

Unraveling the Micronaire Challenge

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Micronaire is one of the most challenging fibre quality parameters to manage because it is subject to penalties for being too high or too low, and in recent seasons, Australian cotton growers have seen both ends of the micronaire spectrum. Micronaire (an indirect measure of fibre fineness and maturity) is measured by passing air through a bundle of fibres and measuring the air resistance using a HVI (High Volume Instrument) machine. Fibre fineness is the linear density of the fibre, while fibre maturity is a measure of the degree to which fibre walls are thickened with cellulose.

In general, differences in fibre fineness are related to variety, but fibre maturity is affected by many factors, especially those that affect photosynthesis which leads to the production of cellulose laid down in the inner wall of the fibre cell. Micronaire is complex, as the climate during boll filling (temperature and radiation levels) and crop specific factors such as boll load, crop stress, variety, and defoliation practices all contribute to final differences. The extent of all these factors and the variation in micronaire that they generate is best illustrated by the variability in micronaire across regions and between seasons. For the past 23 years the CSIRO cotton breeding team has included two control varieties, Namcala and DP16 in CSIRO breeding trials which are spread from Emerald to Hillston. In those years, micronaire has varied up to 1.4 between regions in the same season and up to 1.2 between seasons in the same regions.

Temperature, radiation levels, and crop stress (e.g. water) have direct effects on micronaire as they influence photosynthesis. Boll load variations (sometimes caused by stress) and defoliation are examples of indirect effects on micronaire. Higher boll loads create a greater demand for assimilates for each boll and depending on plant size (e.g. leaf area), which provides the supply of assimilates, increased competition may decrease the amount of cellulose available for each fibre and consequently lower the fibre maturity and micronaire. Defoliating crops too early may reduce micronaire as the removal of leaves will limit the carbohydrate supply to the later bolls causing them to have immature fibre. Opening bolls early will also increase the proportion of immature fibres and may also have a negative impact on yield.

In this article we highlight analyses that are being conducted to unravel the degree of effects that contribute to differences in micronaire. Here we present some results that show the effects of variety, boll load and temperature. We also present examples of how we are using the knowledge to assess how seasonal effects are contributing to differences in micronaire.

Temperature

It is well recognised that warm, sunny conditions during the boll filling period will increase micronaire due to increased photosynthate production in the plant to supply the bolls. To estimate the affect of temperature, we have developed a simple technique that estimates the main period during boll filling when the majority of bolls are thickening their fibres. We then calculate the mean daily temperature (an average of daily maximum and minimum) for this period and relate this to the micronaire achieved.

To assess the degree that temperature has affected the variation in micronaire from season to season we have used experimental data taken from the CSIRO breeding trials using an average of the control varieties Namcala and DP16 across a number of seasons and sites. Plotting the micronaire achieved for each season and site we reveal a measurable relationship between micronaire and mean daily temperature during the boll filling stage (Figure 1).

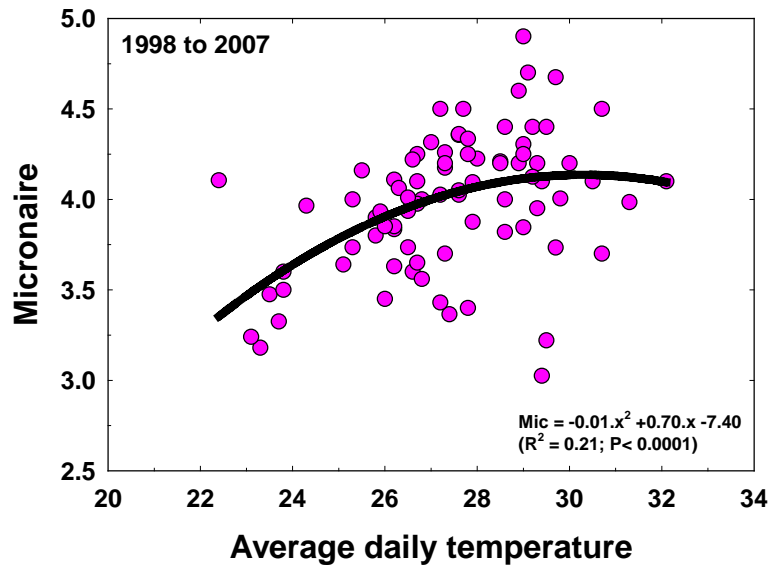


Figure 1: The affect of mean daily temperature (°C) on fibre micronaire during the fibre thickening period using average of CSIRO control varieties Namcala and DP16 from 1998 to 2007.

Similar trends appeared after an extensive analysis of current Bollgard II® and conventional varieties, utilising the Cotton Seed Distributors (CSD) replicated variety trial program. A comparison of Sicot 71BR and Sicot 71B from the four seasons 2004-05 to 2007-08 (Figure 2) revealed that both varieties responded to temperature in the same way.

In both datasets (Figures 1 and 2), temperature accounts for approximately 21% of the variability in micronaire. The influence of the other 'individual crop factors' is very obvious by the outliers. Both figures also suggest that at mean daily temperatures less than 22°C, the incidences of low micronaire (<3.5) may be greater and at mean daily temperatures greater than 28°C, incidences of high micronaire (>4.9) may be more frequent. These numbers are important as we examine the trends in the past three seasons later in this paper.

Variety

There are intrinsic differences in fineness and maturity between varieties which result in differences in micronaire. For example, in 16 large scale, replicated CSD variety trials over the past 3 seasons which have included Sicot 71BR and Sicot 71B, the micronaire of Sicot 71B has averaged 0.19 lower than Sicot 71BR. When we compare the micronaire of these two varieties across a range of growing conditions (Figure 2), it shows that, on average, Sicot 71B will always have 0.1 and 0.2 lower micronaire than Sicot 71BR. Importantly, this comparison showed the relationship was similar across a range of temperatures for both varieties. Breeding efforts are concentrated on achieving mid range micronaire varieties by improving both fibre fineness and fibre maturity.

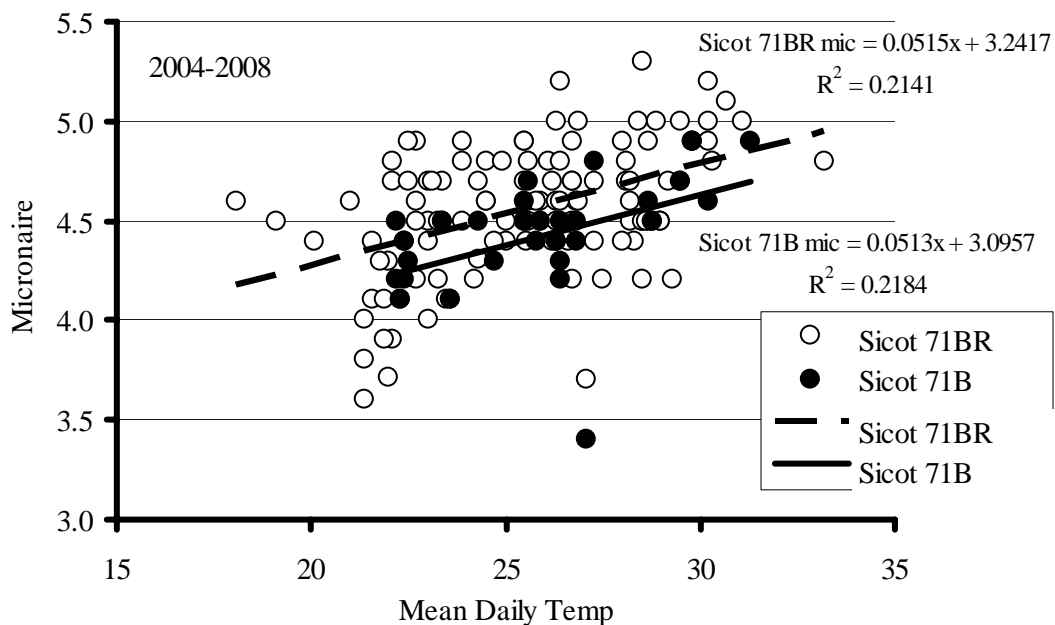


Figure 2. The influence of mean daily temperature during the peak boll-fill period on micronaire for Sicot 71BR and Sicot 71B. Data from CSD's large-scale replicated variety trial program. Sicot 71BR includes 114 sites over 5 seasons. Sicot 71B includes 32 sites over 3 seasons.

Boll Load:

A study conducted by Ken Brook, Brian Hearn & Craig Kelly (CSIRO Plant Industry) (Brook et al. 1992) in the mid 1980's where fruit was removed from plants of similar size showed a similar trend to data generated on current commercial varieties (Figure 3). The trends from these two data sets indicate that an increase in fruit load by 10 bolls/m may result in a reduction of micronaire by 0.05- 0.12. Increasing boll numbers will not only tend to reduce micronaire but obviously increase yield.

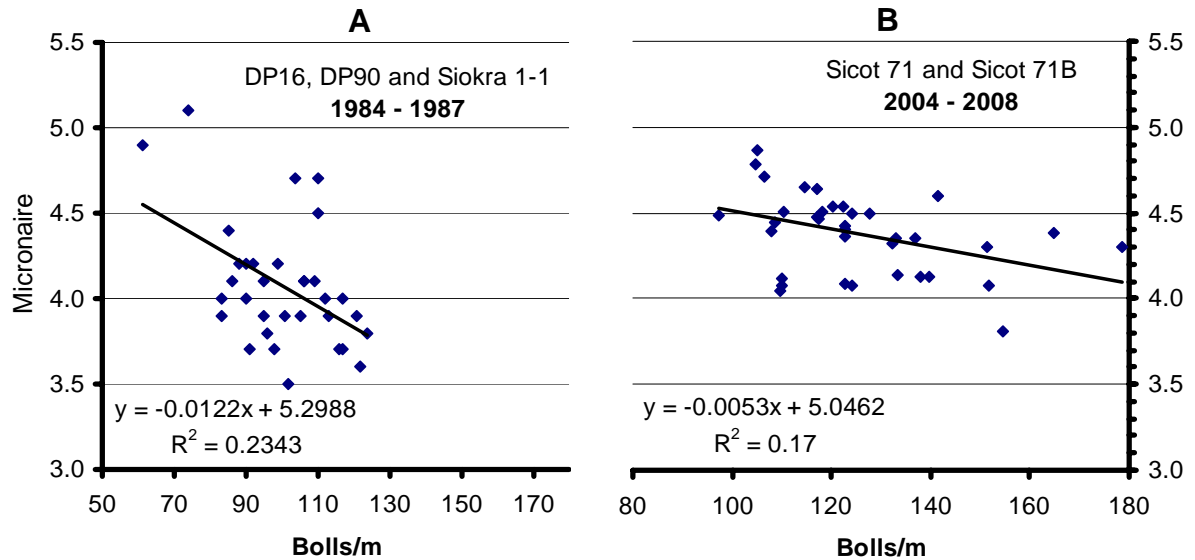


Figure 3. Relationship of micronaire to boll load (bolls/m²). Fewer bolls per metre trends towards higher micronaire. (A) Study done in mid 1980's by Brook, Hearn & Kelly (CSIRO Plant Industry) in Namoi Valley which involved manual fruit removal treatments. (B) Data from CSD segmented picking projects in 2004-05 and 2005-06, 2006-07 and 2007-08 which involved sampling commercial crops across many growing areas.

The past three seasons- an illustration of extremes in temperature affects.

The past three seasons has seen one of the hottest seasons on record in 2005-06, one not too far behind in 2006-07, followed by one of the coolest on record in 2007-08. We have utilised our methodology to estimate the temperature during the period where micronaire develops and historical climate records to analyse these seasons (see figure 4). Utilising a 15 October planting date across the whole of the industry, crops endured mean daily temperatures four and five degrees cooler in 2007-08 than they where in 2006-07 and 2005-06.

In the 2005-06 and 2006-07 seasons, micronaire was generally higher on an industry basis and, using the guideline of 28°C and above from figures 1 and 2, it's easy to highlight the specific regions where cases of high micronaire (>4.9) were more common. These included the northern and western areas such as central Queensland and the Balonne. Likewise, in 2007-08, micronaires were generally lower across the industry and, using the guideline of 22°C and below from figures 1 and 2, the regions where some cases of low micronaire (<3.5) were evident are easily identifiable. These included the southern and eastern areas such as the upper Namoi and Darling Downs.

Interestingly, in no regions other than Hillston in 2007-08, have there been temperatures anywhere near average for the past 3 seasons. Figure 4 also clearly illustrates the contrasts in temperatures between Australian cotton growing regions within the same season. For example, in 2005-06, crops in the hottest areas (Bourke) endured mean temperatures 6°C greater than crops planted at the same time in coolest areas (Dalby).

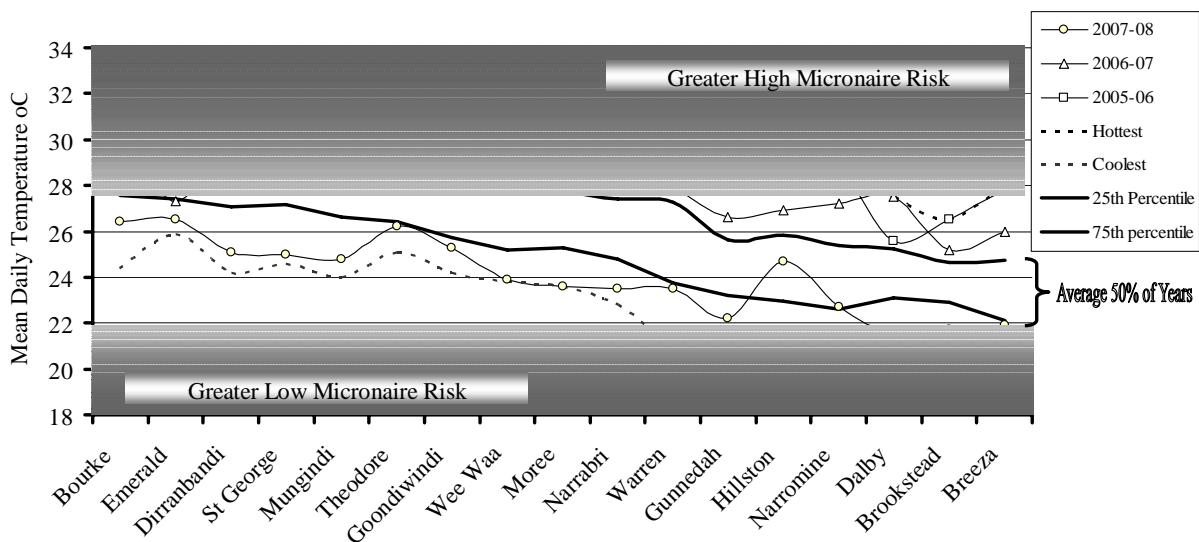


Figure 4. The mean daily temperature during the boll filling period for 15 October planted crops in all major growing regions for the past three seasons. Hottest and coolest records are for the past 50 years. The space between the 25th and 75th percentile represents the average 50% of seasons.

The effect of planting date:

The time of planting is one key management practice that can be used to modify the temperatures that a crop will endure during its boll filling period. Generally, later planting will place boll maturation later into summer, and usually, cooler temperatures.

While we’ve stated previously how mild the 2007-08 season has been, it becomes particularly apparent when analysing the effect of planting date, again, using our methodology that estimates the period of micronaire development (Figure 5). While the planting window for Bollgard II finished on 30 November, there were many crops that endured significant delays in fruit-set due to herbicide damage, providing a similar effect as late planting dates. In some of the western regions, such as St George, while all planting dates resulted in well below average temperatures, planting into November meant these crops were enduring some of the coldest weather conditions for the past 50 years. In fact, for the very late crops, the mean daily temperatures that they endured through their boll fill period were more than 10°C cooler than the previous two seasons. This clearly illustrates why some growers in these regions have endured lower than desirable micronaire for late November planted crops in the 2007-08 season, and, conversely, higher than desirable micronaire for September/ October planted crops in the 2005-06 and 2006-07 seasons.

For growers in the traditional ‘warmer’ areas, the challenge of avoiding high micronaire will be more common than that of low micronaire. In the cooler regions, such as the southern Darling Downs (Brookstead), even in the hottest season in 50 years, 2005-06, the mean daily temperatures were not at the levels that would normally warrant an increased risk of high micronaire. In these regions, however, it is evident, that in anything cooler than an average season, planting into November will significantly

increase the risk of maturing bolls in very cool conditions, potentially increasing the risk of low micronaire.

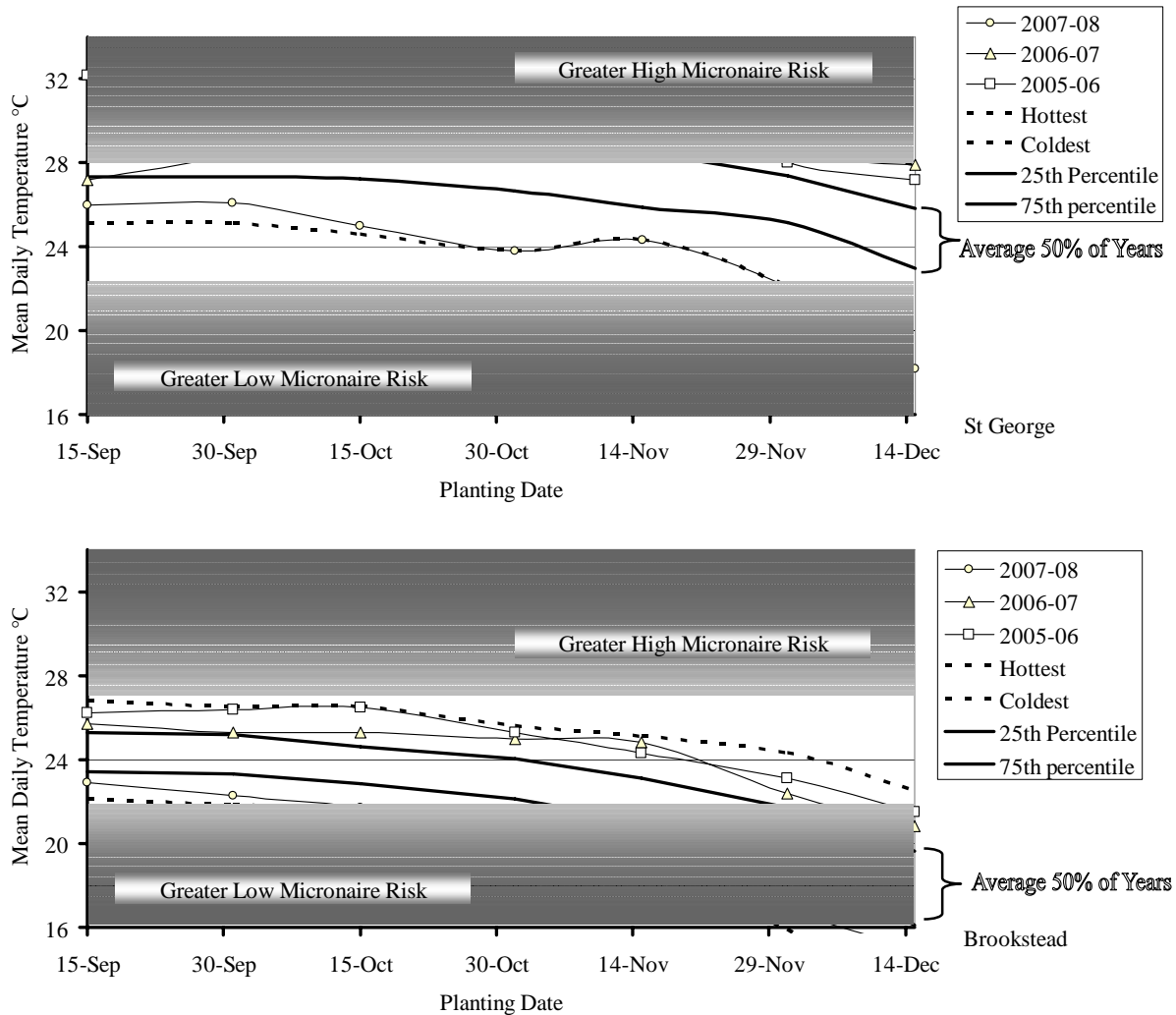


Figure 5: Examples of how planting date can impact on the temperature during the boll filling period that may lead to considerable differences in micronaire using one of the warmest growing regions (St George) and one of the coolest (Brookstead). The space between the 25th and 75th percentile represents the average 50% of seasons.

Conclusion and Management:

Micronaire is a very difficult parameter to manage and predict. As demonstrated in this article, there is no one definitive factor with an overriding influence. Rather, there are a number of factors that all play a role, and their combined influences will determine the overall final micronaire of a particular crop.

It is therefore impossible to suggest a generic management strategy to maintain micronaire in the mid range every year. The reasons for high or low micronaire on a particular field or farm may be unique. For this reason, for some farms or fields, high or low micronaire may be a problem they face every year, while for others it may be a rare event. To get a greater understanding of 'farm specific' influences on micronaire, some growers have gone through the exercise of developing a 'fibre quality history' of their farm through tracking where each module comes from each season. The variability caused by a change in variety can be accounted for by using the relative differences in the published micronaire values. This allows growers to identify specific fields, or sections of fields that may always produce unfavourable quality and seek to find out what the cause may be. Some instances reported by growers who have done this include:

- Uneven field levels resulting in patches of waterlogging.
- Soil compaction causing a lower yielding crop with reduced boll numbers
- Crop variability from 'cut and fill' areas in newly developed fields.
- Irrigation changes.
- Early sowings in full season districts.
- Late sowing in districts with shorter growing seasons.

In regions where the season allows, aim to utilise the full length of the season, rather than finishing the crop off too early. This will not only increase the likelihood of getting higher boll numbers but spread the maturity of fruit over a greater period of time. Bollgard II® technology has a great advantage in these situations as there is less risk of high late-season insect control costs. Sowing date should be modified where necessary; that is to not sow early in full season areas and avoid hot conditions during boll fill and conversely to sow early in short season areas to avoid cool conditions in boll fill.

Research is continuing to understand the effects of climate and management on micronaire (including detailed analyses on fineness and maturity). Current studies are also attempting to quantify the effects of different crop sizes and boll loads on micronaire. This information will help to understand and develop management to optimise micronaire.

Reference

Brook KD, Hearn AB & Kelly CF (1992) Response of cotton, *Gossypium hirsutum* L., to damage by insect pests in Australia: manual simulation of damage. *Journal of economic entomology*, v. 85(4) p. 1368-1377.