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2016

cotton **nutrition** tour

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2016 cotton **nutrition** tour

INTRODUCTION:

Getting your crop nutrition spot on is essential for maximising cotton yield.

Too little nutrition will reduce the crops' yield potential, while too much fertiliser can impact your profitability through increased costs, contamination of groundwater, excessive vegetative growth in the crop, and related insect, disease and harvest problems. Too much fertiliser – particularly nitrogen (N) – also contributes to greenhouse gas emissions and adds to the carbon footprint of the fibre.

Helping growers to get their crop nutrition right is a big focus for the Cotton Research and Development Corporation (CRDC), who manage more than $1 million in investment into nutrition, and CottonInfo, the industry's joint extension program, and hosts of this Cotton Nutrition Tour.

The Tour is designed to bring you, our growers and consultants, the latest nutrition-related research from a team of leading cotton researchers and to have the important discussions – like:

- How much nitrogen is lost, and where does it go?
- What research is underway into phosphorus in raingrown and irrigated cotton? and
- What are our options to minimise losses, reduce greenhouse gas emissions, and improve nitrogen use efficiency?

The tour will feature a host of leading industry researchers and cotton growers, talking about a range of important cotton nutrition topics across five cotton growing valleys: all designed to help you make the most economically beneficial (and environmentally sustainable) decisions for your farm/s.

TOUR DATES:

UPPER NAMOI (GUNNEDAH) - MON 8 FEB
'Ruvigne', Gunnedah NSW
9am-1pm

MACQUARIE (WARREN) - TUES 9 FEB
'Hatton,' Warren
9am-1pm

SOUTHERN NSW (GRIFFITH) - WED 10 FEB
De Bortoli Farms, Benerembah (via Griffith) NSW
9am-1pm

CENTRAL QLD (EMERALD) - THURS 11 FEB
Region bus tour, ex-Emerald QLD
8:15am-1pm

GWYDIR (MOREE) - FRI 12 FEB
Joint field day with CottonInfo & the Gwydir Valley Irrigators Association
'Keytah', Moree NSW
8am-1pm

The 2016 Cotton Nutrition Tour is delivered by the industry's extension program, CottonInfo, with support from CottonInfo partner CRDC, researchers and research organisations, and sponsors Yara, Fertcare®, Koch Fertilizer, SST Software and Incitec Pivot. The tour is also supported by funding from the Australian Government.

The research presented on the tour has been funded by CRDC in partnership with research organisations UNE, USQ, UQ, CSIRO, NSW DPI. The Moree event is held in conjunction with the Gwydir Valley Irrigators Association.

FOR MORE INFORMATION:

CRDC R&D manager Allan Williams manages CRDC's nutrition R&D portfolio. For further information on CRDC's investments, please contact Allan: 02 6792 4088, allan.williams@crdc.com.au.

CottonInfo's carbon technical specialist Jon Welsh extends nutrition R&D to growers. For more information on nutrition as it applies to your farm, please contact Jon: 0458 215 335, jon.welsh@cottoninfo.net.au.

The cotton industry has many resources to assist with nutrition on-farm. To access these, please visit **www.cottoninfo.net.au** or **www.mybmp.com.au**.

THE RESEARCHERS:

Dr Oliver Knox: chairs workshop.

Dr Chris Dowling: talks nutrient budgeting and monitoring in-crop.

Dr Dio Antille: covers N losses and spatial variability.

Dr Francois Visser: explores mineralisation and its importance.

Dr Ben Macdonald: discusses how N is lost.

Dr Brendan Griffiths: covers the P considerations.

Jon Baird: discusses how water interacts with N and impacts on profitability.

Dr Vadakattu Gupta: explores the bacterial component of the N cycle.

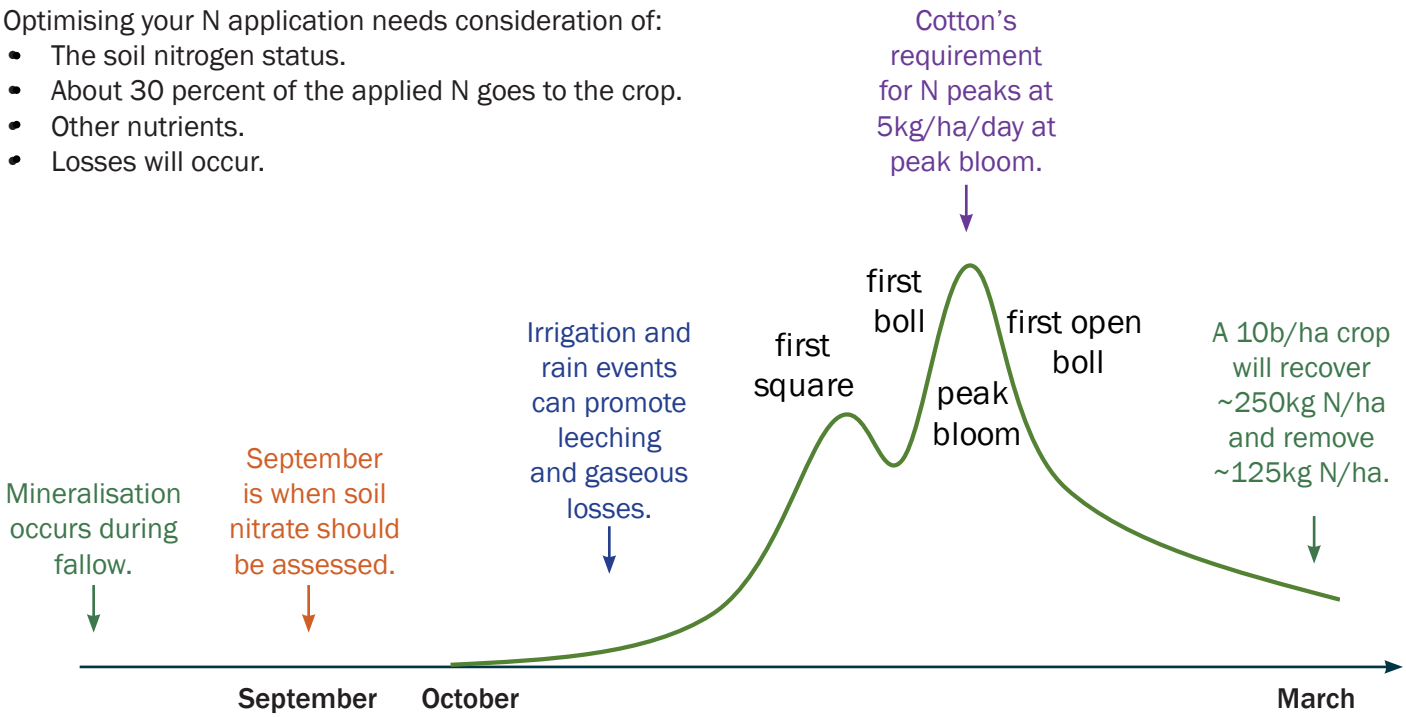
Dr Graeme Schwenke: covers ways to reduce emissions.

Nigel Corish: provides a growers perspective: research into practice.

THE N CYCLE:

Optimising your N application needs consideration of:

- The soil nitrogen status.
- About 30 percent of the applied N goes to the crop.
- Other nutrients.
- Losses will occur.



Sustainable cotton production: higher yields, more often

Dr Oliver Knox, UNE

What is the research/technology?
My research spans a range of soil issues and fertiliser use or misuse, with particular reference to nitrogen (N), phosphorus (P) and potassium (K).

I also work closely with the CottonInfo Regional Development Officers (RDOs) and their trial data, carrying out analysis, interpreting results and assisting with the delivery of extension messages around the issues of nitrogen fertiliser use efficiency.

Their work spans the industry and so provides opportunities to assess if what we know of the science of N cycling and crop uptake is correct and transferable. Whilst we know a lot about N cycling we don't know everything and so as researchers we're addressing these challenges.

For my part, I have a student looking at how carbon and nitrogen cycle down the soil profile, which links into the microbial and soil biology work I have done with Gupta, which in turn links into the mineralisation work that Francois is doing.

Why do I need to be aware of this research/ technology?
We want to give you access to the best science to explain the way your soils, the nutrition within them and the plant interact to produce the quality product you grow. If we can do this, then you can continue optimising your nutritional decisions.

How will it benefit my operation?
What I hope you will take away from this is that too much N costs you money, is bad for the environment and in most cases will not give you more yield because other factors limit production in your system and some of these you can't manage for until they happen.

What are the current barriers to adoption/ commercialisation?
I believe there are three main challenges to improving fertiliser use efficiency.

The first is that the science of plant N uptake has changed little, but higher yields have altered some of the numbers. No one likes change as it raises uncertainty about how much N to apply, when and how best to apply it. The science is spot on in terms of predicting how much N you need for a given size of crop, but you need to trust the science.

The second issue is that as the industry has grown we've been exposed to different types of N, alternative methods of application and different farm set ups. As an industry that's prone to looking over the fence there is always the question as to whether I could be doing better if I did what they do and sadly the thing that often sticks out is the N management, even if it is not actually driving higher yields.

The third and final barrier is that the nitrogen cycle is influenced by the weather. Uncertainty in the weather, just like change, is generally something we don't like and plays on your approach to risk. I'd reckon that most of us, if given the choice, would over apply rather than risk getting it short, but have you ever stopped to consider how often does that pay out as an approach or if there is an alternative?

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Nutrient budgeting

Dr Chris Dowling, Fertcare® (Back Paddock Company)

What is the research/technology?
Many crop nutrition research projects are geographically limited due to logistical, equipment or financial constraints, meaning that in some cases the underpinning principles exposed need to be extrapolated to other locations.

The success of this approach is in gaining an understanding of how the research outcomes are related to differences inherent in the local environment. Useful outcomes are generally measured as quantitative change guidelines however directional change is also valuable for extension to other growing environments.

In the area of crop nutrition the amount of definitive research underpinning current soil test calibration is limited, the majority being derived from two or three cotton production valleys and generally for nitrogen (N) and phosphorus (P) only.

This being the case, training in the process of managing crop nutrition that make allowances for the deficiencies in soil test calibration is essential to ensure locally relevant recommendations have a solid foundation and incorporated new research findings.

Where soil nutrient concentrations have started adequate and have declined to the level where response to added fertiliser is likely, the most valuable pieces of information to be gained from research are quantification of the 'critical range', regional drivers of variances of the critical range and crop nutrient removal.

Why do I need to be aware of this research/ technology?
The appropriate manipulation of interactions of local factors such as climate, soil and water management, and crop variety are the key to a successful crop.

For benefits of research to be accessed quickly, directional guidelines based on effects of soil and climate should be provided where a practice is likely to be sensitive to local influences.

There is also need to consider both short and medium term risk to production from crop nutrition and soil fertility - just waiting for nutrient deficiency symptoms in the crop is exposing profitability to the tyranny of 'hidden hunger syndrome.'

How will it benefit my operation?
More profitable and lower risk adoption change to soil fertility and crop nutrition management where there is a lack of local research.

What are the current barriers to adoption/ commercialisation?
Availability of a well-rehearsed process whereby new information can easily be localised and a lack of confidence in the veracity of the crop nutrition tools available. Lack of parameterisation of response models to cope with the soil type by climate interaction for nutrients other than nitrogen.

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FERTCARE®

Improving nitrogen use efficiency

Dr Dio Antille, USQ

What is the research/technology?
This research will develop management practices to improve nitrogen use efficiency (NUE) of applied fertiliser.

The target is to improve NUE in cotton production systems by at least 25 percent. Significant, cost-effective improvements in NUE through reduced gaseous nitrogen (N) losses are possible by reducing upfront N applications and use of enhanced efficiency fertilisers (EEF).

Additional improvements in NUE may be achieved through site-specific N management.

Why do I need to be aware of this research/ technology?
Gaseous losses of N fertiliser from irrigated cotton systems can exceed 40 percent. Nitrogen lost to the atmosphere has environmental implications and represents a financial loss to growers. Such losses can be significantly reduced by adjusting the rate and source of N applied as fertiliser, and without negative effects on yield.

Research has shown that gaseous N emissions from cotton increase exponentially once seasonal N rates exceed 250 kg per ha (the industry's average). However, the maximum rates now reported in the industry are already in the 350 kg N per ha range.

EEF change the timing of N availability to the crop without the need to change the timing of N application. Implementation of the 4-R's principle for N management (right rate, right source, right time and right place) would offer cotton growers major increases in NUE and profitability.

How will it benefit my operation?
Recent projects measuring N20 emissions from cotton showed that whilst it is a small N loss (e.g., 1-2 kg N per annum), it is a reliable indicator of much larger gaseous losses of N.

Data from a previous CRDC project measured total gaseous N losses as high as 70 kg N per ha. These losses are expensive and can be avoided with improved knowledge of the impact of different products and management strategies.

Improved accountability of N supplied from soil organic matter will enable significant reductions in N fertiliser inputs. This project will improve the accuracy of N decision support tools and provide growers with greater confidence to optimise N inputs for maximum return.

What are the current barriers to adoption/ commercialisation?
There appears to be insufficient data available for Australian cotton cropping systems to enable such advances in fertiliser N management and NUE, particularly with regards to EEF. There is also limited information about the amount N mineralised both pre-plant and during the crop season in response to temperature and moisture. This makes it difficult to accurately adjust N rates, optimise NUE and yield, and minimise environmental losses of N.

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Mineralised nitrogen in crop

Dr Francois Visser, UQ

What is the research/technology?

My colleague Ammar Aziz and I from the agribusiness team at the University of Queensland are midway through a CRDC-funded project: *Enhancing and testing the Cotton Carbon Management Tool.*

The main outcome of the project is the development of two web-based software tools for growers and consultants; with the main aims of improving profitability as well as sustainability through enhanced awareness and practice improvements.

The project undertakes specific scientific research in three main areas:

- **N Losses:**
  Importantly, a nitrogen efficiency model will distinguish between the N losses associated with different types of fertilisers as well as their application practices.

- **Predicting mineralisation:**
  Specifically simulating the potential amount of nitrogen that can be 'generated' or mineralised during the growing of a cotton crop, based on C, N and environmental parameters, thereby guiding growers on how this considerable but 'cheaper' source of nitrogen can be optimised.

- **Does it pay?**
  A considerable amount of research has been done on how growers could lower their environmental impacts. However, it has been difficult for growers to assess to what extent these practices will affect their bottom line, and the Nitrogen Optimisation Model (NOM) now tracks the financial outcomes associated with current as well as potential practices.

Why do I need to be aware of this research/ technology?

In order to improve performance we need to be able to measure and track the progress being achieved. With the application of the FarmCarbon and N-$mart tools, growers will be able to do just that for the carbon management of farming operation. They'll also be able to improve their cotton nutrient efficiency in a sustainable way.

How will it benefit my operation?

- **CarbonFarmer (Whole-Farm Footprint Calculator):**
  Allows farmers to assess the sustainability of their whole farm as an integrated unit, taking into account the environmental benefits of the natural vegetation on the farm. The model also enables the farmer to audit a whole crop rotation, including fallow periods, apart from doing individual crop audits. The tool also incorporates a farm to ship module where the additional footprint from farm gate to ship's side can be determined and added to the farm footprint to establish a sustainability result per unit of production at point of export.

- **N-$mart (Nitrogen Optimisation Tool):**
  The NOM provides farmers with a suggested optimal fertiliser application rate based on their current fertiliser regime, as well as the opportunity to simulate different application scenarios to explore maximum profit versus lowest environmental impact combinations.

What are the current barriers to adoption/ commercialisation?

Nutrient planning and management is a complex, costly and crucial part of cotton cropping. It appears that the current fertiliser recommendation models may not encourage growers to adopt a multi-faceted approach that is required to optimise fertiliser management.

Growers need a simple interface whereby they can explore all the different practice scenarios with the accompanying cost and sustainability implications attached to each of these. It is anticipated that the N-$mart tool will meet these requirements. A dedicated website is being developed for both of the tools.

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Nitrogen losses from irrigated cotton

Dr Ben Macdonald, CSIRO

What is the research/technology?

Nitrogen fertiliser losses from irrigated cotton production systems can occur due to water movement via deep drainage and surface run-off.

Nitrogen can be lost as organic nitrogen, urea, nitrate/nitrite and ammonia. Nitrogen fertiliser can also be transformed into different gases, ammonia, nitrous oxides and nitrogen, and lost directly from the soil and water surfaces. All of these losses lower on farm nitrogen use efficiency and yield.

Why do I need to be aware of this research/ technology?

- Excessive fertilisation increases the potential organic and inorganic nitrogen losses.
- The bulk of the water and atmospheric nitrogen losses occurred early in the irrigation season when the cotton plant was small. At this stage there is a large pool of organic and inorganic nitrogen in the soil which can be actively transported by water or transformed into nitrogen and nitrous oxide gases. Later in the season the liable organic and inorganic nitrogen pool has been taken up by the plant which reduces the N losses.
- Early in the season dissolved organic nitrogen and urea as well as nitrate are important components of the total N flux.
- Nitrogen is leached out of the hill early in the season and thus water management during this time is critical.
- Deep drainage losses were greater at the end of the millennium drought and were probably caused by deep cracking.
- Nitrogen present in the storages will be transformed from urea and nitrate to organic nitrogen and some will be potentially lost as nitrous oxide and nitrogen gas. Nitrous oxide is a powerful greenhouse gas and contributes to global warming.
- Nitrate test strips can be used to measure nitrate concentration in the tail water to help determine the success of fertiliser and water management strategies.

How will it benefit my operation?

- Reducing nitrous oxide emissions will earn carbon credits and potentially new income stream. The Cotton Industry has a Carbon Credits Methodology Determination 2015 which can be used to develop practices to achieve nitrous oxide emission reductions. This method is called the *Emissions Reduction Fund — Reducing Greenhouse Gas Emissions from Fertiliser in Irrigated Cotton.*
- Improving nitrogen use efficiency thorough improved water management and fertiliser practice will reduce costs.
- When considering using water run urea beware that in warm weather nitrogen gas emissions could be large.

What are the current barriers to adoption/ commercialisation?

- The relatively affordable price of nitrogenous fertiliser does not create sufficient disincentives to over apply product.
- The social cost of emissions (Australian Carbon Credit Units auction price) from nitrous oxide is currently a trading at circa $13/t/CO2e. A feasibility study undertaken by CottonInfo shows registering a project and generating carbon credits for improved farm nitrogen use efficiency shows a minimal or negative benefit cost due to high transaction costs and ACCU price.

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Phosphorus considerations: irrigated and raingrown

Dr Brendan Griffiths, UNE

What is the research/technology?
This paper/workshop outlines some of the key findings of two CRDC funded projects:

- *Developing soil testing and fertiliser response guidelines to manage P, K and S fertility for irrigated and dryland cropping systems*, led by Prof. Mike Bell and Dr David Lester, and
- *Phosphorus nutrition in rain-grown cotton*, led by me in conjunction with Incitec Pivot Ltd.

Why do I need to be aware of this research/ technology?
Ensuring adequate phosphorus (P) nutrition is a critical part of the cotton production system, both irrigated and dryland.

Despite years of research on cotton nutrition we are continually learning more about the topic, with an increasing focus on meeting the demands of our modern higher yielding cotton varieties.

How will it benefit my operation?
Commercial practice in Australian cotton production is commonly driven by providing replacement amounts of nutrient with limited understanding of the mechanism of crop uptake and use, and this is particularly the case with respect to P.

This presentation outlines why the addition of P-based fertilisers continues to be critical to the long-term optimisation of cotton production, but outlines some of the dynamics of P uptake, how our cotton plants are satisfying their appetite for phosphorus and what is happening to the fertiliser we are applying.

What are the current barriers to adoption/ commercialisation?
There have been some confusing messages coming from Australian research with respect to phosphorus nutrition of cotton, particularly around the likelihood of achieving a consistent response to applied fertiliser P.

The results from these projects provide an insight into why some of the research messages have been confusing. They have also provided some clarity around phosphorus nutrition in both irrigated and dryland cotton cropping systems, and especially how a crop responds to available phosphorus (from native fertility or applied fertiliser) in different parts of the soil profile.

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une University of New England

Optimising N & irrigation application & nitrous oxide emissions

Jon Baird, NSW DPI

What is the research/technology?
The research is focused on optimising the nitrogen (N) and irrigation application rates within a cotton irrigation management system. The study was performed with a holistic approach that examined the interactions and impacts of various N & water strategies in a commercial cotton producing environment.

Experiment management strategies were built to align with common industry practices. The strategies were categorised into three levels: intensive high application rates, moderate input rates and minimal input rates.

Why do I need to be aware of this research/ technology?
The management system developed from the research will lead to greater N use efficiency (NUE) and water use efficiency (WUE), while also ensuring high productivity and optimum gross margin crop returns.

Grower awareness of resource optimisation will increase farm efficiency, reducing the application of excessive inputs while also ensuring greater lint production. By understanding the relationship/ interaction between water use and crop nitrogen uptake, the industry will develop farm management practices that improve resource efficiency.

How will it benefit my operation?
Current results from the research have shown that optimising your crop management strategy can lead to improving crop gross margins by over $1000/ha (22 percent).

Meanwhile, a gross margin based on water applied found savings of $100/ML (14 percent) within the experiment. Investigating the optimum management inputs will reduce resource losses, improve farming system efficiency and result in a more sustainable farming operation.

What are the current barriers to adoption/ commercialisation?
Optimising farm management strategies for individual valleys and even farming systems is the priority for this research. Currently this project has data from one cotton growing region in Australia so further experiments at a number of various valleys are required for greater evaluation of optimum farming management strategies for those specific valleys.

In the short term there is multiple varied N rate trials within Australian cotton regions and if interested growers should contact their local CottonInfo Regional Development Officer (RDO) for more information.

To initiate nitrogen best management practice (BMP) growers should start by conducting regular fallow soil sampling for background soil nitrate levels, consider available irrigation water when N budgeting and follow best management practices for their irrigation management.

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Soil health and cotton crop rotations

Dr Vadakattu Gupta, CSIRO Agriculture

What is the research/technology?
The level of plant available nitrogen in agricultural soils is a product of biological processes involved in mineralisation and immobilisation, nitrogen fixation and gaseous losses.

As part of a CRDC-funded project we have been investigating the effect of crop rotation and cropping system practices on N cycling-microbial communities and processes in cotton soils. During the last two seasons we quantified the abundance and activity of different N cycling microbes in the surface soils in the long-term experiments at ACRI (conducted by Ian Rochester (F6E) and Nilantha Hulugalle (D1)) and linked them to changes in mineral N levels (N availability) in soil.

Briefly, we found that grain legume rotation crops (eg. Vetch and Faba bean) significantly improved microbial activity, catabolic diversity and N mineralisation potential in surface soils in both experiments, however the magnitude of effect varied between the two experiments. Microbial activity and microbial biomass levels were generally lowest in the continuous cotton rotation.

A significant crop rotation and depth based difference was observed in the composition and diversity of microbes involved in N cycling processes such as nitrification, nitrogen fixation and denitrification. Populations of free-living N-fixing bacteria were significantly higher in the field D1 experiment compared to that in the F6E, reflecting the variation in stubble management and timing of fertiliser application that resulted in high levels of mineral N in the F6E experiment throughout the cotton season. Additionally, although the clay vertisols are known to support a diverse community of N fixing-bacteria we found low populations and free-living N fixation probably due to the high mineral N levels in soils.

Why do I need to be aware of this research?
Nitrogen transformations in cotton soils are biologically controlled, however nutrient input management is based only on chemical changes in cotton soils. The new knowledge about abundance and activity of N cycling microbes (e.g. N inputs from free-living N fixation) has the potential to assist in reducing dependency on inorganic N fertilisers.

It is known that nutrient input use efficiency is low for cotton soils resulting in low economic efficiency and potential for higher environmental costs. Identification of microbial factors that help streamline nutrient inputs and nutrient transformation processes for maximum efficiency would assist in the development of improved management options including a new fertiliser application strategies and application of organic amendments.

How will it benefit my operation?

- An improved ability to better manage N cycling processes in cotton crops through management practices in order to achieve higher input use efficiency and improved N inputs through biological processes.

The inherent lower soil organic matter levels in Australian cotton soils necessitates the improvements of soil biological status in order to maintain the biological processes relevant for production, quality of soil resource base and environmental health (e.g. input use efficiency and synchronization of nutrient supply with plant demand and plant health). For example, improvement of cotton nutrition from microbially derived nutrients will contribute towards better nutritional management options. To achieve greater crop N use efficiency in high yielding irrigated cotton it is necessary to consider the N mineralization potential, which is dependent upon the inherent soil fertility and biological activity.

What are the current barriers to adoption?
Current knowledge on biological processes involved in N cycling in cotton soils is mainly from a few experimental plots and very little is known about the abundance and activity of N-cycling microbes in cotton soils across different cotton growing regions.

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Nitrous oxide losses from irrigated cotton

Dr Graeme Schwenke, NSW DPI

What is the research/technology?

Nitrous oxide [N2O] is emitted from the soil (and through the plant) after being produced during the processes of nitrification and denitrification.

Nitrification is when nitrate is produced from ammonium (the ammonium itself comes from urea, anhydrous ammonia, soil organic matter, crop residues, or manures).

Denitrification occurs when nitrate in the soil converts to the gases nitric oxide [NO], nitrous oxide [N2O], and di-nitrogen [N2] in the presence of labile carbon under anaerobic conditions [oxygen depleted].

Direct losses of N2O from the soil during a season are small, with the current Australian emission factor for irrigated cotton at 0.5 percent of N applied, or 1.25 kg N/ha from a 250 kg N/ha fertiliser application.

However, losses of the other gases produced during denitrification, particularly N2, are likely to be 40 times as great, e.g. 50 kg N/ha from 250 kg N/ha applied.

We are researching ways to reduce N2O emissions from cotton soils because N2O is a long-lived greenhouse-warming gas with 300 times the warming potential of CO2 on a 100 year timescale. N2O is also the main man-made gas depleting the earth's protective ozone layer.

Methods being trialled include reducing the N fertiliser rate, splitting N fertiliser application vs all pre-sowing, altering N fertiliser placement, and altering irrigation timing.

Another option is to use an enhanced efficiency fertiliser (EEF) which has shown large reductions in N2O emissions in dryland sorghum, but did not increase NUE enough to be economical.

Why do I need to be aware of this research?

- To reduce the environmental impact of cotton growing: agriculture is a major producer of N2O into the atmosphere, contributing to global warming and ozone depletion. The amount of N2O produced from applied fertiliser increases with increasing N rates used, but the increase in emissions can be exponential at high N rates above the optimum needed for the crop.
- Activities that reduce N2O emissions by increasing the N use efficiency can be used to gain 'carbon credits' through the Australian Government's Emissions Reduction Fund. Allowable activities include: modifying the rate, timing, method or efficiency of fertiliser application.
- As well as environmental benefits, improving N use efficiency is also economically and agronomically beneficial to cotton growers.

How will it benefit my operation?

- Optimising N fertiliser rates reduces input costs from over-application of fertiliser N with no additional yield.
- Reducing N losses that occur from denitrification means less N is needed for the same yield result.

What are the current barriers to adoption?

- There is uncertainty surrounding the various avenues of N loss and the total amount of applied N that is lost from the system, so large N rates are being used to cover potential losses 'in case'.
- More research is needed to quantify N losses and NUE under alternative N fertiliser management and irrigation management strategies.
- There needs to be a price incentive for cotton produced using practices that minimise N2O emission. The "Emissions Reduction Fund" may provide this incentive if the carbon price is sufficient and the participation costs are feasible.

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NSW GOVERNMENT Department of Primary Industries

Soil health research in practice

Nigel Corish, cotton grower & Nuffield scholar

What is the research/technology?
The Nuffield scholarship research study looked at ways to improve nitrogen use in irrigated cotton. Areas researched during the studies included product, timing, rotations and cover crops, irrigation methods and precision technology.

The research I am implementing after undertaking the scholarship at "Yambocully" Goondiwindi is to move to a 100 percent liquid nitrogen fertiliser program. Also, introduce a zero till/minimum till system into flood furrow irrigation. Once Bollgard 3 is introduced will look at going to a full zero till system. I'm also looking to introduce a complete rotation program into the farm to build up organic matter using legumes and cereals.

Why do I need to be aware of this research/ technology?
There are too many losses under a synthetic based fertiliser program, which can be up to 50 percent through leeching, denitrification and volatilisation. Growers need to be aware of the losses in their current system, and how soil health and irrigation affect nitrogen use efficiency on their farm.

How will it benefit my operation?
- Increase in applied nitrogen use efficiency
- Improvements in: soil health, water use efficiency, gross margins.
- Reduction in: input costs and greenhouse gas emissions.

What are the current barriers to adoption/ commercialisation?
The challenges I have had with the research to date is that it was slower planting and we had lower than ideal plants per metre (average of 7 per metre) due to planting too deep. The cost of liquid nitrogen is expensive, I have budgeted on applying 200 units of nitrogen as N26 at a cost of 40 cents per litre.

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Gunnedah: Rod Smith

What's the most important decision you make re nutrition?
Cotton is a crop that has a high demand for nutrients. One of the most important decisions we make around nutrition is nitrogen rates and application as nitrogen is the most limiting nutrient on our farm. High-yielding cotton has a high demand for nutrients, but often production is limited by soil fertility and the crop's ability to accumulate nutrients. We try to manage this as best we can.

How do you decide how much N, P and K you apply, and when? What impacts this?
We soil test and develop our nutrient budget very carefully. We soil test sometime between May and August, 0-30 cm for all nutrients, 30-90 cm for nitrogen. We use various tools like leaf and petiole testing during the season to track nutrient availability. Forward planning is critical on our farm as a crop that lacks nutrition at key stages of growth will never reach its full potential and we are very conscious of that.

What research (from this tour) most interests you, and why?
It will be interesting to find out what the researchers have to say about sustainable cotton production: higher yields, more often and optimising nitrogen and irrigation application because we are always looking to become more efficient and optimising economic return on farm. Over time, the costs associated with growing cotton have risen, placing pressure back on us to always be chasing higher yields.

Warren: Gus O'Brien

What's the most important decision you make re nutrition?
I believe nitrogen management is the most crucial crop nutrition decision I make in the planning of my crops nutrition strategy. Rate, timing and method of application are the three main aspects of this process.

How do you decide how much N, P and K you apply, and when? What impacts this?
Nitrogen: I target a 15 bale yield and work my numbers around this. In my environment there is no penalty for too much N. Residual N will be picked up by the following crop, if not cotton then wheat. Under this strategy I have been achieving 14 to 15 bale averages where the season allows and following with 4 tonne wheat crops with protein without water and up to 7 tonne when water is available. (This includes the addition of more N).

My strategy is simple: I target 320 to 350 units of N/ha with 1/3 broadcast as Urea up front. 1/3 broadcast early season before a rain event and 1/3 water run over at least 4 irrigations to even out the uniformity. Sometimes I will fly on an extra dose to the head ditch end of the field, say the first 200 meters to allow for N movement down the field. I also run water down every row as I have found running water down every second furrow pushed N down the field. I have found the 74 type variety's that produce a lot of late yield if the season allows pay a huge penalty if the crop is not fully green to the finish.

Phosphorus: Hatton and Bellevue have generally not given big responses to P. We have been trying to keep a maintenance rate of around 200kg of Map. This is broadcast pre-season during land prep, sometimes with the addition of zinc. I have also used Flowphos as sowing in the past but this was expensive and I believe my money is better spent on upping the broadcast rates of high analysis products like MAP and MOP.

Potassium: Historically K has not been a big part of our program. We have used Foliar K at Flowering in the past however I think this was more of a feel good thing. This year we have broadcast 200kg MOP to build the levels before they become problematic.

Warren: Gus O'Brien (cont.)

Greenhouse gas emissions are becoming more heavily scrutinised. Are you likely to become more conscious of N loss pathways?
I am very conscious of the loss pathways of N and I am also very concerned about future regulation of N fertilisers. I believe the losses in the kind of system that I run are overstated and the full story is not being told.

What research (from this tour) most interests you, and why?
Yield is king in my system so I'm very interested in Oliver's sustainable cotton production: higher yields, more often. I'm interested to hear the different approaches to budgeting nutrients from Chris, although I'm sceptical of making changes to mine. And if I can make my applied N go further that is a clear win for me, so interested to hear from Dio about improving nitrogen use efficiency (particularly interested to hear what has changed over the last 20 years).

I'm very aware of the value of mineralised N, so interested in Francois' talk, plus always interested in other growers' perspectives, so looking forward to hearing from Nigel.

Griffith: Darrell Fiddler

What's the most important decision you make re nutrition?
Two key decisions:

- Getting the N rate right for individual fields. We currently use a base rate of around 250kg N but this varies for individual fields (from 220 to 310kg/N) based on acquired knowledge of how paddocks perform and if back to back or fallow ground; and
- Providing adequate P (aiming for 60 units of P available).

How do you decide how much N, P and K you apply, and when? What impacts this?
We determine N, P and K applications through pre season soil tests and past experience with individual fields. I have reduced the amount of N I apply by 50 units after observing the CottonInfo trials over the last three years.

Greenhouse gas emissions are becoming more heavily scrutinised. Are you likely to become more conscious of N loss pathways?
Yes because it is a financial loss.

What research (from this tour) most interests you, and why?
I am keen to hear what Oliver has to say because being sustainable in profitable cotton production is the main goal of what we do. Also the CottonInfo N trial work has changed my approach to Nitrogen budgeting and timing of N application. I believe we need to have ongoing grower-driven cotton nutrition trials that are easy to evaluate at the end of the season.

Emerald: Ross Burnett

What's the most important decision you make re nutrition?
Determining the potential yield we are aiming for, and making nutrition decisions to support this.

How do you decide how much N, P and K you apply, and when? What impacts this?
Target yield, soil tests, cropping history. N is a split application to try be more efficient and minimise losses and also feed the crop as demand is at peak. All other nutrients are applied pre plant, typically as soon as possible after picking by spreading so all following operations spread it through the profile.

Greenhouse gas emissions are becoming more heavily scrutinised. Are you likely to become more conscious of N loss pathways?
Yes. We have altered our practices over the years from spreading urea in crop, to dropping it in the water furrows then cultivating, to now making sure we drill it into the hill and have adequate soil cover to minimise losses.

What research (from this tour) most interests you, and why?
Dr Oliver Knox's presentation on sustainable cotton production: higher yields, more often - is of most interest as the cotton production in this region typically has a higher percentage of back to back fields compared to other valleys, and our yields can vary greatly year to year.

Emerald: Cam Geddes

What's the most important decision you make re nutrition?
Critical decisions are timing of planting and ground preparation. In regards to application of nutrition, there is no set way; nutrition is ever changing so sampling is very important. We hope to use technology to better inform our decision making.

How do you decide how much N, P and K you apply, and when? What impacts this?
We decide how much N, P and K to apply through soil sampling as a basis but also leaf sampling. We look at the previous crop and the removal rates from that season based off yield but also soil sampling to see if that matches what we expect and tweak our nutrition rates. Over the past few years we have changed our application from applying N at the start of the season to now splitting our rates, and trying to pre-empt so applying at the beginning of the season and then throughout the season.

Greenhouse gas emissions are becoming more heavily scrutinised. Are you likely to become more conscious of N loss pathways?
I've always been conscious of trying to make informed decisions of what the loss pathways of N could be and what practices limit those emissions. Overall it's something you have to judge when calculating the removal and residual nitrogen, it can't be a huge difference. Soil sampling has allowed us refine our decision making however it's all about trying to pick a realistic mark. I'm trying to understand more about soil biology and nutrition is the soil and observe what is happening throughout the season. Becoming more aware of what is happening in the soil allows us to be more efficient in saving resources and the environment.

What research (from this tour) most interests you, and why?
I'm excited to hear from Dr Gupta and Nigel Corish, because their work really applies to what I'm doing. Soil is often overlooked with most attention going to managing the plant, however if you think about the crop itself, half of it's under the ground. So I'm starting to think more about what is happening in the soil.

Emerald: Tim Mackinlay

What's the most important decision you make re nutrition?
Nitrogen is the most important decision we make around cotton crop nutrition however phosphorous is becoming more important.

How do you decide how much N, P and K you apply, and when? What impacts this?
We do soil sampling every year to help us decide how much nitrogen, phosphorus and potassium to apply. We also have to decide whether we apply all up front or side dress. A lot of decisions are collective input but also previous management of fields and cropping history have an impact on the nutrition we apply.

Greenhouse gas emissions are becoming more heavily scrutinised. Are you likely to become more conscious of N loss pathways?
We are reasonable with the loss of nitrogen on our farms. We drill everything, we don't spread or water run at the moment so we try to keep losses minimal.

What research (from this tour) most interests you, and why?
I'm looking forward to hearing from Chris Dowling from Fertcare/Back Paddock, he is always interesting to hear from especially as we look at nutrient budgeting and rates. It's interesting to hear not just about replacement rates and what is coming out of the crop but how we combat it and looking broadly at cropping nutrition as a whole program.

From overleaf: Cam Geddes.

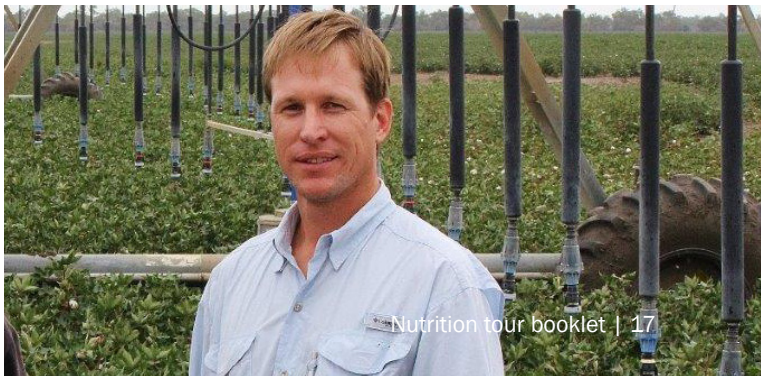
Moree: Nick Gillingham

What's the most important decision you make re nutrition?
Rate and timing. We need to know we'll have enough available to the crop but will also consider how much we put up front, looking at the season.

How do you decide how much N, P and K you apply, and when? What impacts this?
For N we look at what the research says the crop will demand for our target yield. Similarly for P and K, we'll look at the research and consider what's remaining. We conduct soil tests before a cotton crop to guide us on what's going to be available throughout the season, but are careful to consider variability across a field in soil testing. We'll also change our rates if we're planting skip row cotton.

Greenhouse gas emissions are becoming more heavily scrutinised. Are you likely to become more conscious of N loss pathways?
We've always been conscious of loss pathways from a profitability perspective so we minimise our emissions as much as possible anyway. We use drilled urea rather than spread and water run urea in crop, we don't use any anhydrous ammonia because of potential losses. I think eventually regulation will happen but losses should be considered now regardless.

What research (from this tour) most interests you, and why?
I'm interested in Oliver's talk re higher yields, more often as our goal is to maintain profitability through yield. Similarly, Ben's nitrogen losses from irrigated cotton presentation re cost and emissions reductions. Interested in Jon nitrogen and irrigation application and nitrous oxide emissions sessions to help improve N use and efficiency. And local research, trials and issues are always relevant.



Improving nitrogen use efficiency

Dr Dio Antille, USQ

Background and Aim

- Timeframe: Jul 2015 to Jun 2018,
- Over-application of N fertiliser to reduce risk:
  - Less return from applied fertiliser,
  - N rate linked to N_2O emissions (exponential increase ≥250 kg N ha^{-1}),
  - Soil N supply often ignored,
- Reduced upfront N and enhanced N formulations may be cost-effective to improve NUE in cotton,
- Reduce uncertainty with regards to magnitude of N losses and the role of SOM in supplying in-crop season mineral N,
- Goal is to reduce N fertiliser inputs by 25% without compromising on productivity.

Outline Methodology

- Benchmark existing decision support systems (DSS) for nitrogen management,
- Develop, implement and test N management strategies in cooperation with growers, including:
  - Optimum N application rates,
  - Enhanced efficiency fertiliser formulations
- Assess the feasibility of precision N management in cotton.



Outline Methodology

- DSS: Collate existing data + collect field data on N losses and soil N supply from SOM to improve accuracy of DSS, which already exist in the industry,
  - Greater confidence in the use of DSS to optimise N inputs

- Experimental: compare growers selected strategies to N management with up to 2 selected strategies per site per year,
  - E.g., change of timing, placement or use of EEF such as ENTEC®-urea and polymer-coated urea
  - Use labelled ^{15}N-urea to partition uptake, losses (N_2O), and soil N supply,
  - Data collected used to update DSS

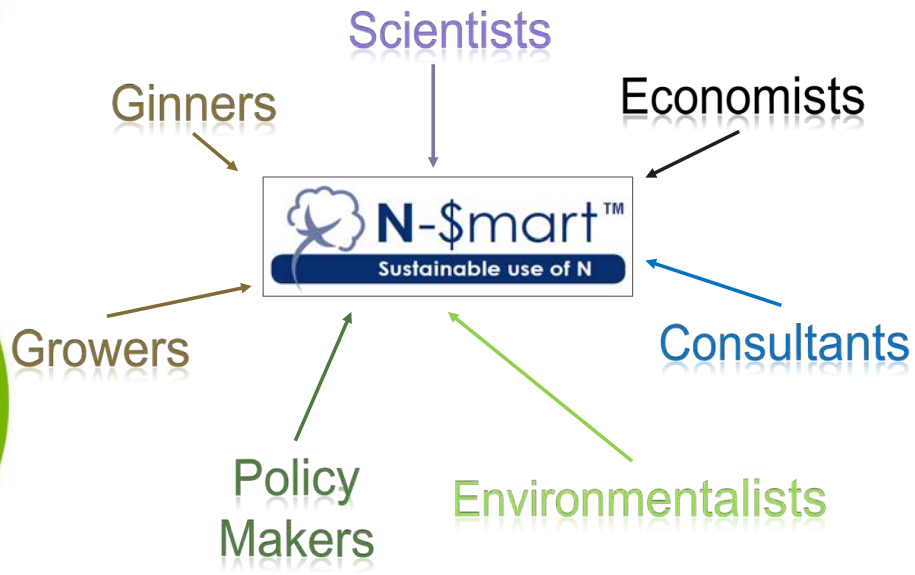
- Feasibility for precision N management: determine if management zones could be identified,
  - Yield monitoring, remote sensing technology

Overview of the experimental sites in Yargullen, QLD. (1): Furrow-irrigated cotton site, (2) Close-up of semi-automatic chambers used to monitor nitrous oxide emissions, and (3) Overhead-irrigated cotton site.

Mineralised nitrogen in crop

Dr Francois Visser, UQ

ONE LANGUAGE - ONE GOAL



FOUNDING PRINCIPLES OF MODEL

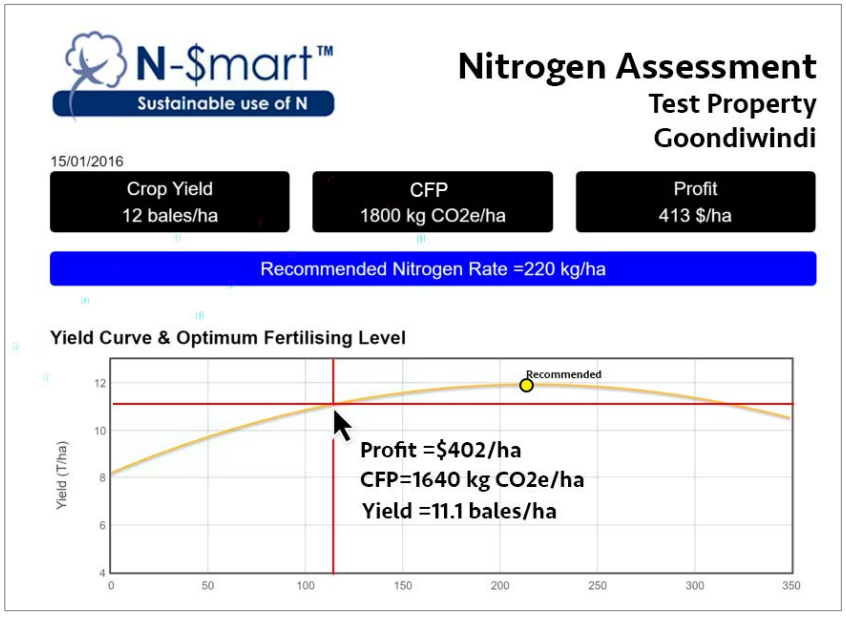
- **An industry / farmer level tool – approximately 15 minutes for standard N assessment**
- **Limited to data inputs available at farm level, including soil test reports**
- **Four outputs: Gross profit ($/ha), carbon footprint(CO2e/unit), progress (%/unit) and yield/ha**
- **Measures progress made in environmental impact improvements (%) through a range of chosen scenarios**

NITROGEN OPTIMISATION MODEL

- ✓ **Grower engagement tool –N Budgeting**
- ✓ **Scenario and management planning tool**
- ✓ **N mineralisation tool.**

N-$mart™ Sustainable use of N

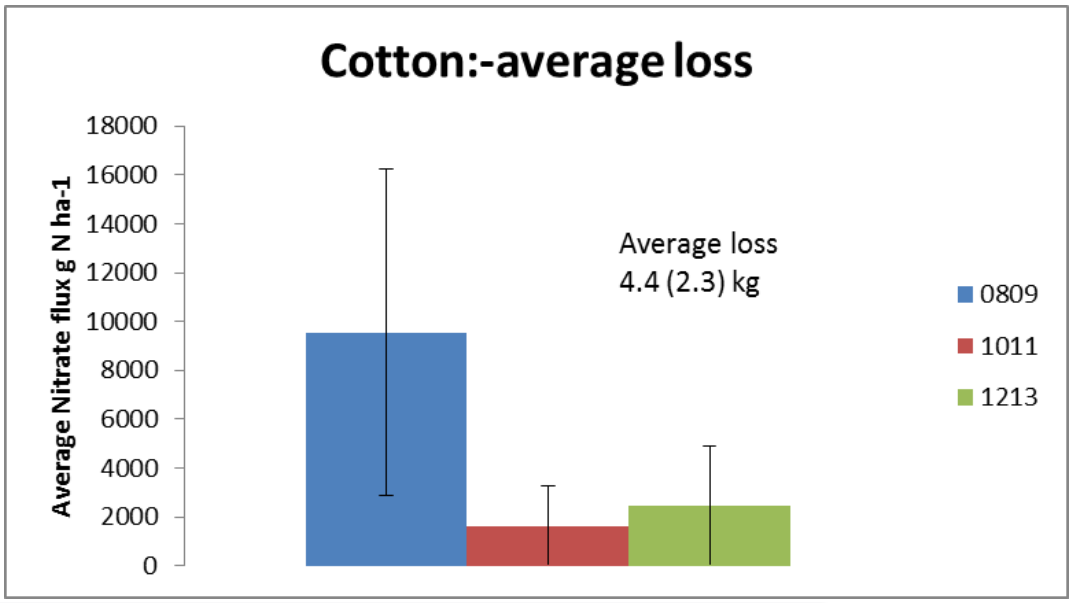
Example of Result



Nitrogen losses from irrigated cotton

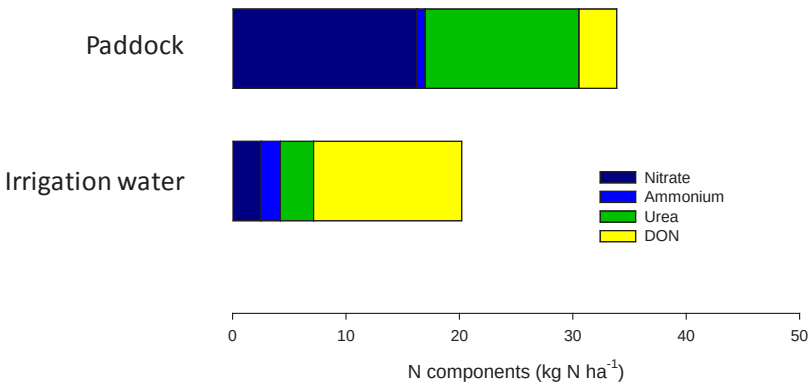
Dr Ben Macdonald, CSIRO

Deep drainage



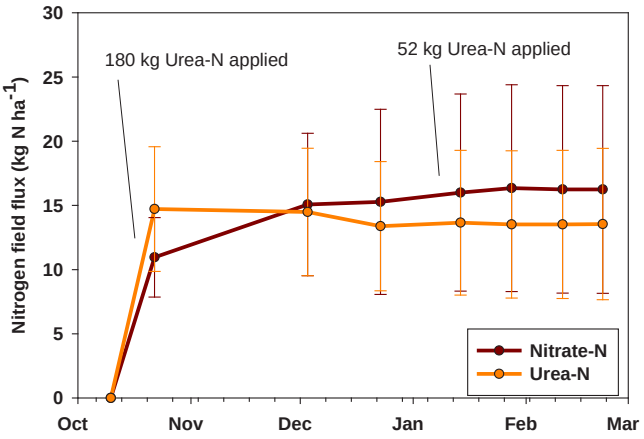
1 | N flux water | Macdonald

Source of the field Losses



2 | N flux tail water FertCare | Macdonald

Loss of nitrate and urea field occur early in the season



3 | N flux tail water FertCare | Macdonald

Optimising N & irrigation application & nitrous oxide emissions

Jon Baird, NSW DPI

NSW GOVERNMENT Department of Primary Industries

Australian Government
Cotton Research and Development Corporation

Optimising Water and Nitrogen without sacrificing Productivity

Jon Baird: Research & Development Agronomist- NSW DPI

Of the management strategies researched, the "moderate" input strategy (210 kg N/ha with a deficit of 70 mm) was deemed the optimum strategy as it resulted in good WUE, NUE and importantly for growers higher gross margins per hectare.

Typical Australian cotton grower management strategies were incorporated to investigate three levels of inputs- high, moderate and low. The treatment inputs contained three irrigation systems set at soil water deficits of 50 mm, 70 mm & 100 mm, and nitrogen application rates of 160 kg N/ha, 210 kg N/ha & 260 kg N/Ha.

Experiment yields resulted with the moderate input strategy (70mm with 210 kg N/ha) having the greatest yield (13.66 b/ha), 0.2 b/ha greater than the next two treatments (260 kg N/ha at both 50 & 70 mm deficit), and 2.4 b/ha greater than the low input strategy (160 kg N/ha at 100 mm deficit) (Figure 1). The higher applied Nitrogen rates of 210 & 260 kg N/ha (at both 50 & 70 mm deficits) had significantly higher yields then the lower Nitrogen rate of 160 kg N/ha.

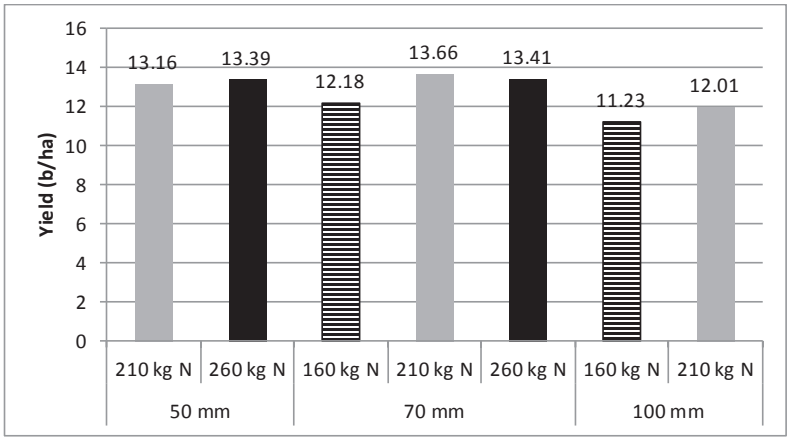


Figure 1: Experiment Yield (LSD>1.07 b/ha)

Nitrogen Use Efficiency-

- Irrigation management played a major role in the cotton plant's ability to uptake Nitrogen
- The intensive irrigation deficit (50 mm) improved the variability of nitrogen uptake within the trial compared to the larger irrigation deficits (70 & 100 mm).
- Optimum range for experimental internal crop NUE (iNUE) was 12.7 to 13.3 kg lint/kg crop N. Crop iNUE was determined by dividing lint yield by crop N uptake. Evaluating iNUE allows for the determination of the amount of under or over fertilisation that occurred in respect to the economic optimum N rate.

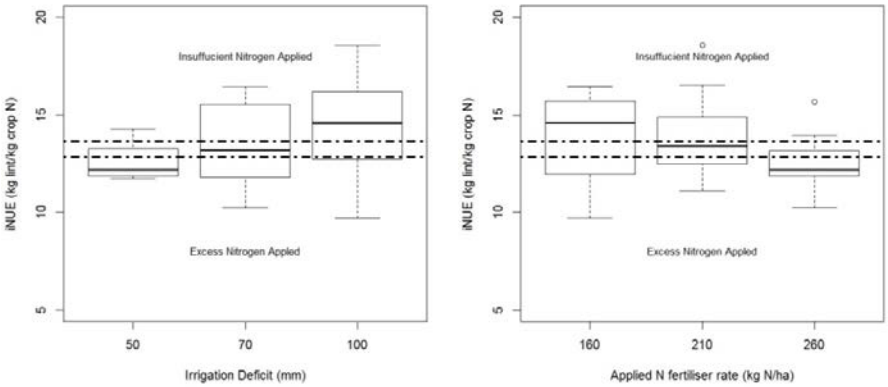


Figure 2 : Experiment iNUE

Water Use Efficiency-

- Although it received two extra irrigations the 50 mm used a similar amount of water to the 70 mm treatment (6.33 & 6.22 ML/ha respectively)
- This meant that yield played a major role in the difference in values for water use within the experiment
- Nitrogen rate did not influence water use, but plant biomass did. Larger plants absorbed more water especially later in the season.

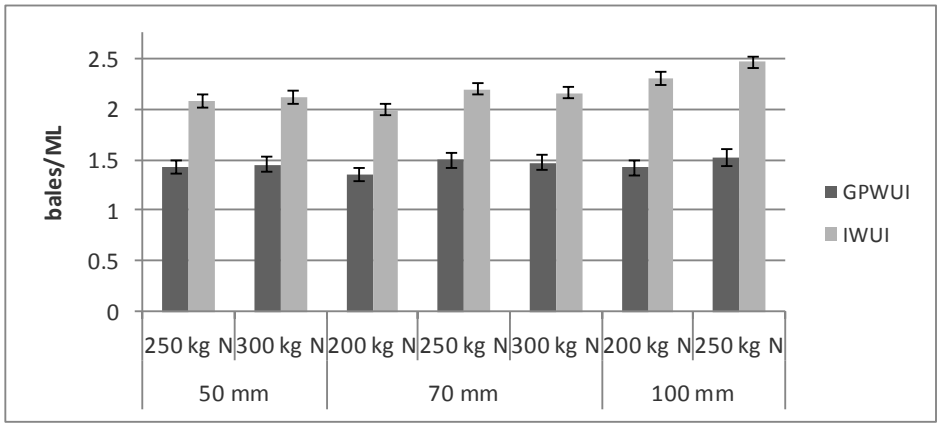


Figure 3; Experiment GPWUI (total crop WUE) & IWUI (applied WUE)

Treatment Crop Gross Margins-

- The moderate management returned the highest crop gross margin of $4,345/ha, a $1,000/ha improvement on the return from the low input strategy and $210/ha greater than the high input strategy
- The low input strategy (160 kg N/ha at 100 mm deficit) had the lowest growing cost ($2970/ha) but still had returns of more than $300/ha below the next strategy.

for the "moderate strategy" of 210 kg N/ha at the 70 mm deficit, while the "intensive strategy" of 260 kg N/ha with a 50 mm deficit returned a margin of $4,345/ha. The low input strategy was used as a base for gross margin comparisons (Figure 3). As Figure 3 highlights, there was a gain of $210/ha by the moderate strategy over the intensive input strategy. While the low input strategy (160 kg N/ha at 100 mm deficit) had a gross margin return of over $1000/ha less than the moderate input strategy, highlighting that optimising your cotton management inputs does not equal reducing your productivity or more importantly your crop gross margin.

For growers that are restricted for farm productivity by available water, a gross margin aimed at a mega litre basis was also evaluated. Again the experiment treatments were compared back to the low input treatment, with the only treatment to have a greater return on water use being the 210 kg N/ha with a 100mm deficit ($65/ML). While the moderate strategy with the higher lint yield resulted in a mega litre margin equal to the low input treatment even though it had an extra two irrigations applied. The 50 mm irrigation strategy resulted in $50/ML decrease, while the worst performing treatment was the 160 kg N/ha at a 70 mm deficit which returned $105/ML lees than the moderate treatment.

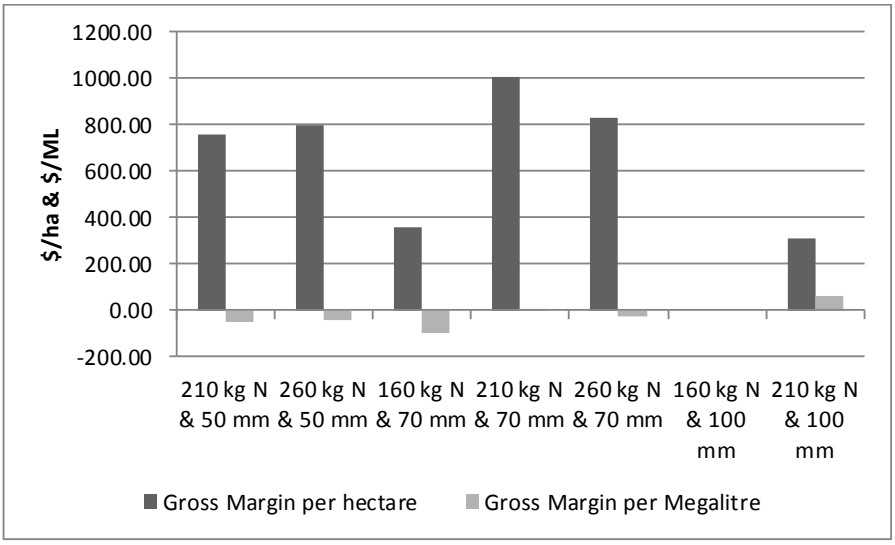


Figure 3: Treatment Gross Margins compared to the low input strategy (160 kg N/ha & 100 mm deficit)

A gross margin is not indicative of farm profit because it does not include the overhead or operating costs such as administration, permanent labour, depreciation and finance expenses, which have to be met regardless of enterprise size or mix.

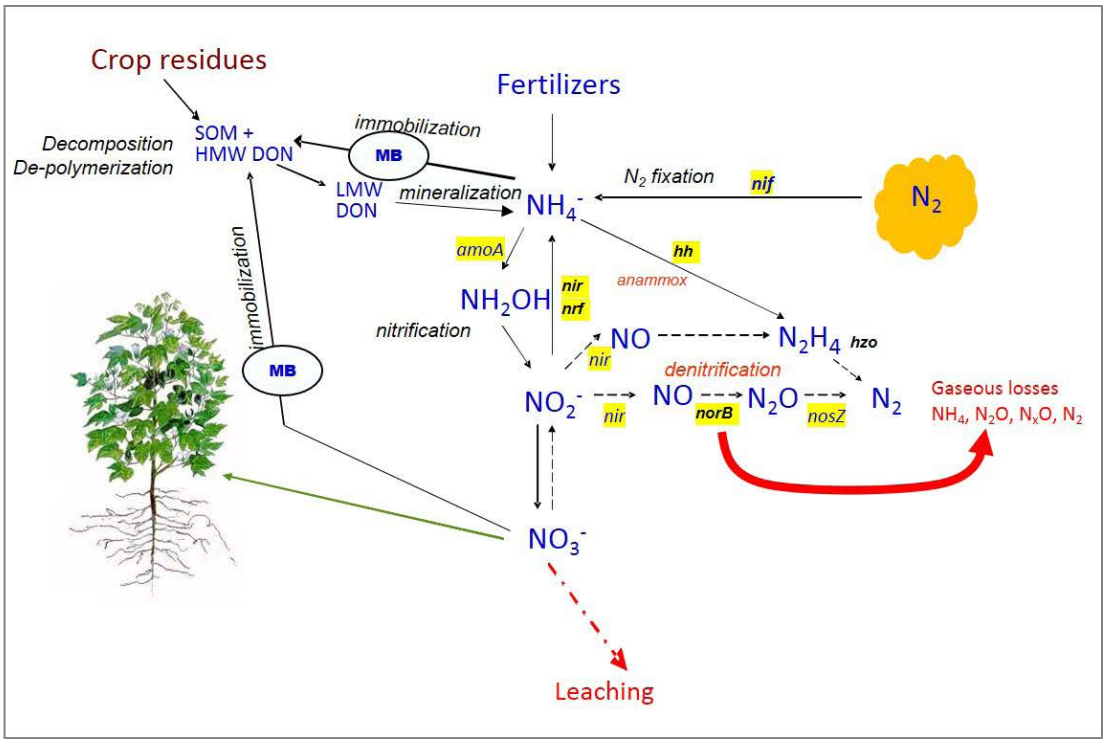
The trial results showed that the "moderate" management strategy (210 kg N/ha & 70 mm deficit) was most optimum system for growers to utilise within their farming business. We must acknowledge that the experiment has only one year of data and it is specific to the Upper Namoi region. The management strategy was within significant difference of the leading NUE & WUE treatments and had the greatest productivity and gross margins. This reiterates that cotton growers in Australia can apply inputs with efficiency in mind and continue to produce yields that are considered high and profitable.

Soil health and cotton crop rotations

Dr Vadakattu Gupta, CSIRO Agriculture

Biological processes

- Decomposition
- Depolymerization
- Mineralization
  - Nitrification
- Immobilization
- Denitrification



Nitrous oxide losses from irrigated cotton

Dr Graeme Schwenke, NSW DPI

N strategies to reduce N_2O emissions

Action on the Ground: Cotton . . . . . Graeme Schwenke (NSW DPI)

- **2014-2015**
  - 3 farms (Gunnedah, Moree, Emerald)
  - Treatments: 3 x N fertiliser rates x 3 replicates
    - Farmer's N rate, +25%, - 25%
    - N_2O emissions were measured in hill, irrigated furrow and non-irrigated furrow positions in each plot

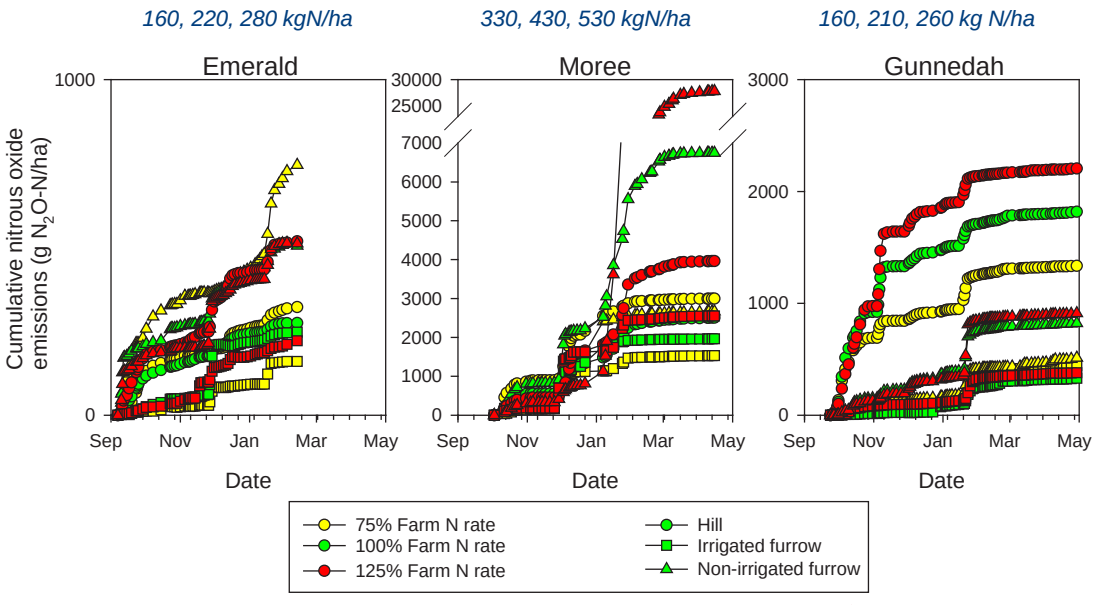
- **2015-2016**
  - 3 farms (Gunnedah, Moree, Emerald)
  - Treatments: All N pre-sow, split N, N placed near irrigated furrow or non-irrigated furrow, irrigate every furrow vs every second furrow, shorter duration of irrigation.

Australian Government Department of Agriculture

Australian Government Cotton Research and Development Corporation

NSW Government Department of Primary Industries

Cumulative N_2O emitted over time from hills, irrigated furrows, and non-irrigated furrows in 3 N rates at 3 farms

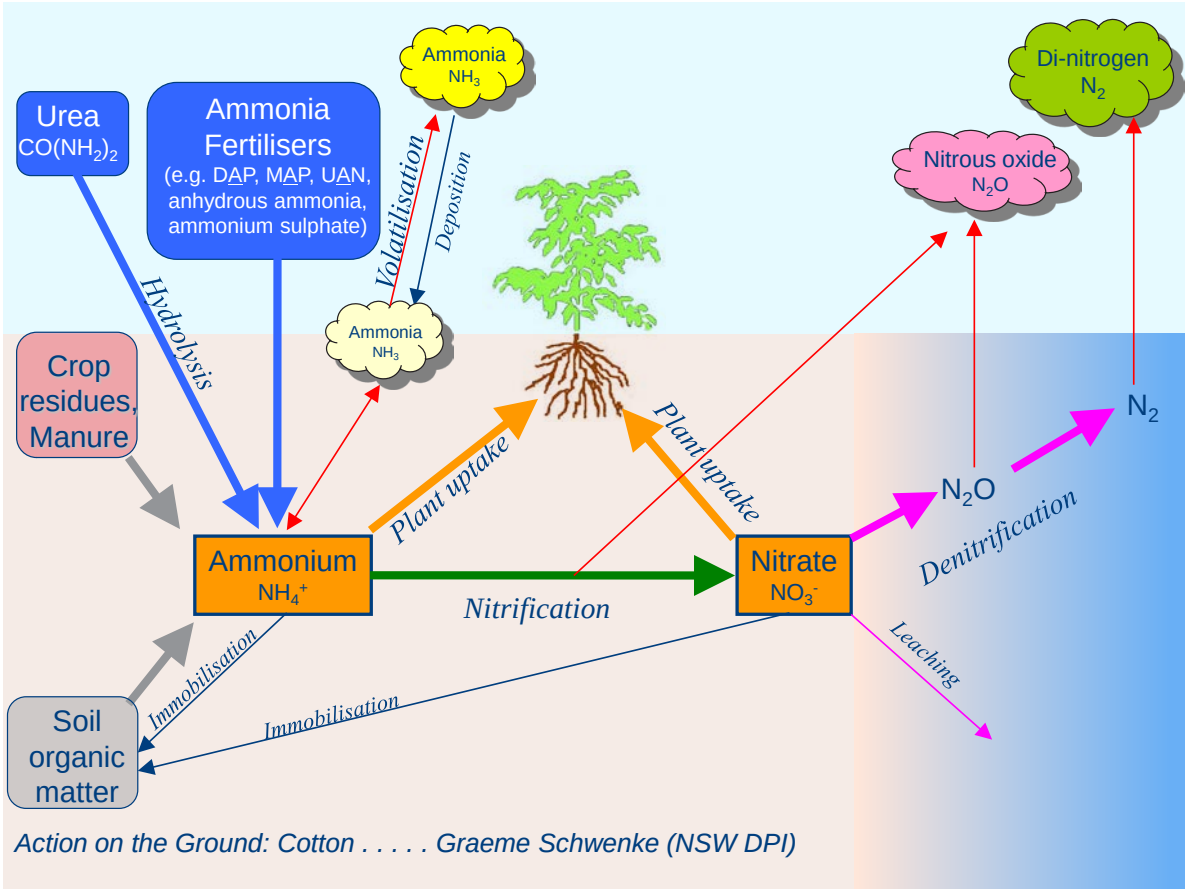


2014-2015 Results

- Initially, N_2O emissions were higher in the beds where N had been applied pre-sowing.
- Later in the season, emissions were greater from the non-irrigated furrows after rainfall and irrigation, particularly after additional N was added.
- Total N_2O losses were greater at higher N rates, especially the +25% rate at Moree
- Lint yield was not related to N rate at any site.
- Increasing N rate reduced N use efficiency and increased environmental impact.

Action on the Ground: Cotton . . . . . Graeme Schwenke (NSW DPI)

NSW GOVERNMENT | Department of Primary Industries



Action on the Ground: Cotton . . . . . Graeme Schwenke (NSW DPI)

Soil health research in practice

Nigel Corish, cotton grower & Nuffield scholar

Recommendations to Industry

- Stop growing back to back cotton.
- Plant more rotations
- Plant cover crops
- reduce water logging
- Reduce tillage
- Create management zones and use VRT.

Roots of chickpea plant pPLANT

Faba bean crop

Roots of a faba bean plant

COTTON AUSTRALIA

Australian Government
Cotton Research and Development Corporation

NUFFIELD AUSTRALIA FARMING SCHOLARS

What Have I Changed?

- Confidence.
- Ability to Question everything, and ability to implement change.
- I have not ploughed since returning from my studies, saving money on fuel and labour, and also time
- Planted more legumes.
- Planted my first cover crops.
- Purchased new zero till planter.
- Improved irrigation techniques.
- Using NDVI satellite imagery.

Wheat planted into french millet cover crop

Boss double disc planter

COTTON AUSTRALIA

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NUFFIELD AUSTRALIA FARMING SCHOLARS

Discussion

- How can I introduce conservation farming practices to irrigated cotton?
- Implementing rotations, cover crops and zero till
- Stop treating the soil like dirt.

JG Boswell Company California

Notes

Notes

Notes

Meet our team

Led by CottonInfo Program Manager Warwick Waters (0437 937 074, warwick.waters@crdc.com.au), the CottonInfo team of Regional Development Officers, Technical Specialists & *my*BMP experts are all here to help!

Regional Development Officers

Regional Development Officers provide cotton research outcomes and information directly to growers, agronomists, consultants and agribusinesses in each region. Contact your local Regional Development Officer for the latest research, trials and events in your area.

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Technical Specialists

Technical specialists are experts in their fields and provide in-depth analysis, information and research to the industry, for the benefit of all growers. Contact the technical specialists to learn more about water use efficiency, nutrition, soil health and much, much more.

Sally Ceeney	Janelle Montgomery	Lance Pendergast	Sandra Williams	René van der Sluijs
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*my*BMP team

The *my*BMP team run the industry's best management practice program, *my*BMP. Contact the *my*BMP team to learn more about - or to participate in - *my*BMP.

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CottonInfo is a joint initiative of Australian Government Cotton Research and Development Corporation, CSD Cotton Seed Distributors, Cotton Australia

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Best Practice

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