# Effect of Nitrogen Application Level on Cotton Yield and Fibre Quality- Results from Recent Trials in Australia

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## Abstract

# Background

A recent extensive review showed that the effect of Nitrogen application levels on fibre quality were rather varied and often inconsistent. As a consequence, trials were conducted in Australia in 2018 and 2019 in four locations using three popular high yielding commercial varieties common in the Australian system. Nitrogen was applied at application levels ranging from zero to excessive.

# Results

These trials concluded that in general, the application of moderate (100 to 200 kg.ha$^{-1}$) levels of N resulted in the highest yield and produced longer, more even, and stronger fibre. N application levels also negatively affected colour and lint turn out.

# Conclusions

Nitrogen plays a major role in determining the yield, lint turn out and fibre quality. However excessive application levels over 14 to 15 kg of N for each bale produced has no economic benefit and has the potential of negatively affecting yield and fibre quality.

## Introduction

In order to obtain further clarification on the effects of Nitrogen (N) application levels on various fibre quality parameters, research was undertaken over two years in four locations using three popular high yielding (> 2000 kg.ha$^{-1}$) commercial Upland cotton (*Gossypium hirsutum* L.), varieties common in the Australian system. In all cases Urea, containing 46% N was applied at application levels ranging from zero (0 kg.ha$^{-1}$) to moderate (100 to 200 kg.ha$^{-1}$) to high (300 kg.ha$^{-1}$) and excessive (400 kg.ha$^{-1}$). For ease of interpretation fibre properties were all measured by high volume instruments which is the preferred method of cotton classification for cotton trading (ICAC/ITMF 2018)

## Materials And Methods

Three studies were undertaken during the 2018/2019 growing season (planted in 2018; defoliated, harvested and ginned in 2019) at the Australian Cotton Research Institute (ACRI) in Narrabri (149º36'E,30º12'S) in the Namoi Valley of New South Wales (NSW), on grey cracking clay soil, one at the Irrigation Research and Extension Committee (IREC) in Griffith (34°17'24'S 146°2'24E) in the Murrumbidgee Valley (Southern region) of NSW, on Mundiwa clay loam soil and one at Toobeah (28.4169°S 149.8702°E) in the MacIntyre Valley (Central region) of Queensland (Qld) on grey vertosol soils. Two further studies were undertaken during the 2019/2020 growing season (planted in 2019; defoliated, harvested, and ginned in 2020); one at ACRI and one at Cecil Plains (27.5316°S 151.1930°E) on black vertosol soils on the Darling Downs in Central Qld.

A summary of the respective field operations employed on each of the fields are presented in Table 1. The cotton varieties used for the trials were two CSIRO varieties, containing Bollgard® 3 technology stacked with Roundup Ready Flex, Sicot 746 B3F (Stiller 2016a) and Sicot 714 B3F (Stiller 2016b), currently the two most popular Upland varieties grown in Australia as well as Sicala V-2 (Reid 1995), a popular CSIRO conventional variety grown in the late 1990s. All fields were subjected to standard management practices for irrigated Upland cotton in Australia.

Field A was first subjected to harvest aids by ground rig, with a mixture of leaf defoliant (0.1 L. ha$^{-1}$ Dropp® UltraMAX liquid by Bayer Crop Science) and boll opener (1.0 L.ha$^{-1}$ Prep® 720 by Bayer Crop Science). The field was again sprayed by ground rig with a mixture of leaf defoliant (0.15 L.ha$^{-1}$ Dropp® UltraMAX) and boll opener (1.5 L.ha$^{-1}$ Prep® 720). The field was then subjected to a further spray by ground rig with a mixture of leaf defoliant (0.2 L.ha$^{-1}$ Dropp® UltraMAX) and boll opener (2.0 L.ha$^{-1}$ Prep® 720). The trial was conducted using a randomized complete block design, with four replications. Seed cotton from 32 plots, containing four rows spaced at 1 meter, was harvested by a single row Case IH 1822 spindle harvester (CNH America, Racine, WI), which was maintained and operated via normal industry practice and manufactures recommendations. An average of 0.234 kg seed cotton sample was collected from each replicate produced and was ginned using a 20-saw gin (Continental Eagle, Prattville, AL) with a Mitchell feeder and pre-cleaner located at ACRI.

Field B was first subjected to harvest aids by air, with a mixture of leaf defoliant (0.15 L.ha$^{-1}$ Dropp® liquid by Bayer Crop Science), boll opener (0.5 L.ha$^{-1}$ Promote® 900 by ADAMA) and crop oil (0.5 L.ha$^{-1}$ Canopy® by Caltex). The field was again sprayed by air with a mixture of leaf defoliant (0.15 L.ha$^{-1}$ Dropp®), boll opener (2.0 L.ha$^{-1}$ Promote® 900) and crop oil (0.5 L.ha$^{-1}$ Canopy®). The field was then subjected to a further spray by air with a mixture of leaf defoliant (0.18 L.ha$^{-1}$ Dropp®), boll opener (0.9 L.ha$^{-1}$ Promote® 900) and crop oil (0.5 L.ha$^{-1}$ Canopy®).

The field was harvested using a grower owned and operated John Deere 7760 spindle round module harvester (Moline, IL), with Pro16 row units, which was maintained and operated via normal industry practice and manufacturers recommendations. Only part of the field was utilized for this trial (3.05 ha per treatment), using a randomized complete block design, with three replications. A total of sixty-four part round modules were harvested. The round modules were dropped in the field and picked up by a mast-type tractor mounted implement that holds the module with the axis parallel to the tractor rear axle and were then staged together in the sequence that they were harvested. All modules were ginned, under similar standard commercial conditions, at the Namoi Cotton Limited MacIntyre No. 1 gin, situated in Goondiwindi, Qld. This gin is a Continental Eagle (Prattville, AL) high-capacity saw gin, equipped with four 181 gin stands, with no flow-through air lint cleaners and two stages of controlled-batt saw lint cleaners, capable of producing 60 bales. hour$^{-1}$.

Field C was first subjected to harvest aids by ground rig, with a mixture of leaf defoliant (0.175 L.ha$^{-1}$ Escalate® UltraMAX liquid by ADAMA) and boll opener (0.5 L.ha$^{-1}$ Promote® 900). The field was again sprayed by ground rig with a mixture of leaf defoliant (0.2 L.ha$^{-1}$ Escalate® UltraMAX) and boll opener (2.5 L.ha$^{-1}$ Promote® 900). The field was then subjected to a further spray by ground rig with a mixture of leaf defoliant (0.15 L.ha$^{-1}$ Escalate® UltraMAX ) and boll opener (0.5 L.ha$^{-1}$ Promote® 900).

The field was also harvested using a grower owned and operated John Deere 7760 spindle round module harvester (Moline, IL), with Pro16 row units, which was maintained and operated via normal industry practice and manufacturers recommendations. The field utilized for this trial was sown with the two varieties using a randomized complete block design, with four replications, with each replication 0.156 ha. A total of sixteen part round modules were harvested. The round modules were dropped in the field and picked up by a mast-type tractor mounted implement that holds the module with the axis parallel to the tractor rear axle and were then staged together in the sequence that they were harvested. All modules were ginned, under similar standard commercial conditions, at Southern Cotton situated in Leeton, NSW. This gin is a Lummus Corporation (Savannah, GA) high-capacity saw gin, equipped with four 222 gin stands, with one stage of flow-through air lint cleaners and two stages of batt-less saw lint cleaners, capable of producing 60 bales.hour$^{-1}$.

Field D was first subjected to harvest aids by ground rig, with a mixture of leaf defoliant (0.1 L.ha$^{-1}$ Dropp®), boll opener (1.5 L.ha$^{-1}$ Prep®) and adjuvant (0.05 L.ha$^{-1}$ Hasten by Victorian Chemicals). The field was sprayed a second time with a mixture of leaf defoliant (0.12 L.ha$^{-1}$ Dropp® liquid), boll opener (1.5 L.ha$^{-1}$ Prep®) and adjuvant (0.05 L ha$^{-1}$ Hasten). The field was sprayed again with leaf defoliant (0.15 L.ha$^{-1}$ Dropp®), boll opener (2.0 L ha$^{-1}$ Prep®) and adjuvant (0.05 L.ha$^{-1}$ Hasten). The trial was conducted using a randomized complete block design, with four replications. Seed cotton from 32 plots, containing four rows spaced at 1 meter, was harvested by a single row Case IH 1822 spindle harvester (Racine, WI), which was maintained and operated via normal industry practice and manufactures recommendations. An average of 0.234 kg seed cotton sample was collected from each replicate produced and was ginned using the same 20-saw gin (Continental Eagle, Prattville, AL) with a Mitchell feeder and pre-cleaner located at ACRI.

Field E was first subjected to harvest aids by air, with a mixture of leaf defoliant (0.2 L.ha$^{-1}$ Dropp®), boll opener (0.8 L.ha$^{-1}$ Promote® 900) and crop oil (0.5 L.ha$^{-1}$ Canopy®). The field was sprayed a second time with a mixture of leaf defoliant (0.2 L ha$^{-1}$Dropp® UltraMAX), boll opener (2.2 L.ha$^{-1}$ Promote® 900) and crop oil (0.5 L.ha$^{-1}$ Canopy®). The trial was conducted using a randomized complete block design, with four replications. Seed cotton from 16 plots, containing 18 rows spaced at 1 meter, was hand harvested, due to the uncertainty created by COVID and accessibility to a mechanical harvester. An average of 0.234 kg seed cotton sample was collected from each replicate produced and was also ginned using the 20-saw gin (Continental Eagle, Prattville, AL) with a Mitchell feeder and pre-cleaner located at ACRI.

For Fields A & D, samples collected after ginning were subjected to objective measurement, as per ASTM D5867 (ASTM 2012a), using an Uster® Technologies AG HVI™ 1000 (Knoxville, TN) at ACRI. Two sub samples of each sample were evaluated for fibre length in terms of upper half mean length (UHML in mm), length uniformity (UI%), short fibre index (fibres < 12.7 mm) (SFI%), elongation (EL%), bundle strength in g.tex$^{-1}$ (STR) and micronaire (MIC).

For Fields B & C, classing samples, from opposite sides, of each bale were collected at the gin after bale formation, with samples for Field E collected after ginning. All these samples were subjected to objective measurement, as per ASTM D5867 (ASTM 2012a), using an Uster® Technologies AG HVI 1000 (Knoxville, TN) either at Australian Classing Services in Wee Waa (Fields B & E) and ProClass in Griffith (Field C) respectively, both of which are certified classing facilities as they comply with the requirements of the Australian Cotton Industry’s Best Management Practice Manual for Classing. Two sub samples of each sample were evaluated for UHML, UI%, SFI%, EL%, STR, MIC as well as for colour in terms of yellowness (+ b), reflectance (Rd) and trash in terms of leaf count, % area and leaf grade. Visual classing of the lint was assessed for colour (CG) and visible trash (LG) according to the 2018 grades as established by USDA-AMS, as per ASTM D1684 (ASTM 2012b).

All fibre samples were conditioned under standard conditions of 21+/-1°C and relative humidity % of 65+/-2 as per ASTM D1776 (ASTM 2015).

For all fields, the percentage of the weight of usable fibre per the weight of un-ginned seed cotton (lint turn out) was calculated either by the commercial ginning operators or by technicians at ACRI.

Cotton nitrogen use-efficiency (NUE) was also calculated for evaluating efficiency of the conversion of N fertiliser into cotton lint as per Eq. 1.

$$\text{NUE} = \frac{\text{Lint produced (kg.ha}^{-1}\text{)}}{\text{N fertiliser applied (kg.ha}^{-1}\text{)}} \qquad (1)$$

A NUE of 13 to 18 kg lint/kg of N is recommended for irrigated cotton, with values below 13 indicating that too much N was applied and values above 18 indicating that insufficient N was applied (Rochester 2014).

To evaluate for statistical differences between treatment means, ANOVA was conducted on the experimental data using Genstat 16.0. Where significant statistical differences, at the $\alpha = 0.05$ and lower level were identified, Fisher’s least significant differences (LSD) were calculated from which the means differences were derived. For ease of interpretation, non-significant results were designated as n.s. Means, with the same letter were not significantly different.

## Results

Tables 2 to 6 summarize the total weight of seed cotton harvested, total weight of lint harvested, lint turn out and yield as well as fibre quality as measured by objective measurement using an HVI instrument for all fields (A to E) with visual assessment also conducted for the larger/commercial trials for two fields (B and C), as well as the hand harvested field (E).

**ACRI (A &D)**

Table 2 shows that there were statistically significant differences between the four N application levels for lint turn out and fibre strength for Sicot 746 B3F. At 48.7% the highest lint turn out was obtained from 0 $kg.ha^{-1}$, whereas the application of 200 $kg.ha^{-1}$, resulted in slightly stronger fibre than that achieved for 0, 100 and 300 $kg.ha^{-1}$, respectively. Although not significant, the application of 200 $kg.ha^{-1}$, produced slightly longer, more even, and uniform fibre. The application of 200 $kg.ha^{-1}$ also resulted in the highest average yield of 8.5 $bales.ha^{-1}$ (bale = 227 kg), which was 0.9, 0.6 and 0.6 $bales.ha^{-1}$ higher than that achieved for 0, 100 and 300 $kg.ha^{-1}$ respectively, although 100 $kg.ha^{-1}$ achieved the most desirable NUE of 18.

There were no statistically significant differences between the four N application levels for lint turn out and fibre properties for Sicala V-2. The results did, however, indicate that overall, the most favourable results were obtained with the application of 200 $kg.ha^{-1}$, which also resulted in the highest average yield of 8.5 $bales.ha^{-1}$, which was 0.7, 0.2 and 0.9 $bales.ha^{-1}$ higher than that achieved for 0, 100 and 300 $kg.ha^{-1}$ respectively, whilst 100 $kg.ha^{-1}$ achievedthe most desirable NUE of 19. Similarly, the application of 200 $kg.ha^{-1}$, resulted in producing the longest and amongst the most even, uniform, and strong fibre.

Table 5 shows that there were no statistically significant differences between the three N application levels for lint turn out and fibre properties for all three varieties. The results for Sicot 746 B3F did, however, indicate that overall, the application of 200 $kg.ha^{-1}$, resulted in the strongest and one of the most uniform and even fibres produced withone of the highest lint turn out (46.7%), although 100 $kg.ha^{-1}$ achieved the highest yield at 10.5 b. $ha^{-1}$. The NUE for all applications were mostly either too high or low for the yield achieved.

The results for Sicot 714 B3F indicated that overall, 0 $kg.ha^{-1}$ produced the longest, even, uniform, and strongest fibre with amongst the highest lint turn out (44.0%), whilst 200 & 300 $kg.ha^{-1}$ produced the highest yield, with 200 $kg.ha^{-1}$ achieving the better NUE of 13.

The results for Sicala V-2 indicated that overall, 100 $kg.ha^{-1}$ produced the longest, strongest and amongst the most even and uniform fibre, with amongst the highest lint turn out (40.8%), and with 200 $kg.ha^{-1}$ achieving the highest yield (7.7 $bales.ha^{-1}$) whilst 100 $kg.ha^{-1}$ achievedthe most desirable NUE of 17.

**Toobeah (B)**

Table 3 shows that there were statistically significant differences between the three N application levels for most fibre properties for both Sicot 746 B3F and Sicot 714 B3F.

In terms of Sicot 746 B3F, overall, the best fibre quality was achieved with 200 $kg.ha^{-1}$which resulted in a slight, but statistically significant, longer, more even, and stronger fibre and although the colour and trash values, as measured by HVI, were marginally, but statistically significantly, better, did not improve the visual determined colour and leaf grade, which was 31-3.

There were no statistically significant differences in lint turn out between the three N applications. At a yield of 14.0 $bales.ha^{-1}$, the application of 200 $kg.ha^{-1}$, also produced amongst the highest yield with an NUE of 16, although at a lower lint turn out.

Similar results were obtained for Sicot 714 B3F, where overall, the best fibre quality was also achieved with 200 $kg.ha^{-1}$, resulting in a marginal, but statistically significant, longer, more even, and stronger fibre and although the colour and trash values, as measured by HVI, were also slightly, but statistically significantly, better, did not improve the visual determined colour and leaf grade which was 31-3.

There were no statistically significant differences in lint turn out between the three N applications. At a yield of 14.2 $bales.ha^{-1}$, the application of 200 $kg.ha^{-1}$, also produced amongst the highest yield and lint turn out, with an NUE of 16.

**IREC (C)**

Table 4 shows that there were no statistically significant differences between the two application levels for all the fibre properties and lint turn out for both Sicot 746 B3F and Sicot 714 B3F. However, the application of 136 $kg.ha^{-1}$ did produce a marginally longer, more even, uniform, and stronger fibre, with higher lint turn out for Sicot 746 B3F.

At a NUE below 13 the application of 300 $kg.ha^{-1}$ was excessive for the resultant yield.

**Cecil Plains (E)**

Table 6 shows that there were no statistically significant differences between 0 and 300 $kg.ha^{-1}$ for all of the fibre properties for both Sicot 746 B3F and Sicot 714 B3F. Similarly, there were no practical differences in lint turn out and yield between 0 and 300 $kg.ha^{-1}$ for both varieties, although Sicot 714 B3F achieved higher yields and as a consequence favourable NUE.

## Discussion

Growing Season

The three studies conducted during the 2018/2019 growing season all experienced hot and warm weather, with the number of days above 36°C and 40°C and the number of nights above 25°C also above average and rainfall below average. This resulted in an increase in the accumulation of day degrees which was expected to have a positive effect on fibre quality specifically micronaire and colour (Luo et al. 2016;Bange et al. 2022). Similarly, the two studies conducted during the 2019/2020 growing season also experienced hot and warm weather, with the number of days above 36°C and 40°C and the number of nights above 25°C experienced in Narrabri also above average. Cecil Plains, however, did not record any nights above 25°C and experienced more than double the number of cold shock days than the average. Narrabri received just above average rainfall whereas Cecil Plains received less than average rainfall.

Yield

The yield for the five trials were variable with only the small scale trial at Cecil Plains (Field E) achieving the yield as per the Cotton Seed Distributors (CSD) Variety Performance Comparison Tool which provides one the ability to compare varieties grown in a local area. This was in all likelihood due to the fact that this trial was harvested by hand which is more efficient in removing all fibre from the plant whereas some harvest loss can occur when using mechanical cotton harvesters (van der Sluijs and Roth 2021). The average yield was 10.2 bales.ha$^{-1}$, with Sicot 714 B3F achieving the highest yield of 12.1 bales.ha$^{-1}$ followed by Sicot 746 B3F at 10.2 bales.ha$^{-1}$ and Sicala V-2 with 7.6 bales.ha$^{-1}$. As the expected yields were not achieved the amount of N applied was in most cases excessive as highlighted by a NUE below 13. Indeed, the amount of N required to achieve the average yield for the three varieties was 150, 180 and 100 kg.ha$^{-1}$ with higher application levels resulting in no economical benefit to the grower and possibly leading to higher costs (i.e., increased defoliation etc.) and quality downgrades (Buster 2021). This equates to an average of 14 to 15 kg of N for the current varieties for each bale produced.

Lint turn out

The lint turn out results for the five trials were variable with only the small scale trials (Fields A & D) at ACRI and to a lesser extend at Cecil Plains (Field E) achieving the expected lint turn out (47% for Sicot 746 B3F, 45% for Sicot 714 B3F and 39% for Sicala V-2 (Stiller 2016a;2016b;Reid 1995). The lint turn out for the larger commercial trials (Fields B & C) that were ginned at high capacity throughput gins were lower. This was not entirely unexpected as these gins, as do most modern gins, have either two and three stages of lint cleaning as part of their processing system to remove foreign matter left in the lint after the seed cotton cleaning and ginning stages. With a recent study showing that lint cleaners can reduce bale weights by up to 27 kg and reduce lint turn out by up to 2% (van der Sluijs 2020).

Overall, although there was not a statistically significant effect of N application level on lint turn out, there does seem to be a trend in a decrease in lint turn out with increased N application levels. This is consistent with previous studies that showed that in general increased N application rates led to reduced lint turn out (van der Sluijs 2022).

Fibre Quality

The fibre quality results for the five trials were either equivalent or better than the Australian base grade, which is length of 28.7 mm (36 32nds), length uniformity 81%, strength 29 g.tex$^{-1}$, micronaire range 3.5 to 4.9, colour 31(Middling) and trash grade of 3, with no reference values for elongation % and short fibre content %. Base grade refers to the grade of cotton that is used by cotton merchants as a basis for contracts, premiums, and discounts.

With the exception of Field B, there were no statistically significant differences in fibre length with an increase in N application levels. The results for Field B for both varieties showed significant improvement in length by one grade (37 to 38 32 nds), with the application of 200 kg.ha$^{-1}$, with a reduction in length with the application of 400 kg.ha$^{-1}$. Similarly, length uniformity and short fibre content followed the same trend, with length uniformity improving and short fibre content decreasing with the application of 200 kg.ha$^{-1}$. Although, not statistically significant Field A, followed a similar trend, with the results for Fields C, D & E more varied with either 0, 100,136, 200 or 300 kg.ha$^{-1}$, producing the longest and most even fibre.

With the exception of Fields, A & B, there were no statistically significant differences in fibre strength with increased N application levels. The results for Field A for only Sicot 746 B3F and for both varieties from Field B, showed a significant improvement in strength and a resultant, although slight, reduction in elongation, with the application of 200 kg.ha$^{-1}$, with a statistically significant reduction in strength and an increase in elongation with increased application levels. The results for Fields C,D & E and Sicala V-2 from Field A was more varied with either 0, 100, 136, 200 or 300 kg.ha$^{-1}$, producing the strongest fibre.

With the exception of Field B, there were no statistically significant differences in micronaire with an increase in N application levels. The results for Field B for only Sicot 746 B3F showed a slight reduction in micronaire with the application of 400 kg.ha$^{-1}$. Although, not statistically significant the micronaire values for Fields C & D also reduced with increased N application whereas the micronaire value increased with N application levels for Fields A & E. All the changes were of little practical significance as all the micronaire values were within the Australian base grade.

With the exception of Field B, there were no statistically significant differences in HVI colour measurements with an increase in N application levels. The results for Field B for both varieties showed a reduction in Rd and + b with the application of 200 kg.ha$^{-1}$, with both Rd and + b improving with the application of 400 kg.ha$^{-1}$. This change in the colour measurements were of little practical significance as at 31 the visual grade was equal to the Australian base grade. The colour measurements for Fields C & E were varied with no changes to the visual colour grade. Interestingly, with a colour grade of 21 (Strict Middling), Sicot 714 B3F was one grade better than Sicot 746 B3F.The colour and trash grade for both varieties from Field E were exceptional; graded as 11 (Good Middling) with a leaf grade of 1. This was not entirely unexpected as this cotton was harvested by hand and hence was free from impurities and trash as highlighted by the HVI trash results.

## Conclusions

Nitrogen was applied at application levels ranging from zero to excessive to determine the effect of Nitrogen application level on cotton yield and fibre properties. Trials were conducted in 2018 and 2019 in four locations using three popular high yielding commercial Upland cotton varieties common in the

Australian system. Results indicated that in general, the application of moderate (100 to 200 $kg.ha^{-1}$) levels of N resulted in the highest yield and nitrogen use efficiency as well as producing longer, more even, and stronger fibre. Also, N application levels did negatively affect colour and lint turn out.

## Declarations


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### Disclaimer

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by  Textile Technical Services and CSIRO.


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### Availability of data and materials

All data generated or analysed during this study are included in this published article.

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interest

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## Tables

Table 1
Year, location, planting date, variety, N application level, harvest aid dates, harvest date, gin, and gin date

| Designation | Location | Plant date | Varieties | N level kg ha$^{-1}$ | 1st Harvest aid date | 2nd Harvest aid date | 3rd Harvest aid date | Harvest date | Gin | Gin date |
|---|---|---|---|---|---|---|---|---|---|---|
| A | ACRI Narrabri, NSW | 19 October 2018 | Sicala V-2 Sicot 746 B3F | 0, 100, 200 & 300 | 16 April 2019 | 27 April 2019 | 4 May 2019 | 04 June 2019 | Mini Gin | 21 June 2019 |
| B | Toobeah QLD | 16 October 2018 | Sicot 746 B3F Sicot 714 B3F | 0, 200 & 400 | 11 March 2019 | 20 March 2019 | 26 March 2019 | 11 April 2019 | Namoi MacIntyre | 17 May 2019 |
| C | IREC Griffith, NSW | 12 October 2018 | Sicot 746 B3F Sicot 714 B3F | 136 & 300 | 30 March 2019 | 11 April 2019 | 01 May 2019 | 07 May 2019 | Southern Cotton | 13 August 2019 |
| D | ACRI Narrabri, NSW | 04 November 2019 | Sicala V-2 Sicot 746 B3F Sicot 714 B3F | 0, 100, 200 &300 | 07 April 2020 | 20 April 2020 | 28 April 2020 | 14 June 2020 | Mini Gin | 30 July 2020 |
| E | Cecil Plains QLD | 07 November 2019 | Sicot 746 B3F Sicot 714 B3F | 0 & 300 | 28 April 2020 | 10 May 2020 | * | 29 May 2020 | Mini Gin | 30 July 2020 |

Table 2
Total weight per plot of seed cotton harvested, lint turn out, yield, and average fibre properties as measured by HVI for Field A per N level

| N level kg.ha$^{-1}$ | Seed Cotton (kg) | Lint (kg) | Lint Turn Out % | Yield b.ha$^{-1}$ | NUE | MIC | UHML (mm) | UI (%) | SFI (%) | STR (g.tex$^{-1}$) | EL (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sicot 746 B3F** | | | | | | | | | | | |
| 0 | 1,728 | 0,843 | 48.7b | 7.6 | * | 4.75 | 30.07 | 84.2 | 5.8 | 31.4a | 3.5 |
| 100 | 1,839 | 0,848 | 46.2a | 7.9 | 17.9 | 4.73 | 30.43 | 84.6 | 5.4 | 33.1b | 3.4 |
| 200 | 1,808 | 0,848 | 46.9a | 8.5 | 9.6 | 4.79 | 30.73 | 85.0 | 5.2 | 33.6b | 3.5 |
| 300 | 1,828 | 0,862 | 47.2a | 7.9 | 6.0 | 4.81 | 30.61 | 84.5 | 5.4 | 33.2b | 3.5 |
| p-value | n.s. | n.s. | < .001 | n.s. | * | n.s | n.s | n.s | n.s | < .001 | n.s |
| **Sicala V-2** | | | | | | | | | | | |
| 0 | 1,864 | 0,782 | 41.9 | 7.8 | * | 4.81 | 29.08 | 83.7 | 5.4 | 31.7 | 4.1 |
| 100 | 1,978 | 0,807 | 40.8 | 8.3 | 18.8 | 4.74 | 29.29 | 84.2 | 5.2 | 32.5 | 3.7 |
| 200 | 1,991 | 0,821 | 41.2 | 8.5 | 9.6 | 4.88 | 29.64 | 84.1 | 5.4 | 32.6 | 3.7 |
| 300 | 1,913 | 0,769 | 40.2 | 7.6 | 5.8 | 4.82 | 29.57 | 84.5 | 5.1 | 33.0 | 3.6 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |

Table 3

Total weight of seed cotton harvested, lint turn out, yield, and average fibre properties as measured by HVI and visual assessment for Field B per N le

| N level $kg.ha^{-1}$ | Seed Cotton (kg) | Lint (kg) | Lint Turn Out % | Yield $b.ha^{-1}$ | NUE | MIC | UHML (mm) | UI (%) | SFI (%) | STR ($g.tex^{-1}$) | EL (%) | Trash | | | Colour | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Leaf | % Area | Count | Rd | +b |
| **Sicot 746 B3F** | | | | | | | | | | | | | | | | |
| 0 | 22,580 | 9,324 | 41.3 | 13.7 | * | 4.50b | 29.72a | 81.0a | 9.3a | 33.2a | 5.1b | 3 | 0.34b | 39b | 81.6b | 7.4b |
| 200 | 23,060 | 9,323 | 40.4 | 14.0 | 15.9 | 4.50b | 30.48b | 82.0b | 9.6b | 34.2b | 5.0a | 3 | 0.30a | 36a | 80.1a | 6.9a |
| 400 | 23,023 | 9,490 | 41.2 | 14.0 | 7.9 | 4.40a | 29.72a | 81.0a | 9.3a | 33.0a | 5.1b | 3 | 0.29a | 36a | 81.8b | 7.4b |
| p-value | n.s. | n.s. | n.s. | n.s. | * | < .001 | < .001 | < .001 | < .001 | < .001 | < .001 | n.s. | < .001 | < .001 | < .001 | < .001 |
| **Sicot 714 B3F** | | | | | | | | | | | | | | | | |
| 0 | 24,145 | 9,512 | 39.4 | 14.0 | * | 4.60 | 29.21a | 80.8a | 9.8b | 31.8a | 5.3b | 3 | 0.33b | 37a | 79.6b | 7.7b |
| 200 | 24,442 | 9,729 | 39.8 | 14.2 | 16.1 | 4.60 | 29.97b | 82.0b | 9.7b | 33.1b | 5.2a | 3 | 0.29a | 38b | 78.1a | 7.3a |
| 400 | 24,563 | 9,808 | 39.9 | 14.2 | 8.1 | 4.60 | 29.72b | 81.5b | 8.7a | 32.4a | 5.3b | 3 | 0.34b | 38b | 79.4b | 7.9b |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | < 0001 | < .001 | < .001 | < .001 | < .001 | n.s. | < .001 | < .001 | < .001 | < .001 |

Table 4

Total weight of seed cotton harvested, yield, lint turn out and average fibre properties as measured by HVI and visual assessment for Field C per N level

| N level $kg.ha^{-1}$ | Seed Cotton (g) | Lint (g) | Lint Turn Out % | Yield $b.ha^{-1}$ | NUE | MIC | UHML (mm) | UI (%) | SFI (%) | STR ($g.tex^{-1}$) | EL (%) | Trash | | | Colour | | Visual | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Leaf | % Area | Count | Rd | +b | CG | LG |
| **Sicot 746 B3F** | | | | | | | | | | | | | | | | | | |
| 136 | 3,506 | 1,309 | 29.8 | 6.9 | 11.5 | 4.47 | 31.50 | 83.5 | 7.4 | 34.6 | 5.1 | 3 | 0.28 | 27 | 82.4 | 7.2 | 31 | 3 |
| 300 | 3,673 | 1,314 | 29.8 | 7.3 | 5.5 | 4.42 | 31.06 | 83.3 | 7.6 | 33.5 | 5.0 | 3 | 0.31 | 28 | 82.4 | 7.2 | 31 | 3 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **Sicot 714 B3F** | | | | | | | | | | | | | | | | | | |
| 136 | 3,960 | 1,787 | 34.9 | 9.2 | 15.4 | 4.65 | 30.48 | 83.0 | 7.8 | 33.8 | 5.4 | 3 | 0.30 | 28 | 81.3 | 7.5 | 21 | 3 |
| 300 | 4,107 | 1,307 | 34.9 | 9.5 | 7.2 | 4.57 | 30.86 | 83.4 | 7.3 | 33.8 | 5.5 | 3 | 0.31 | 31 | 81.1 | 7.7 | 21 | 3 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s | n.s | n.s |

Table 5
Total weight of seed cotton harvested, lint turn out, yield, and average fibre properties as measured by HVI for Field D per N level

| N level kg.ha$^{-1}$ | Seed Cotton (g) | Lint (g) | Lint Turn Out % | Yield b.ha$^{-1}$ | NUE | MIC | UHML (mm) | UI (%) | SFI (%) | STR (g.tex$^{-1}$) | EL (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sicot 746 B3F** | | | | | | | | | | | |
| 0 | 2,649 | 2,299 | 46.7 | 8.7 | * | 4.71 | 29.31 | 82.2 | 8.9 | 30.2 | 6.4 |
| 100 | 2,818 | 2,421 | 46.2 | 10.5 | 23.8 | 4.65 | 29.77 | 82.0 | 8.5 | 31.2 | 5.9 |
| 200 | 3,033 | 2,654 | 46.7 | 9.4 | 10.7 | 4.55 | 30.66 | 82.5 | 7.0 | 32.6 | 5.8 |
| 300 | 3,234 | 2,796 | 46.4 | 9.4 | 7.1 | 4.45 | 31.01 | 83.4 | 7.0 | 32.4 | 5.6 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **Sicot 714 B3F** | | | | | | | | | | | |
| 0 | 2,911 | 2,270 | 44.0 | 9.1 | * | 4.84 | 29.82 | 82.3 | 7. 5 | 30.9 | 6.5 |
| 100 | 2,993 | 2,358 | 44.1 | 11.1 | 25.2 | 5.01 | 28.96 | 81.6 | 8.7 | 29.4 | 6.8 |
| 200 | 3,346 | 2,613 | 43.8 | 11.5 | 13.1 | 5.06 | 29.60 | 82.1 | 8.5 | 30.2 | 6.2 |
| 300 | 3,506 | 2,698 | 43.5 | 10.1 | 7.6 | 4.71 | 29.31 | 82.2 | 8.9 | 30.2 | 6.4 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **Sicala V-2** | | | | | | | | | | | |
| 0 | 2,572 | 1,783 | 41.0 | 6.9 | * | 4.39 | 29.52 | 82.8 | 7.7 | 31.6 | 6.1 |
| 100 | 2,836 | 1,953 | 40.8 | 7.3 | 16.6 | 4.36 | 29.80 | 82.7 | 7.4 | 31.7 | 5.7 |
| 200 | 2,996 | 2,040 | 40.4 | 7.7 | 8.7 | 4.36 | 29.52 | 83.2 | 6.7 | 31.0 | 6.1 |
| 300 | 3,017 | 2,023 | 40.1 | 6.7 | 5.1 | 4.10 | 28.85 | 82.0 | 8.8 | 30.2 | 6.1 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |

Table 6
Total weight of seed cotton harvested, lint turn out, yield, and average fibre properties as measured by HVI and visual assessment for Field E per N level

| N level | Seed Cotton | Lint | Lint Turn | Yield | NUE | MIC | UHML | UI | SFI | STR | EL | Trash | | | Colour | | Visual | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kg.ha$^{-1}$ | (g) | (g) | Out % | b.ha$^{-1}$ | | | (mm) | (%) | (%) | (g.tex$^{-1}$) | (%) | Leaf | % Area | Count | Rd | +b | CG | LG |
| **Sicot 746 B3F** | | | | | | | | | | | | | | | | | | |
| 0 | 2,263 | 1,022 | 45.1 | 11.3 | * | 4.09 | 31.01 | 83.4 | 7.0 | 31.9 | 5.3 | 3 | 0.23 | 19 | 85.3 | 8.8 | 11 | 1 |
| 300 | 2,402 | 1,039 | 43.3 | 11.4 | 8.7 | 4.14 | 31.39 | 83.3 | 6.9 | 32.4 | 5.4 | 2 | 0.22 | 16 | 84.8 | 8.8 | 11 | 1 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **Sicot 714 B3F** | | | | | | | | | | | | | | | | | | |
| 0 | 2,841 | 1,223 | 43.0 | 13.5 | * | 4.10 | 31.45 | 84.2 | 6.0 | 32.4 | 5.5 | 3 | 0.30 | 20 | 84.8 | 8.8 | 11 | 1 |
| 300 | 2,729 | 1,203 | 44.1 | 13.2 | 10.0 | 4.20 | 30.48 | 82.8 | 7.2 | 31.6 | 5.4 | 2 | 0.27 | 18 | 85.4 | 8.8 | 11 | 1 |
| p-value | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s | n.s | n.s |