

- Region and potential maturity/growth habit of the crop. Late crops will potentially reduce fibre quality by having more immature bolls causing more neps, lower micronaire and possibly reducing grade associated with delays in harvest causing lint to be exposed to rainfall.
- Disease issues that will affect healthy growth.
- Possible water and heat and impacts on fibre length. If water will be limited at flowering consider varieties that have inherently higher length. Skip row configurations are an option for dryland growers.
- Micronaire expectations. If performances of varieties (including Bollgard ® II) in your region are susceptible to producing higher micronaire, consider varieties that have inherently lower micronaire.
- Okra leaf versus normal leaf types. Okra leaf varieties are also known to cause an increase in trash content as the leaf shape stops the leaf from falling easily to the ground. Approximately half a grade decrease can result. A balance between the okra varieties positive attributes and the potential for a small downgrade need to be taken into account.

Discussion with seed companies on COMPARATIVE data (not only absolute values) of fibre properties for varieties grown in your region will assist with these decisions.

Irrigation systems and schedules to optimise fibre elongation in first weeks of flowering.

Good plant moisture status is critical in the first 20 days after flowering to allow potential fibre elongation rates. With about five weeks of effective flowering and another three weeks to complete fibre elongation, a total of eight weeks without stress is required to have uninterrupted fibre length in all bolls. Healthy soil and irrigation scheduling to take account of soil water holding capacity and evaporative demand are key approaches to managing plant moisture status.

Management for uniform crop setting

Plant vegetative size and structure needs to be balanced with boll setting pattern to optimise fibre micronaire. Uniform boll setting is achieved by having the appropriate plant type for the region and climate. Crop monitoring for insect management and to optimise water, nutrition and use of growth regulators is needed to facilitate this balance. Sowing date can also impact on fibre thickening by determining climate conditions during thickening. Full season locations with a history of high micronaire should consider later sowing dates.

Management a timely harvest

Ceasing crop growth for a timely harvest involves a number of important decisions. Late flowering and especially regrowth will cause fibre quality problems directly in fibre properties (micronaire

and neps) and indirectly with grade. Delayed harvests also expose clean lint to increased chances of weathering through humid conditions or rainfall increasing microbial damage reducing colour grade. Poor and untimely defoliation can have significant impact on fibre maturity as well as the amount of leaf trash. Specific considerations include:

- Late season mepiquat chloride (Pix ®) - The application of Pix at the last effective square has become a common practice in many cotton growing regions. The aim is to reduce top growth of the plant and minimize plant resources going into fruit that is unlikely to be pickable at harvest time. Pix is unlikely to have a negative effect on fibre quality and may help reduce neps in late crops that are going to produce bolls outside the normal harvestable range.
- Irrigation and Nitrogen Management – Excess nitrogen rates or events which cause late regrowth (eg. excess soil moisture at harvest), can reduce fibre quality by having fibre development occurring in cooler weather (reducing micronaire and increased chance of bolls with immature fibre).
- Defoliation - The type of defoliation product is unlikely to impact on fibre quality if timing is correct. Early defoliation can cause a significant reduction in all desirable fibre properties and significantly increases the number of neps in the upper top quarter of bolls. This can also significantly increase the number of neps, as the top quarter of plant is where the least mature fibres occur. Length and strength are only affected with very early defoliations. Micronaire is however, more sensitive to timing of defoliation as the fibres require the increased time to mature. Extremely early defoliation has the effect of damaging all bolls in all positions and this is evident with the large increase in neps when defoliations were conducted at 5% and 17% timings (Roberts et al. 2004).

Agronomic and crop physiology research into fibre quality

As fibre quality is an important consideration for Australian farm profitability and industry credibility in the marketplace, most field trials are tested for fibre quality. Existing and new information becomes a valuable resource for understanding the impacts of management and environment on quality. Over the last few years the industry has increased its focus on fibre quality by investing additional research to improve and integrate this knowledge. Specific research in agronomy and crop physiology for improving fibre quality includes:

- Quantifying the differences in different row configurations in dryland cotton production systems to optimise the balance between yield and fibre quality.
- Quantifying the impacts of temperature and radiation on fibre quality traits.
- Understanding the impacts of different agronomic practices on fibre quality. Specific examples include:
 - Comparing the relative performance of Bollgard II and non Bollgard II crops
 - Performance of premium fibre type varieties with different agronomy.
 - Impact of plant population on fibre quality.

- Quantifying the contribution of immature bolls on the level of neps in harvested cotton.
- Development of methodologies and tools to predict the impact of climate and management on fibre quality (eg. Figure 2). The development of a fibre module for the OZCOT model has also added considerable value to the simulation model's usefulness as it allows virtual experimentation on management effects on both yield and quality together. Validation of the module is already under way.
- Conducting research that explores the impact of the farming system on fibre quality through to performance of textile production. Advanced technologies that measure fibre properties that are being used in this evaluation include AFIS PRO (length, nep, seed coat fragment and trash), the 'Cottonscan' (fineness) and the 'SiroMat' (maturity and maturity distribution). Micro and industrial scale spinning machinery will also be used to investigate the effects of variety, agronomy and harvest management on textile quality, with the micro-spinning system allowing small fibre samples (less than 1 kg) from field trials to be converted quickly and efficiently to yarn and knitted fabric. Using a micro-spinning system increases the number of field and agronomic variables able to be tested.

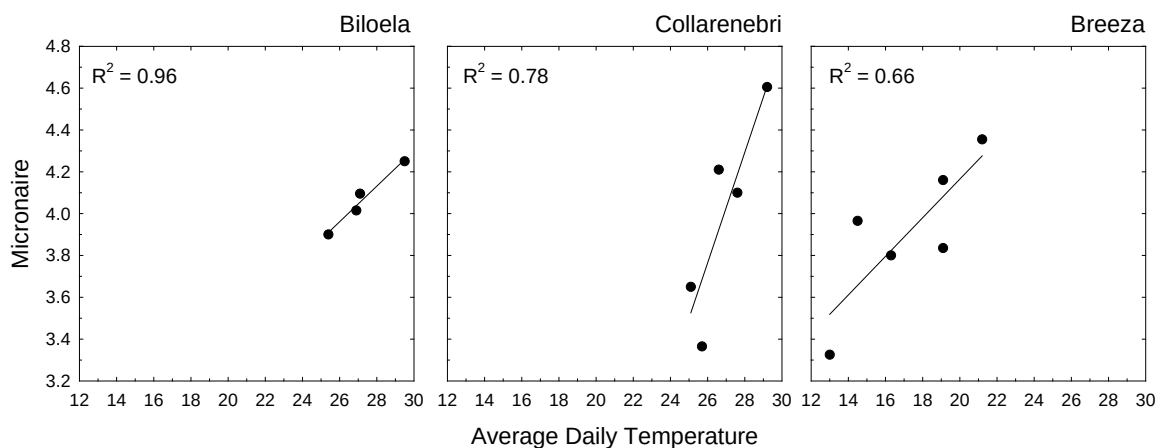


Figure 2: Example of methodologies developed to assess the impact of climate on fibre quality. The graphs show the relationship of measured HVI micronaire control varieties (average of DP16 and Namcala) to average daily temperature during boll filling from CSIRO breeding trials from 1989 to 2005.

The cumulation of all the fibre quality research and extension will be for the Cotton CRC to develop FIBREpak and to deliver decision support systems (eg. HydroLOGIC) that assists with crop management decisions that involve yield and quality issues.

Conclusions

In aiming for high yielding crops, growers must continually keep in mind the factors that affect fibre quality. Varietal selection with good fibre characteristics are part of the equation, however minimising water stress, uniform growth and boll set and correct defoliation timings are also essential to allow fibres to develop properly. To reduce average nep numbers, management should aim to discourage late season bolls. There may be circumstances where late bolls should not be

picked as they may introduce low micronaire or high neps which incur a penalty greater than the yield they add. Current research aims to improve knowledge of the impacts of crop management and climate on fibre quality. New and existing knowledge of these impacts will be integrated and delivered to the industry through FIBREpak and through a range of new decision support tools that consider yield and quality together.

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References

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