Title
Nitrogen Allocation in High Yielding Bollgard II® Cotton

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Introduction
Nitrogen supply is directly correlated with cotton flower bud production, leaf production and expansion, and fruit retention (Marcus-Wyner and Rains, 1982; Zhu and Oosterhuis, 1992). ‘Cutout’ is reached in cotton plants when vegetative growth slows due to competition for assimilates from reproductive growth (Pettigrew et al., 2000) and at this stage of development, root absorption of nutrients can decline (Wright, 1999) and nutrient demands of the fruit (bolls) is supplemented through translocation of nutrients from vegetative structures (Pettigrew et al., 2000). Therefore an adequate supply of nitrogen, both pre- and post- cutout is essential for the bolls to develop and to achieve high lint yields.

Transgenic cotton varieties, such as Bollgard II released in 2001, have higher boll retention rates than conventional varieties leading to potentially higher demands for nutrients particularly during the boll development stage. Higher demand from the fruit could result in variation in the partitioning patterns of nutrients, and in the amount of nutrients redistributed from leaves to fruit. It is generally assumed that higher boll numbers place additional demands on leaf and stem sources of nutrients (Lopez et al., 2008; Oosterhuis and Steger, 1998; Oosterhuis et al., 1997), and that the vegetative fraction can redistribute up to 60% of the stored N to the fruit (Zhu and Oosterhuis, 1992). In addition to changes in fruit retention, higher yields (>2000 kg lint/ha) that are being attained by Australian growers may have also have changed nutrient redistribution. The influence that variation in boll nutrient demand has on the partitioning of nutrients in the whole plant, and the flows of nutrients between vegetative and reproductive structures is not well documented for high retention/yielding cotton crops.

Materials and Methods
Based on the variation between previously recorded yields three field experiments were undertaken in 2007-2008 in the cotton-growing region of north-west New South Wales Australia (‘Keytah’, Moree (149°31’E, 29°29’S), the Australian Cotton Research Institute (ACRI), Narrabri (149°59’E, 30°12’S) and ‘Cardale’, Narrabri (149°65’E, 30°27’S)). Measurements were taken to compare total nitrogen uptake and redistribution. Cotton (Gossypium hirsutum cv Sicot71 BRF) was sown at each site and crop development was monitored. Cutout and maturity occurred at Keytah 127 and 172 days after sowing, at ACRI 132 and 174 days after sowing, and at Cardale 133 and 190 days after sowing. Four replicate random 1m² samples of plants were cut every ten days from flowering to maturity, partitioned into leaves, stems (including petioles) and fruit and dried at 70°C for five days. Once dry, samples were ground using a Foss Tecator Cyclotec 1093 sample mill fitted with a 1mm screen. Samples were analysed for nitrogen using a Leco CHN analyser. Data was analysed in terms of total content (mg/m²) and concentration in tissues (mg/g dry weight) to illustrate gross differences, and to account for the differences in plant size and dry weight fractions between sites.

Results
The yields recorded at each site were 3270 kg/ha (ACRI), 3090 kg/ha (Keytah) and 2130 kg/ha (Cardale). At all three sites plants accumulated nitrogen in the reproductive fraction until maturity except for at ACRI where a slight decline was observed (Figure 1). In all crops peak nitrogen content in the vegetative fraction occurred at cutout. The higher yielding crops from ACRI and Keytah maintained a lower N concentration in the fruit compared to the lower yielding crop at Cardale. The lower yielding crop (Cardale) showed a decrease of over 50% of the N concentration in the fruit between flowering and maturity (Figure 1). The three sites showed
similar patterns of redistribution from the leaves and stems to the fruit, the highest decrease in the N content of leaves recorded at Cardale (a decrease of 4825mg N/m$^2$), second highest at Keytah (3829 mg N/m$^2$ decrease) and the lowest at ACRI (2012 mg N/m$^2$ decrease), following inverse yield order. The same pattern was followed in the stems, plants N content declining by 4579.47 mg N/m$^2$ at Cardale, 3120.62 mg N/m$^2$ and 912.06 mg N/m$^2$ at ACRI (Figure 1).

![Figure 1](image)

Figure 1 Nitrogen content (mg/m$^2$) and concentration (mg/g) in the (a) leaves, (b) stems and (c) fruit of cotton plants from flowering to maturity at Keytah, Moree, ACRI, Narrabri and Cardale, Narrabri.

**Discussion**

Despite having a higher demand for N from resulting from a higher boll number, the higher yielding crops did not show an increase in the redistribution of N from the leaf and stem fractions compared to the lower yielding crop. The nitrogen content of the stems declined by 3% at Keytah, at 7% at Cardale and by 8% at ACRI. In the leaves, nitrogen declined by 47% at Keytah, 55% at Cardale and 24% at ACRI. At maturity, the proportion of the total plant N in the fruit was highest at Cardale (74.2%) – the lowest yielding crop, and lowest at ACRI (64.9%) – the highest
yielding crop. The decline of the N concentration in the fruit at *Cardale* by 50% could be attributed to growth dilution, since the number of bolls did not increase in this time.

Redistribution of leaf and stem N followed an inverse yield order; contrary to the theory that a higher boll load would place a higher demand for leaf and stem N. A higher demand for N from the fruit fraction did not result in a higher efficiency of N use within the plant, since while producing more bolls, higher yielding plants maintained a higher N concentration in the leaves and stems than the lower yielding plants between flowering and maturity. Higher yielding plants also maintained a constant fruit N concentration of around 2%, despite the rapid accumulation of fruit dry weight as they developed. This indicates that plants were able to supply the developing fruit with N from leaves and stems, and may have maintained N uptake from the roots to supplement this supply. At ACRI a total of 2924 mg N/m² was redistributed from the leaves and stems, equating to 10.6% of the fruit N at maturity. At *Keytah* the 6949mg N/m² redistributed from the leaves and stems equating to 31.4% of the fruit N, and at *Cardale*, the 9405 mg N/m² redistributed from the leaves and stems equating to 40.8% of the fruit N.

In this study, the plants with a lower fruit dry weight showed a higher efficiency of redistribution from stems to leaves than plants with a higher boll number (fruit dry weight – data not shown). Since none of the sites studied was deficient in N supply, the difference in plant growth rate, plant size and final yield, as well as the efficiency of boll production could be due to other environmental and management factors, such as temperature, water and nutrient supply. This indicates that the addition of N will not contribute in itself to a higher yield, or an increase efficiency of partitioning, but rather a complex interaction of water, nutrient supply and environmental conditions. This information will add to the understanding of how high yielding crops use N, and aid in contributing to efficient N management to optimise boll development and lint yields.

**References**


