10. First Flower to Open Boll

This period is the critical phase for developing cotton fibres. As flowers are setting, fibres lengthen and as bolls grow fibres thicken (mature) by laying down cellulose in the secondary wall of the fibre leading to differences in Micronaire. Fibre lengthening is highly influenced by temperature and crop water availability, while fibre thickening leading to differences in micronaire is influenced by the amount of cellulose production affected by photosynthesis which is affected by temperature (see Figure 10.1) and solar radiation (cloudiness) as well as internal competition from bolls on the plant.

There are instances where too many bolls on a plant lead to lower fibre maturity, because of the increased competition between bolls for photoassimilate. Therefore the decisions that affect the availability of resources for growing fibres during this period are important to realise the potential fibre quality attributes of a variety. It is important to maintain a healthy crop whilst maintaining the balance of plant vegetative size with a uniform boll setting pattern.

Management considerations from first flower to open boll are:

- *Avoiding water stress on developing fibres by monitoring soil moisture.*
- *Maintaining a uniform boll setting pattern through crop monitoring to optimise Micronaire.*
- *Optimising the time of cutout so that crops mature at the appropriate time for local conditions and to maximise yield potential.*

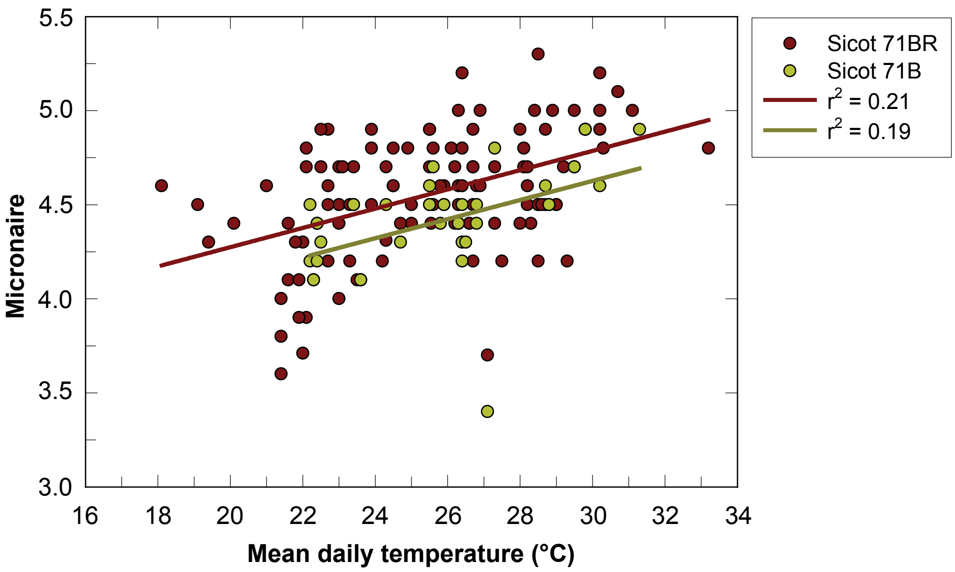

Figure 10.1: The influence of mean daily temperature during the peak boll-fill period on Micronaire for Sicot 71BR and Sicot 71B. Data from CSD's large-scale replicated variety trial program. Sicot 71BR includes 114 sites over 5 seasons. Sicot 71B includes 32 sites over 3 seasons. From Kelly et al. (2008).

Figure 10.2: Immature cotton fibres with low Micronaire (associated with maturity ratios less than 0.85) and will dye a lighter hue and will abrade more readily and give a poorer appearance. Micronaire is generally associated with immature fibre (see chapter 3 on fibre biology for definitions). (Photos: CSIRO).

Avoiding water stress on developing bolls

The impact of late water stress will depend on the exact timing, duration and extent of stress. Generally boll sizes will be reduced rather than resulting in a significant reduction in boll numbers. This can reduce yield and can also reduce Micronaire, but cause little effect on fibre length. A longer duration of stress approaching cutout will cause shedding of later bolls reducing potential yield. The crop Micronaire may be maintained because of the loss of bolls which may have subsequently had low Micronaire. In large vegetative crops that are stressed prior to boll opening, both boll size and number can be reduced, with significant reduction in yield and fibre quality. Use of appropriate irrigation scheduling practices to avoid stress will help to optimise yield and quality.

Maintaining a uniform boll setting pattern through crop monitoring to optimise Micronaire

A critical management concept is the need to balance ‘sinks’ with ‘sources’. Sinks are where resources are utilised (e.g. growth of the fibre and boll), and sources are what provides the resources (e.g. leaves). The balance of sinks to sources on a plant comes from differences in green leaf area to the yield potential (number of bolls). To sustain boll and fibre production (the sinks) cotton needs a canopy of young healthy leaves that are illuminated by the sun to sustain photosynthesis. From a fibre development perspective changes in the relationship between canopy leaf area and boll number affect the maturity (thickness of the secondary cell wall) of developing fibres leading to differences in Micronaire.

For example if boll load is strong (high boll number) on a crop growing with a small canopy there will be strong competition for resources between bolls resulting in less resources for each boll for secondary wall thickening. This results in lower fibre maturity and Micronaire (see Figure 10.3). Conversely if boll load is small on a canopy that is large and actively growing, there is a chance that fibre maturity and Micronaire will be high as there are plentiful resources for each individual boll for secondary wall thickening. Therefore there is a need during this growing period to assess both boll loads and plant size and growth.

Uniform boll setting is also important in balancing the quality of the lint harvested. Micronaire values are highest in the middle branches and decline in the top bolls. If, for example, early and late fruit are lost this may pre-dispose crops to higher Micronaire. A reasonable Micronaire can therefore be achieved by harvesting bolls from all nodes on the plant. This also applies to other quality attributes such as: fibre length (shorter from lowest to highest fruiting branch); for neps (highest with top bolls); and for colour grade (best in the middle of the plant).

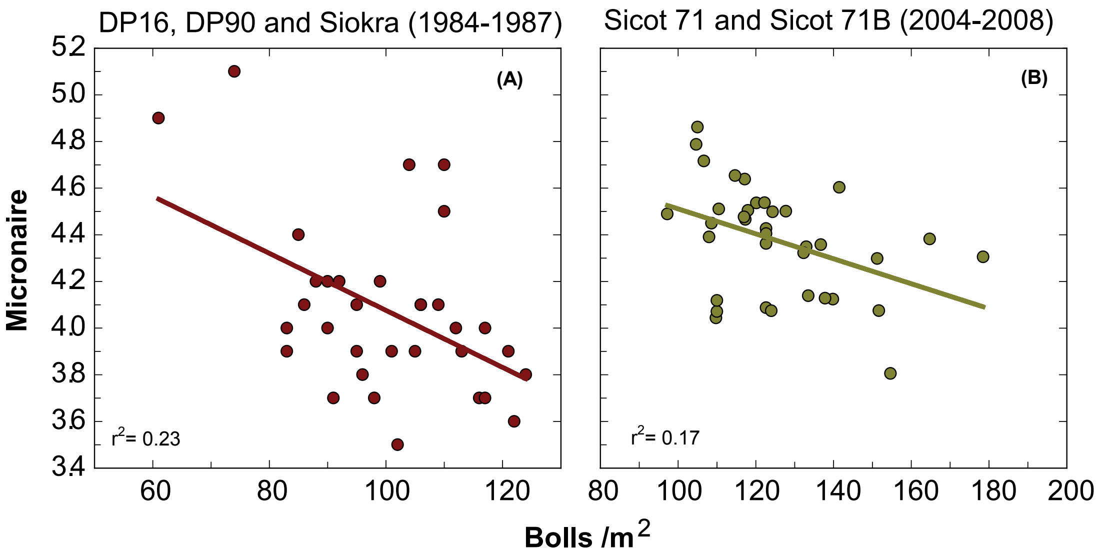

Figure 10.3: Relationship of Micronaire to boll load (bolls/m^2). Fewer bolls per metre trends towards higher Micronaire. (A) Study done in mid 1980's by Brook et al. (1992) (CSIRO Plant Industry) in Namoi Valley which involved manual fruit removal treatments. (B) Data from CSD segmented picking projects in 2004-05 and 2005-06, 2006-07 and 2007-08 which involved sampling commercial crops across many growing areas (Kelly et al. 2008).

High boll load, small plant

Under these circumstances, there is a need to maintain healthy leaves with appropriate nutrition, water (see above) and pest management to avoid low Micronaire. Monitor and control major pests such as mites and aphids that can significantly affect leaf photosynthesis. It will also be important to monitor these crops to avoid early cutout (see next page).

Low boll load, large plant

These circumstances may arise from effects of water or temperature stress or insect damage and there is a need to restrict vegetative growth with growth regulators, water and crop nutrition as soon as possible to avoid generating excessive resources for fibre growth that will lead to high Micronaire. At the same time it is important to encourage growth of new fruit while protecting existing with appropriate pest management. This will help build sinks that help to reduce Micronaire and restrict further rank growth. Major pests to monitor that will directly affect boll number include mirids, Helicoverpa, and green vegetable bug (GVB). There are also instances in dryland crops where high Micronaire can also occur when there has been significant fruit loss due to early water stress and the crop regains ability to grow due to renewed access to water and nutrition.

To assist in managing vegetative growth in balance with boll setting pattern during this growth phase monitor: vegetative growth rate (VGR – see sowing to first flower chapter); boll numbers and retention; and how the crop is progressing towards an appropriate cutout date for the particular region (see below). The crop development tool on the CottASSIST website will help track both fruit development against potential and VGR (http://cottassist.cottoncrc.org.au/CDT).

Figure 10.4: Crops that have small plant sizes with high boll loads are susceptible to premature senescence which can lower Micronaire. Many factors which influence plant size (e.g. soil compaction, crop water status, crop nutrition) need to be carefully planned and assessed to avoid these situations (Photo: Robert Eveleigh, CSD).

Decisions on whether to apply growth regulators should be tempered with information on fruit loads and retention.

For further information on pests and their control refer to the cotton IPM and pest management guidelines.

Optimising the timing of cutout

Cutout is the point at which the crop ceases to produce new fruiting sites (squares). The timing is important as it influences the time when the crop matures. Later cutout means later maturity. Timing crop maturity has important implications for maintaining quality by ensuring a timely harvest to avoid adverse weather conditions; ensuring that defoliation practices are effective to reduce trash; and avoiding instances where there are too many immature bolls that may increase incidences of neps. However as the timing of cutout is directly related to the timing of crop maturity it can also significantly effect yield. Early cutout, like early crop maturity, may reduce yield. Therefore the timing of cutout (resources permitting) must balance the opportunity for further fruit production, that contributes to yield, with potential losses in fibre quality and harvesting difficulties.

The latest cutout date that optimises yield and quality allows the squares and bolls on the plant at cutout to mature and open, and to be harvested before cool and wet weather (see chapter open boll to harvest on harvest timeliness risks). This time can be estimated by predicting the date when the last effective square is produced, leading to the last effective flower. The last effective flower tool on the CottASSIST website can be used to predict this date using the date of first frost (see Table 10.1) or using the date when bolls are expected to be open ready for harvest (http://cottassist.cottoncrc.org.au/LEFT/). This time also approximately coincides with when Nodes Above White Flower (NAWF) equals 4. When a crop reaches this point it has attained 95% of it harvestable yield. The use of NAWF as a monitoring tool for managing cutout is discussed below.

Table 10.1: Dates of last effective square and flower for various regions calculated using the CottASSIST last effective flower tool (http://cottassist.cottoncrc.org.au/). Last effective flower estimated by assuming boll growth ceasing at first frost at the end of the season (2°C measured in a screen). Times for other locations can be calculated using CottASSIST.

Location	**Last Effective Square**			**Last Effective Flower**		
	Earliest	Average	Latest	Earliest	Average	Latest
Emerald*	11 Feb	21 Feb	7 Mar	11 Mar	24 Mar	4 Apr
Dalby	3 Jan	26 Jan	10 Feb	7 Feb	1 Mar	18 Mar
St George	24 Jan	10 Feb	22 Feb	22 Feb	11 Mar	23 Mar
Goondiwindi	18 Jan	3 Feb	14 Feb	17 Feb	6 Mar	19 Mar
Moree	10 Jan	28 Jan	15 Feb	12 Feb	28 Feb	16 Mar
Narrabri	6 Jan	27 Jan	13 Feb	9 Feb	27 Feb	15 Mar
Gunnedah	2 Jan	21 Jan	5 Feb	7 Feb	23 Feb	11 Mar
Bourke	27 Jan	7 Feb	18 Feb	24 Feb	8 Mar	18 Mar
Warren	31 Dec	22 Jan	6 Feb	6 Feb	22 Feb	9 Mar
Hillston	27 Dec	16 Jan	27 Jan	28 Jan	16 Feb	27 Feb

*Frost only recorded on 20 occasions since 1957

Monitoring the timing of cutout

The timing of cutout can monitored using NAWF (see Figure 10.5) and be managed by fruit load, irrigation and nutrient management or utilising a late season application of a high rate of Pix®.

Crops approaching cutout (NAWF=4) too rapidly can indicate plant stress due to insufficient water and nutrition, early fruit development or high fruit loads. Management strategies in these instances can include providing irrigation or nutrition to resolve stress and/or to promote vegetative growth. The strategy of promoting new growth must consider if there is time remaining to mature bolls by considering the time of last effective flower.

Crops that that are slow in approaching cutout can indicate loss of bolls (physiological shedding or pest pressure), or continued plant growth due to on-going availability of water and nutrition. If fruit loss is suspected, measure fruit retention, and monitor VGR and apply Pix if necessary. If crops are continuing to grow and the time of last effective square and flower have passed consider extending irrigation intervals and using a late season, high rate growth regulator application to restrict futher vegetative growth, induce cutout and avoid immature bolls at harvest.

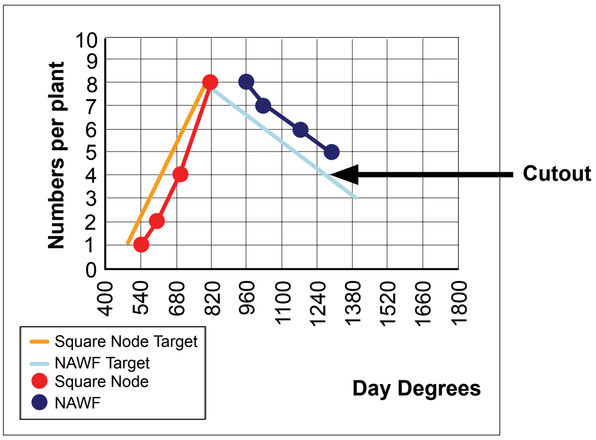

Figure 10.5: Monitoring nodes above white flower (NAWF) in conjunction with the timing of last effective square and flower is useful in determining whether crops are approaching the most appropriate time for cutout (NAWF=4). The crop development tool on the CottASSIT website can assist in monitoring NAWF (http://cottassist.cottoncrc.org.au/).

Bolls produced after the optimum cutout date may not contribute greatly to yield or quality. Along with monitoring NAWF it may also be useful to identify fruiting branches (with ribbons or tags that can be removed prior to harvest) that produced the last effective flower. This will assist in ensuring that bolls produced on fruiting branches above this marked position are not included in assessment of harvest aid timing decisions.

Late season growth regulator application

The application of high rates of growth regulator late in the season has become a common practice in many cotton growing regions.

The aim is to assist cessation of production of late vegetative growth (and unnecessary late fruit). The application growth regulator is unlikely to have a negative effect on fibre quality and may help reduce neps in late crops that would have produced bolls outside the normal harvestable range. The practice can also reduce risk of providing late season food source for insect pests. Decisions on cutout application of growth regulators are based on factors such as:

- Attainment of target boll numbers;
- Resumption of unnecessary late vegetative growth or fruiting; and
- Reaching last effective square or flower date for the region.
- Ensuring that the crop will not endure significant stress following application of the growth regulator as the combination may reduce yield substantially more than the effect of the stress alone.

Further reading

Brook KD, Hearn AB, Kelly CF (1992) Response of cotton to damage by insects pests in Australia: Compensation for early season fruit damage. Journal of Economic Entomology 85, 1378-1386.

Kelly D, Bange MP, Constable GA (2008) Unravelling the Micronaire challenge. In Proc. 14th Aust. Cotton Conf. 12-14 August, Gold Coast Aust. (The Aust. Cotton Growers Research Organisation).