CottonInfo nitrogen management trials: Darling Downs
Nitrogen Fertiliser Use Efficiency on the Darling Downs
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Key findings

- Increasing Nitrogen (N) application rate increased the Vegetative Growth Rate but did not reliably increase node number and total bolls per plant.
- N uptake increased with increasing N application at the overhead site and one of the flood sites however; more N in the plant did not mean higher lint yields.
- The lint yield response to applied nitrogen (N) plateaued at lower than expected rates; 85 kg N/ha at the overhead site, 130 kg N/ha and 100 kg N/ha at the two flood sites.
- Nitrogen recovery in the plant at defoliation was around 13-30 percent higher in the overhead irrigation system compared to the flood systems.
- The amount of lint produced for each kilogram of N taken up by the crop, where the yield plateaued, was very similar across the sites at 17.9, 17.3 and 18.6 kg lint/kg of crop N uptake for the overhead and two flood sites, respectively.
- Increasing N application did not reliably result in more mineral N at the end of the season.

Trial aim

The aim of this series of trials was to investigate the response cotton growth and lint yield to applied N on two different irrigation systems to determine if irrigation system influences the recovery fertilizer N.

However, for the purposes of this summary a focus has been placed on the influence of applied N on crop N uptake and subsequent lint yield.

Trial details

Location:
Four trials were planted, two overhead and two flood-furrow irrigated. However, only three are reported here, one overhead site and both flood sites. The second overhead site had other influences on lint yield that impacted on the N treatments. A brief summary of the locations and nitrogen treatments imposed are provided in (Table 1).

Soil type:
Soil types at each site are broadly classified as Vertosols. Pre-season soil tests indicated that the sites would be responsive to N application (Table 1) with N contents in the 0-90cm soil profile of 100, 115 and 45 kg N/ha for Overhead 1, Flood 1 and Flood 2, respectively.

Rainfall:
Oct-Mar (mm): 287.2mm

Site	Location	Previous crop	Upfront N rates (kg/ha)	In-crop N (kg/ha)	Starting Soil N (kg/ha) 0-90cm
Overhead 1 (OH1)	Kincora	Maize	0, 25, 50, 75, 100, 125, 200, 300	60	100
Flood 1 (F1)	Nandi	Cotton	0, 40, 80, 120, 160, 200, 280, 360	50	115
Flood 2 (F2)	St Ruth	Cotton	0, 40, 80, 120, 160, 200, 280, 360	20	45

Table 1: Summary of the trial locations, irrigation methods, and nitrogen treatments imposed at each of the trial sites.

Management:
Each of the sites was watered up as soon as possible after planting, the overhead (OH1) site and Flood 2 (F2) were planted with Sicot 74 BRF on 11 and 27 October, respectively. Flood 1 (F1) was planted with Sicot 75BRF on 23 October.

Management of each of the sites was left to the grower and their consultant. The only management that varied in the trial area was the application of N otherwise everything that happened in the remainder of the field was also applied to the trial area.

Treatments:
The N application treatments are detailed in Table 1. The total N applied in each treatment was applied as a split between upfront and in-crop. The upfront N application was sown approximately 10 weeks before planting at each of the sites. The upfront N application at the overhead site was reduced because it was anticipated that N would be fertigated in-crop through the irrigator, and no in-crop application of N was intended at either of the flood sites, although one in-crop application of N was inadvertently applied at each flood site as well.

Seasonal review:
Above average temperatures and dry conditions were experienced in the first part of the 2014-15 cotton season. The warm conditions can be seen in Figure 1 below with separation of the 2014-15 line (blue) from the long term average line (green). Temperature was then close to average for the remainder of the season.

Rainfall during the cotton season was below average with 287.2mm falling in the October to March period compared with the longer term average of 439.4mm (Dalby).

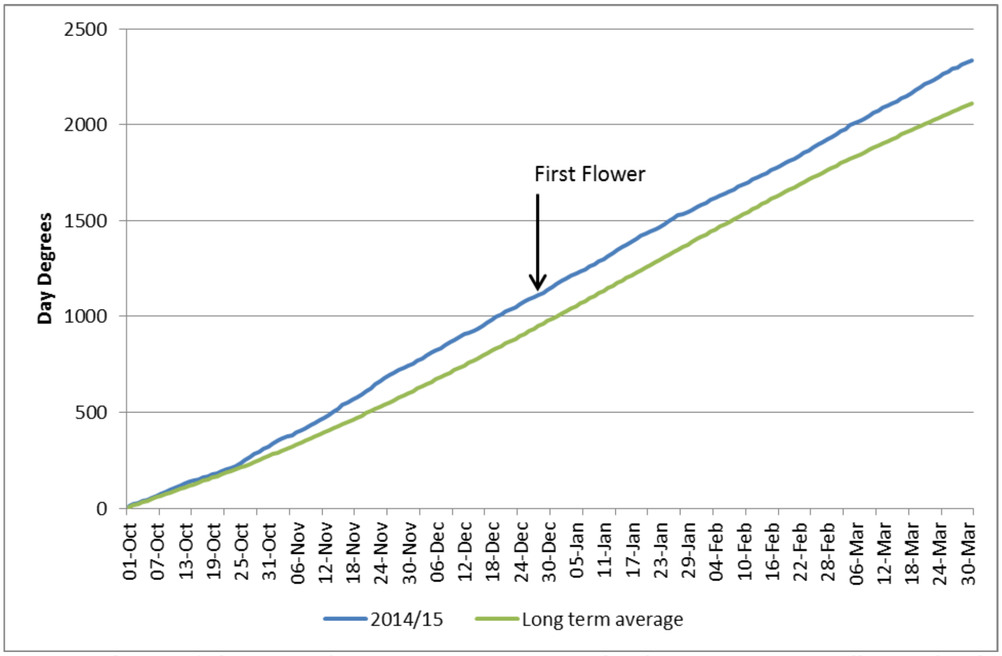

Figure 1: Comparison of the 2014/15 Day Degrees to the long term at Dalby. The indication of first flower represents when it was observed in-field as defined as one flower per metre of plant row.

There were the extended periods of below average solar radiation during the vegetative, flowering and boll development periods (Figure 2). Given the lint yields that were achieved the reduction in solar radiation during those periods does not appear to have had an influence.

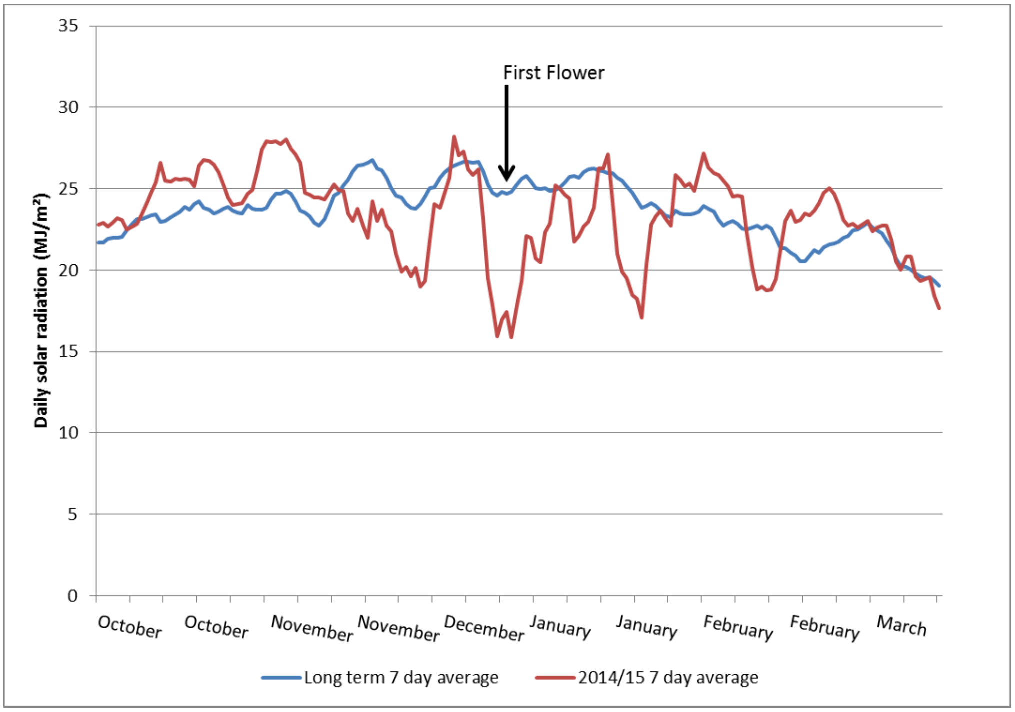

Figure 2: Comparison of the daily solar radiation in 2014/15 to the long-term average at Dalby, showing a reduction solar radiation through the vegetative, flowering and boll development periods of the 2014/15 season. The indication of first flower represents when it was observed in-field as defined as one flower per metre of plant row.

Trial results

NOTE: The lint yield results reported here do not indicate an optimum N rate rather they report on the N rate at which there were no further statistical differences in lint yield. Optimum rates have not been determined because this was not the intent of this series of field trials and are site and seasonally specific.

At OH1 and F1 increasing N application increased plant height but did not influence node number per plant or the total number of bolls per plant, meaning that at these two sites there was only an increase in VGR but no benefit to yield characteristics such as node and boll number. At F2, where there was less available N, plant height, node number per plant and boll number per plant all increased as N application increased.

Site	Total applied N (kg/ha)	Plant height (cm)	Node Number (per plant)	Total bolls (per plant)
Overhead Site 1	60	87.3 a	ns (mean 25.3)	ns (mean 17.3)
	135	105.1 b		
	260	99.9 b		
	360	107.3 b		
Flood site 1	50	74.9 a	ns (mean 26.8)	ns (mean 16.8)
	130	89.1 b		
	250	91.0 b		
	410	101.5 b		
Flood site 2	20	66.7 a	21.6 a	12.8 a
	100	76.7 b	23.7 b	15.3 a
	220	82.6 b	24.9 b	16.7 ab

	380	92.7	b	26.7	c	21.6	b

Table 2: Summary of the influence of N application on the plant growth for the sites; Overhead 1; Flood 1; and Flood 2. Plant height was influenced at all sites. Node number per plant and total bolls per plant were only influenced at Flood site 2. Significant differences in each column and within each site are indicated by the different letters.

Turnout, determined from hand ginned samples, showed a reduction as the rate of applied N increased, across the range of N used in the treatments, by 1.5 percent, 0.8 percent and 2.1 percent for OH1, F1 and F2, respectively. However, only at the flood sites was there further decline above 200 kg N/ha to maximum N application rates with 0.7 percent and 0.4 percent for F1 and F2, respectively.

The uptake of N by the crop increased at first flower, mid-flowering (3 weeks after first flower) and at defoliation (Figure 3; sampled within a week prior to the first defoliation spray being applied) as the rate of applied N increased at the OH1 and F2 sites. However, very rarely does more N in the crop at defoliation result in an increase in lint yield (Figure 4; where an R^2 of 1 represents a relationship of one factor completely influencing the result of another).

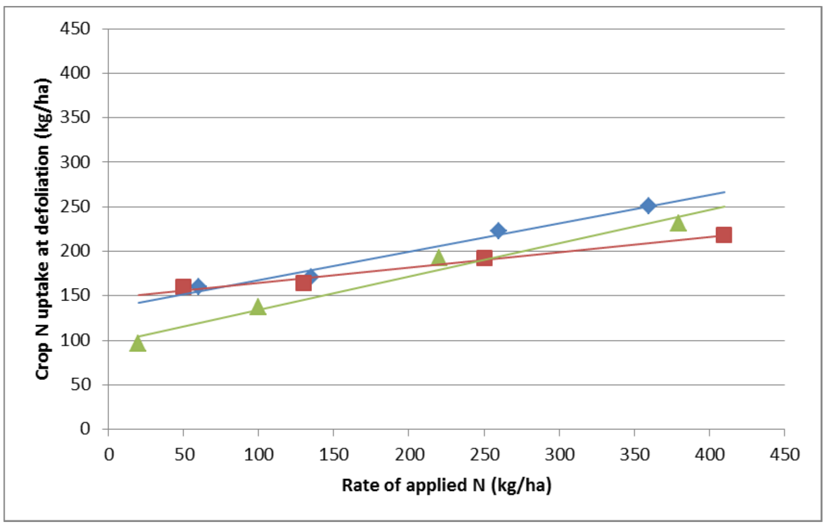

Figure 3: The relationship between the rate of applied N and crop N uptake at defoliation at Overhead 1 (blue), Flood 1 (red) and Flood 2 (green).

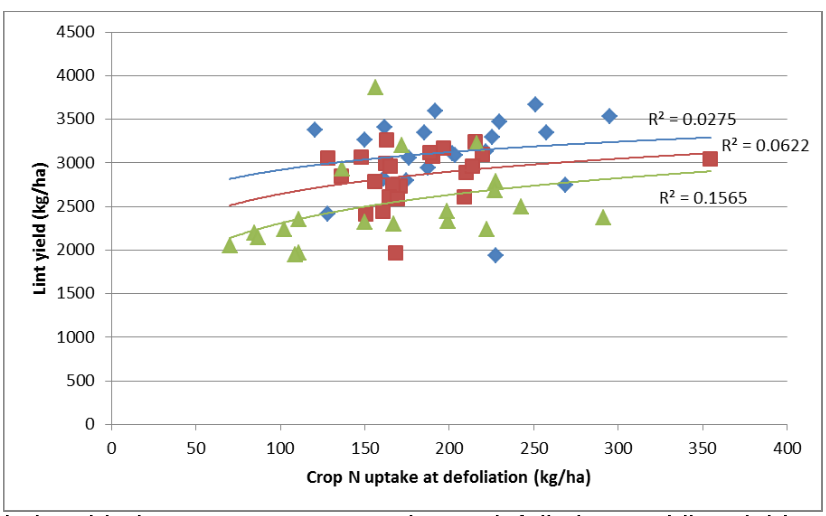

Figure 4: The relationship between crop N uptake at defoliation and lint yield. The low R^2 values highlight that rarely do increases in crop N uptake at defoliation result in increases in lint yield for the sites; Overhead 1 (blue), Flood 1 (red) and Flood 2 (green).

The lint yield response at each of the sites was interesting and unexpected given current industry recommendations, with the yield plateau occurring at much lower rates than was initially anticipated in the setup of the trials. There were no further statistical increases in lint yield above N application rates of 85 kg N/ha, 130 kg n/ha and 100kg N/ha for OH1, F1 and F2, respectively.

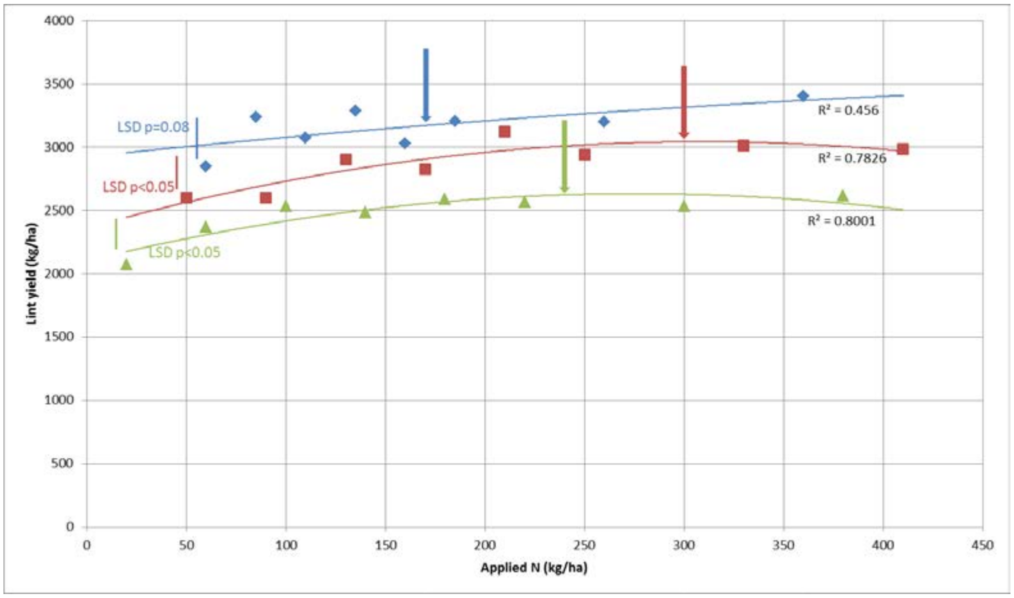

Figure 5: The relationship between the application N and lint yield at OH1 (blue), F1 (red) and F2 (green). The coloured arrows represent the N rate applied by the grower to the rest of the field. The small coloured vertical lines represent the least significant differences from the analysis of variance conducted. The lines of best fit between the data points are fitted using Polynomial equations.

Nitrogen recovery efficiency (RE) at defoliation (plant N uptake (kg/ha) / available N supply (kg/ha)) was calculated for each rate of applied N at each site. The resulting RE's for the N application rate at which there were no further significant increases in lint yield were 0.91, 0.70 and 0.80 for OH1, F1 and F2, respectively, indicating that at those rates most of the available N was being acquired by the plant. The results also show that the RE at OH1 is around 13-30% higher than the two flood sites.

The internal NUE (iNUE; kg lint / kg crop N uptake at defoliation) was also measured. This showed that there was little difference in the ability of plants under the different irrigation systems to convert N in the plant to lint. Where lint yield showed no statistical response to further N application the iNUE's were 17.9, 17.3 and 18.6 for OH1, F1 and F2, respectively.

Increasing application of N did not reliably increase residual soil mineral N with an increase in residual mineral N only occurring at OH1 and F2. Flood 1 did not have increasing levels of residual soil N with increasing applied N rates. However, there was a consistent effect of increasing levels of unaccounted for N as the applied N rates increased reaching maximum levels of 25% at 260 kg of applied N/ha at OH1, 65% at 250 kg of applied N/ha at F1 and 34% at 100 kg of applied N/ha at F2.

Discussion or interpretation of results

The influence of N on plant growth is consistent with existing knowledge that increasing N application will produce increase VGR and that this does not always equate to improvements in lint yield.

The relationship between N application and crop N uptake at defoliation highlights a couple of things. Firstly, despite the F2 site having around half the mineral N at the start of the season, compared to the other two sites, the crop was still able to acquire similar amounts of N by defoliation. Given that N recovery at the two flood sites was similar and both lower than that of the overhead site the indication is that more mineralisation occurred to meet the plant demand at F2.

Secondly, the flatness in the response curve means that it takes large amounts of applied N to influence crop N uptake at defoliation (Figure 3). In addition, there are only very weak relationships between crop N uptake at defoliation and lint yield (Figure 4) at each of the sites meaning that even if more N does get into the crop very rarely will it result in additional lint yield.

The flatness of the response of lint yield to N application was surprising however, given that it occurred across the three sites suggests a seasonal effect rather than individual site limitations. It is difficult to draw much out the response without being able to assess the seasonal influence which has been identified by other work conducted by the Regional Development Officer's as a major influence of lint yield in irrigated cotton in Australia. To some extent the response in the 2014-15 season highlights the need to treat each season individually by utilizing options such as in-crop nutrient monitoring to tailor nutrient inputs as required.

The impact on results from one of the overhead sites from factors outside the treatments limits the ability to able to determine if irrigation system influences N recovery. There is some indication that N recovery in the plant defoliation is better under the overhead system however it does not appear to be able to produce more lint with that N with iNUE at similar levels to the two flood sites. A contributing factor is around the management of soil moisture, for example in Sorghum other researchers have shown that using a smaller soil moisture deficit for scheduling produces better NUE, compared to these sites where similar soil moisture deficits 50-70mm were used to schedule irrigations. This will be considered in future work.

Increasing N application did not always lead to an increase in the amount of residual post-season N, meaning that this can become a very inefficient and uncontrolled way applying N to a subsequent crop. In fact at F1 where the there was no relationship between N application during the cotton crop and residual post-season N additional N resulted in larger amounts of N unaccounted for (up to 268 kg N/ha at the highest rate of applied N). Thus the old adage of what is not used in this crop will be available for the next crop is fraught with the risk of just excess losses.

Acknowledgements
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