Assessment of the degree of impact of factors affecting micronaire in cotton

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Abstract
Cotton fibre micronaire is an indirect measure of fibre linear density and maturity. Factors affecting supply and partitioning of assimilates to fruit affect micronaire. High micronaire occurs when there is an excess of assimilates due to good growing conditions and/or fruit number is low. Conversely low micronaire occurs when growing conditions are poor and/or fruit number is high. Little research has established the degree of impact of factors influencing micronaire, so a field experiment was conducted to investigate impacts on micronaire from changes in: planting dates; cultivar; canopy manipulation; and fruit number. A significant interaction of planting time, canopy manipulation and fruit load was measured where a later planting with a canopy impacted by terminal removal prior to flowering reduced micronaire, while normal and regulated (with growth regulator such as mepiquat chloride) canopies with normal fruit numbers in the earlier planting increased micronaire. Fruit removal in late planted treatments in normal and regulated canopies had similar micronaire to their earlier planted equivalents indicating compensatory mechanisms. Cultivar and planting time were the only consistent main effects on micronaire, with late planting time reducing micronaire. Canopy manipulation was not effective in generating differences in leaf area, but terminal removal delayed maturity lowering micronaire. Results highlighted that understanding significant changes in micronaire resulting from these treatments need to account for cultivar effects, the influence of management modifying the period of fibre thickening, and direct influences on boll growth. Knowledge will be used in crop simulation helping to refine management improving quality of Australian cotton.

Key Words
cotton, fibre, quality, micronaire, management

Introduction

Micronaire is a measure of cotton fibre quality that is obtained from differences in pressure when air is passed through an accurately weighed plug of cotton fibres. The method measures specific surface area and reflects a combination of the sample's linear density and fibre maturity. A reduction in linear density, wall thickness, or fibre perimeter decreases the micronaire reading as there are more fibres in the plug of cotton increasing air resistance. Low micronaire may indicate the presence of immature fibre while high micronaire may indicate that fibre is coarse. Both situations are problematic for spinners and fabric manufacturers. The optimum micronaire where cotton growers are not penalised ranges from 3.8 to 4.5 (no units).

Fibre growth and development is affected by most factors which influence plant growth. Since the fibre is primarily cellulose, any influence on plant photosynthesis and production of carbohydrate will have a similar influence on fibre growth (Pettigrew, 2008). Fibre thickening which influences micronaire is affected by temperature (Gipson and Joham 1968) and radiation (Pettigrew 1995), with large reductions in fibre thickening at lower temperatures or cloudy weather. Boll load and crop canopy also affect micronaire (Brook et al. 1992), with high boll loads having lower micronaire, presumably from internal competition. Little research has been conducted attempting to develop an integrated understanding at a canopy level of these impacts on micronaire. This paper presents research that aims to provide additional knowledge on the degree of impacts of planting time, cultivar, canopy manipulation, and fruit load on micronaire.

Methods

Cultural Details

A field experiment was conducted at Narrabri NSW Australia in the 2008-2009 season using cultivars Sicot 70BRF (average micronaire 4.2) and Sicot 71BR (average micronaire 4.7) grown with high input management and insect control. A split plot design with four replicates and 8 m long by 3 m wide (3 rows) plots were used. Main plots were two planting times (16 Oct. (P1) and 14 Nov. 2008 (P2)), and sub plots were a factorial combination of two cultivars, two fruit removal treatments (fruit removed and retained), and three canopy manipulations (tipped, normal, and regulated). Fruit removal was achieved by sequentially removing every second fruit (square, flower or boll) from every plant in 3m by 3m in the plot starting from

the bottom of the plant. Fruit were removed at the start of the estimated fibre thickening period (116 days after planting (DAP) in P1 and 104 DAP in P2) estimated using the methodology of Bange et al. (2011). Canopy manipulation was undertaken as an attempt to generate differences in canopy size (LAI) by pinching out the terminal with curved forceps to promote extra vegetative growth (Wilson et al. 2003), or using mepiquat chloride (growth regulant) to restrict vegetative growth. Terminal removal was conducted around the appearance of first square (56 DAP in P1 and 55 DAP in P2), while the growth regulant was applied around the appearance of first flower (84 DAP in P1 and 82 DAP in P2). Growth regulant was also applied after fruit removal to prevent additional vegetative growth.

Measurements

At the start of the estimated fibre thickening period LAI was measured only on the fruit retained treatment by taking $1m^2$ of plants from within the centre row, removing leaf and measuring leaf area using a Licor (LI-300) leaf area meter. At harvest the number of open bolls in $1m^2$ in each plot was undertaken to determine final boll number (bolls/m^2) and lint was collected from these open bolls to calculate final boll weight (g seed cotton/boll). At harvest (28 May 2009) lint was collected from $1m^2$ and kept for yield and fibre quality analyses. Fibre micronaire measurements on ginned lint samples were performed using a high volume instrument (HVI). Meteorological data for the experimental period were collected 2 km from the field site.

Results

At the time of when the fibre thickening period was occurring, both average daily temperature and solar radiation were declining. The initiation of the fibre thickening phase for P2 was 22 d later than P2 (Figure 1). Average temperature for the fibre thickening phase was 25.4 for P1 and 23.8 ^oC for P2, while average daily radiation was 24.8 for P1 and 22.6 MJ/m^2 for P2.

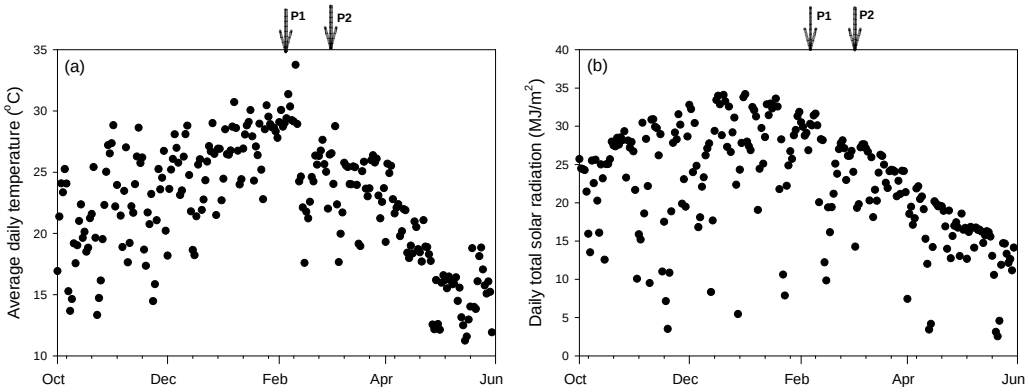

Figure 1. (a) Average daily temperature and (b) daily solar radiation conditions experienced during the experiment. The arrows designate the estimated initiation of the period of fibre thickening. (P1 – first planting, P2 –second planting).

Final boll number was also affected by all treatments (Table 1). Significant interactions were measured for planting time, canopy manipulation, with fruit treatment and for planting time, fruit treatment and cultivar. No significant differences in boll numbers were found among canopy manipulation treatments for the fruit removal treatments, however in the fruit retained treatments across the canopy treatment there were some differences with the normal canopy in P2 with fruit retained recording the highest (mean 144 bolls). When comparing varieties Sicot 70BRF in P1 with fruit retained had similar low boll numbers to the fruit removal of both varieties in P1. The only main effect that was consistent across treatments was the fruit removal treatment with the fruit removal treatment (mean 90) resulting in less bolls than the fruit retained treatment (mean 124).

LAI was only significantly affected by planting time (mean P1 2.29, mean P2 3.06 – Table 1). Significant interactions were also measured for final boll size. An interaction for planting time, canopy manipulation with fruit treatments resulted in considerable combinations of these treatments contributing to differences in boll size. The interaction of fruit treatment and cultivar resulted in Sicot 70BRF with fruit removed having the same boll size as Sicot 71BR with fruit retained and vice versa.

Changes in planting time, cultivar, canopy manipulation, and fruit removal all affected fibre micronaire (Table 1). A significant interaction of planting time, fruit treatment, and canopy size was also measured.

Treatments that produced the lowest micronaire were P2 treatments with a canopy that the terminal removed (tipped) with fruit retained or removed. Highest micronaire was measured P1 treatments in normal and regulated canopies with their fruit retained. Across all treatment the only main effects that were consistent were cultivar and planting time. Micronaire of cultivar Sicot 70BRF (mean 4.01) was lower than Sicot 71BR (mean 4.35), while P2 (mean 3.94) had lower micronaire than P1 (mean 4.42).

Table 1. Effect of planting time, canopy manipulation (tipped (T), normal (N) regulated (R)), fruit removal, and cultivar on micronaire, boll number at harvest, and final boll size. Only significant main effects and highest order interactions are shown. LAI at flowering was only measured in the fruit retained treatments.

Variable	Planting	Canopy Size	Fruit Removed		Fruit Retained	
			Sicot 70BRF	Sicot 71BR	Sicot 70BRF	Sicot 71BR
Micronaire	1	T	4.00	4.60	4.35	4.50
		N	3.78	4.38	4.43	4.88
		R	4.05	4.58	4.68	4.83
	2	T	3.60	4.03	3.60	3.63
		N	4.05	4.35	3.80	4.03
		R	3.93	4.33	3.90	4.10
LSD (0.05)	Planting (P)				0.09***	
	Canopy Manipulation (C)				0.10***	
	Fruit Treatment (FT)				0.09*	
	Cultivar (V)				0.09***	
	P x C x FT				0.21*	
Boll Number ($/m^2$)	1	T	104	89	124	133
		N	92	90	118	103
		R	85	101	106	130
	2	T	89	89	123	118
		N	74	82	132	156
		R	91	91	125	121
	Fruit Treatment				7***	
	P x C x FT				18*	
	P x FT x V				26*	
LAI	1	T	-	-	2.33	2.41
		N	-	-	2.52	2.11
		R	-	-	2.52	1.87
	2	T	-	-	3.10	3.22
		N	-	-	2.85	3.18
		R	-	-	2.84	3.14
LSD (0.05)	Planting				0.40***	
Boll Size (g/ seed cotton/boll)	1	T	4.5		4.9	
		N	4.4		4.7	
		R	4.7		4.8	
	2	T	4.5		4.8	
		N	5.1		5.1	
		R	5.1		5.2	
LSD (0.05)	Canopy Manipulation				0.14***	
	FT x V				0.16***	
	P x C x FT				0.28*	

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

Discussion

Management effects were able to generate significant differences in micronaire however, only planting time and cultivar effects were consistent. Lower micronaire with the later planting was a result of lower temperature and radiation. Other studies (Constable et al. 1976; Bange et al. 2008) have shown significant decline in micronaire with later plantings in Australia and this has been associated with lower temperatures (Bange et al. 2010). Pettigrew (1995) demonstrated that lower radiation also lowered micronaire on boll cohorts. As expected the cultivar Sicot 70BRF was lower than Sicot 71BR, although the difference was on average less than differences generated by planting time.

Treatments to manipulate the canopy were not successful in changing the LAI (source) at the start of the fibre thickening period. In most instances the only effect of canopy manipulation was the delay in maturity

caused by the tipped treatment; a similar outcome reported by Wilson et al. (2003). The delay in maturity (5 d) associated with this treatment would have exposed more bolls to lower temperatures and radiation lowering micronaire similar to that reported by Brook et al. (1992).

The removal of fruit in an attempt to increase the source to sink ratio did not increase micronaire of the remaining bolls. In fact there were more instances where treatments that had fruit retained had higher micronaire. The most likely reason for this is that the removal delayed maturity (again 5 d later) and allowed new bolls to develop later in the season and lowering the overall final micronaire. At harvest there was 27% less bolls than the fruit retained treatments, compared to 50% removal (at treatment implementation) thus indicating new boll development. The micronaire result differed from Brook et al. (1992) where continuous and ongoing removal of fruit generated increased micronaire. Kelly et al. (2006) who compiled cultivar performance data across sites and seasons, and Pettigrew (1995) assessing boll cohorts were also able to generate increased micronaire. In all these cases however, substantially greater reductions in bolls than those implemented in this study were needed to increase micronaire by a small amount.

Treatments in this study were able to generate significant variation in boll number and boll size. Correlation analysis showed that there was a significant ($P < 0.05$) positive correlation of boll size with micronaire (r=0.60). Brook et al. (1992) in their study found a similar response and suggested that an increase in carbohydrate supply to bolls should result in increased micronaire. They also showed that boll size was negatively related to boll number, and in some instances reductions in boll number allowed increases in boll size (and micronaire) when crop maturity was delayed. This suggested that there were compensatory mechanisms affecting these responses. In this study there was no significant correlation of boll number with boll size across all data however, boll size of the later planted (P2), tipped, and fruit removed treatment was similar to the equivalent earlier planted (P1) treatment, and boll size of P2 in other canopy treatments were larger than the equivalent P1 treatments that were the late planted and had fruit removed. Of these treatments the effect translated into lower micronaire for tipped canopies and was similar for the normal and regulated canopies. This suggested a similar response to that of Brook et al. (1992).

Conclusion

This study has highlighted that in capturing understanding of management impacts on micronaire differences in cultivars, and influences of management modifying the period in which fibre thickening occurs need to be especially considered. It also reinforced opportunities to account for impacts of crop sink dynamics on micronaire by coupling these effects to boll growth directly. Further research is needed to generate larger differences in source/sink dynamics and impacts on micronaire.

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