Cotton Catchment Communities CRC

SUMMER SCHOLARSHIP - 2006/2007 SEASON

Project title: Patterns of cotton lint, seed protein and seed oil accumulation in the field

Aims and milestones:

- Determine the patterns of oil, protein and lint accumulation over boll development for 5 cultivars
- Determine the relationship between seed oil and lint yield for 54 cultivars
- Determine the effect of seed oil content on fibre quality parameters

Staff:

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Project Summary

This summer scholarship project was undertaken by Alice McDowell. Alice is in her fourth and final year of Bachelor of Science in Agriculture at the University of Sydney and is majoring in Agronomy. The scholarship commenced on 2nd January, 2007 and was completed on 23rd February 2007.

Background

Cotton (*Gossypium hirsutum*) is the most important fibre crop worldwide (Ruan, 2005). Cotton bolls contain maternal seeds from which the seed coat epidermis initiates filial fibre (lint) (Basra & Malik, 1984). Despite being a by-product of the seed, fibre generates a significantly larger portion of revenue than cottonseed products (Mert, Akiscan & Gencer, 2005).

Photoassimilates enter the bolls from the bracts, and adjacent leaves and are then portioned into boll components: boll walls, lint and seed. The boll walls act as a sink, forming early in development and later providing assimilates to the seed coat via the funiculus, then symplastically transported to the ovule (Benedict, Kohel & Schubert, 1976). Once in the ovule, photosynthates are used for seed development, or fibre development (Ryser, 1992). The seed is composed of 5-12.8% moisture, 15.2-22.7% oil and 17.1-27.6% protein (Turner, Ramey & Worley, 1976) and fibre, which initiates from elongated seed epidermal cells, consisting mainly of cellulose (β-1,4-glucan chains) (Ruan, 2005). Oil biosynthesis in cottonseed requires significantly larger amounts of energy than lint biosynthesis and as a result a cotton plant must fix around twice as much carbon to produce seed compared to fibre (Lewis, 1996). The seed utilises a finite amount of resources and therefore, it has been hypothesised that cotton cultivars with low oil content will have more energy available for lint synthesis, and therefore yield more lint. This information will be useful in cotton breeding selection processes, whereby screening for low oil yielding cultivars may enhance lint yields, and thus economic returns, with less energy going to produce less valuable seed and more energy going to produce more valuable lint, if oil is negatively correlated to lint yield.

Past research has focused on the correlation between seed components, protein and oil, and lint yields, but results have not always been consistent. A comparison of the accumulation of protein, oil and lint over the entire boll development is important in understanding final energy allocation within the boll. In addition, knowledge of cultivar response to different environments is important. If the negative correlation between oil levels and lint yields is established in future research, screening for low oil content cultivars may improve Australian cultivar selection and subsequent lint yields.

Aims and objectives

To determine the pattern of cotton lint, seed oil and seed protein accumulation over boll development in the field, and determine the relationship between lint, seed oil and fibre quality for 54 cultivars.

Methodology

Experiment 1

Gossypium hirsutum cultivar Sicot 71BR was grown in fields at ACRI, Narrabri. Bolls were sampled from 7 days post anthesis (DPA) at 3 day intervals until maturity. To examine the competition for photoassimilates within the bolls, seed, lint and boll wall dry weights were taken for all samples, and protein and oil content of seeds will be determined.

Experiment 2 and 3

Four replicates of fifty-four upland cotton cultivars (*Gossypium hirsutum*) were grown in a Randomised Complete Block Design. Four of these cultivars were selected based on possessing varied oil seed content (Experiment 2) and bolls of these four cultivars were sampled at 7 day intervals from 7 DPA up to maturity. Seed, lint and boll wall dry weights were determined and the oil and protein content of the seeds will also be analysed.

All 54 cultivars were harvested at maturity (Experiment 3). Seed will be tested for oil content, and fibre quality will be analysed by HVI at ACRI, Narrabri.

Data Collection

Bolls were tagged on day of anthesis (flower opening) and picked at assigned 'days post anthesis' (DPA). Bolls were hand separated into seed, lint and boll wall components. These components were then oven dried and weighed (g/boll). Oilseed content will be measured using Nuclear Magnetic Resonance. Nitrogen (N) content will be measured using a Leco C-H-N analyser, and these N values will then be multiplied by a standard value to convert to protein content.

Results

Dry weight accumulation over boll development

Experiment 1

Boll wall dry weights of Sicot 71BR cultivars increased from 7 DPA up to 18 DPA when dry weight reached a plateau. The seed and lint had a relatively consistent and similar dry weight increase over time, but seed dry weight increased rapidly early in development between 12 to 18 DPA whereas lint had a slower dry weight accumulation in early development. Lint reached maximum weight at 45 DPA, while seed continued to accumulate weight up to maturity (56 DPA) (Figure 1).

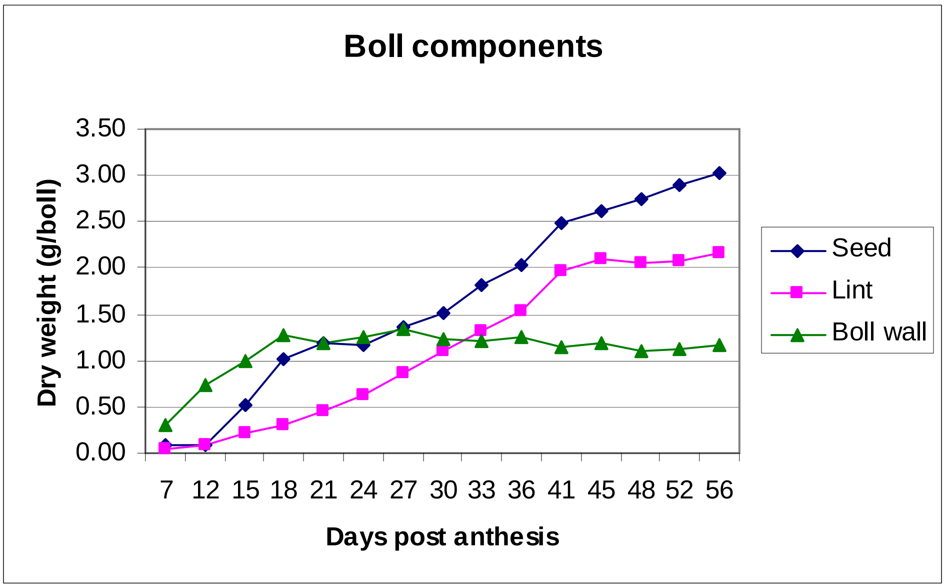

Figure 1. Dry weight accumulation of seed, lint and boll walls (g/boll) over maturity in Sicot 71BR bolls.

Experiment 2

Dry weights of seed, lint and boll walls showed consistent patterns of accumulation across the four cultivars (Figures 2 to 5), and were also consistent with the accumulation for Sicot 71BR boll components in Experiment 1 (Figure 1).

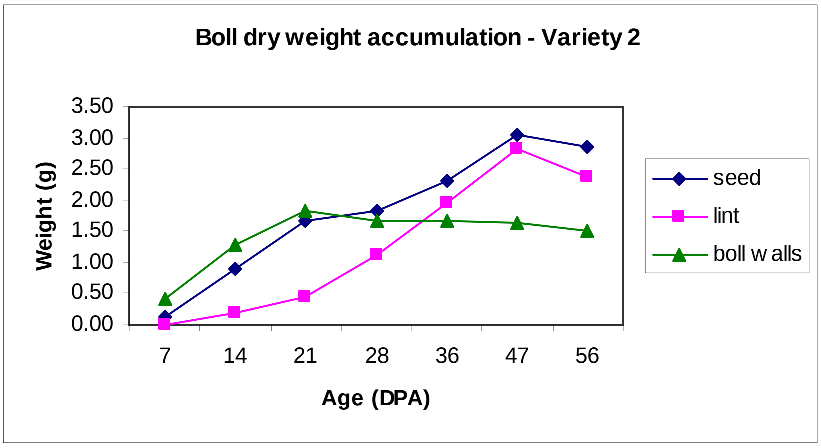

Figure 2. Dry weight accumulation of seed, lint and boll walls (g/boll) over maturity in 'Variety 2' cultivar bolls.

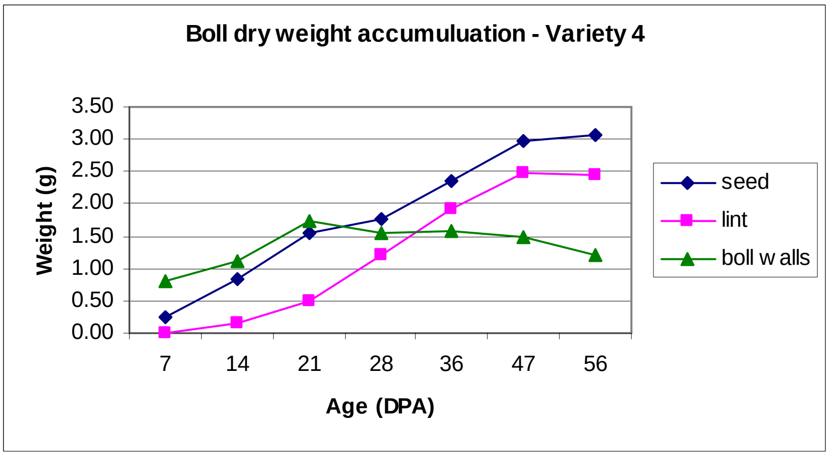

Figure 3. Dry weight accumulation of seed, lint and boll walls (g/boll) over maturity in 'Variety 4' bolls.

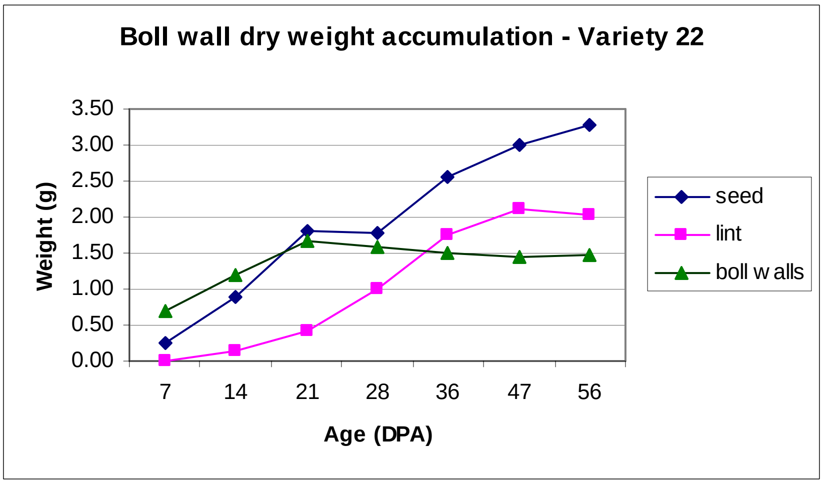

Figure 4. Dry weight accumulation of seed, lint and boll walls (g/boll) over maturity in 'Variety 22' bolls.

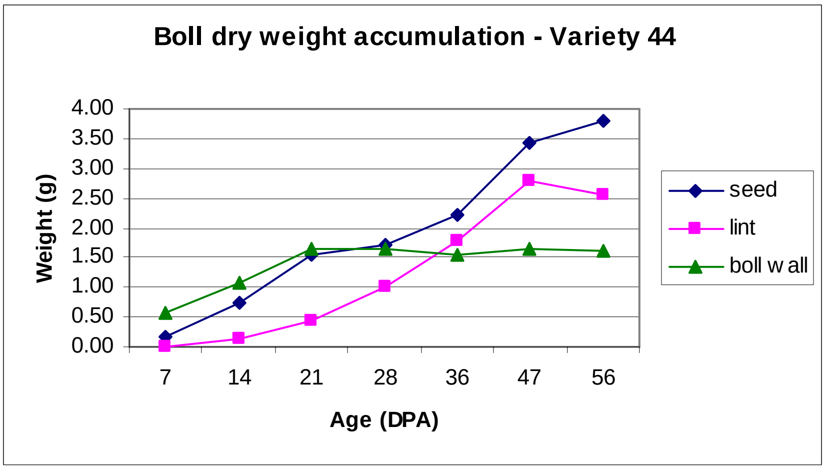

Figure 5. Dry weight accumulation of seed, lint and boll walls (g/boll) over maturity in 'Variety 44' bolls.

Discussion

Boll wall dry weights reached a plateau at approximately 18 DPA in Experiment 1 and 20 DPA in the cultivars in Experiment 2. This early accumulation of maximum dry weight is suggestive of the boll wall's role as a physiological reserve, to subsequently provide assimilates for the seed and lint in later boll development. Benedict *et al.*(1976) observed that peak incorporation of photosynthates into the boll walls occurred at approximately 8 to 10 DPA, after which levels significantly declined until 30 DPA, when incorporation ceased (Benedict *et al.*, 1976).

Secondary cell walls consists of nearly 100% cellulose, therefore dry weight accumulation is indicative of cellulose synthesis (Pettigrew, 2001). Secondary wall thickening begins around 16 to 20 DPA and ceases at around 40 DPA (Haigler, Zhang & Wilkerson, 2005; Ruan, Chourey, Delmer *et al.*, 1997). This is evident in the lint dry weight accumulation for all cultivars (Figures 1 to 5), as the slope of the lint curve begins into increase rapidly from approximately 20 DPA up to 40 DPA, when secondary wall thickening stops, and subsequently dry weight accumulation ceases. Benedict *et al.* (1976) similarly observed this pattern of dry weight accumulation, whereby there is low fibre dry weight up to around 19 DPA and then it rapidly increases up to around 40 DPA.

The seeds accumulate dry weight for a longer period than lint, slowing after 47 DPA in the four cultivars in Experiment 2, or continuing up to 56 (maturity) in Sicot 71BR (Experiment 1). Peak incorporation of photoassimilates into seed oil and fibre occur simultaneously (Benedict *et al.*, 1976). This is evident as the shape of the curves for lint and seed dry weight accumulation in Figures 1 to 5 are similar, which suggests that competition between the two boll components for plant resources for growth is likely.

Conclusion

The temporal accumulation of boll wall, seed and lint dry weight can provide an insight into assimilate partitioning within the boll during boll development. The timing of accumulation suggests when assimilate competition may be occurring. Seed and lint dry weight accumulation occurs in a similar pattern over boll development for all 5 cultivars studied, therefore it might be possible that seed oil, which requires an energy intensive pathway for its biosynthesis, can compete with lint for assimilates. Further data on seed protein and oil accumulation over boll development will provide further insight into seed and lint resource competition.

Presentations and public relations

A summary of this project was included in a CRC media release on the 2006/07 summer projects being undertaken by Cotton Catchment Communities CRC funded students (Cotton Magazine, The Courier: January 2007)

A presentation summarising progress and findings was given to staff of the Australian Cotton Research Institute, Narrabri on 21st February 2007.

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