



Enhancing nitrogen use efficiency & improving phosphorus nutrition in cotton

This project is undertaking research into both nitrogen (N) and phosphorus (P) and is led by NSW Department of Primary Industries (NSW DPI). It aims to increase understanding of the intricate relationship between soil and fertiliser N & P supply, fertiliser placement, fertiliser timing, and irrigation strategy to achieve greater nitrogen use efficiency (NUE) and improved phosphorus soil nutrition.

Optimising NUE can be complex as fertiliser type, application strategy and irrigation management can influence N availability to the plant and N loss to the environment under different farm practice scenarios. Under certain conditions, N losses to the atmosphere, deep subsoil and surface water can be substantial, leading to poor NUE. In addition to applied fertilisers, N mineralised from soil organic matter is also a major source for cotton crops and is subject to the same loss pathways.

In parallel, the project is undertaking research into the dynamics of P uptake by cotton plants from both topsoil and subsoil, and the patterns of crop P accumulation, to better understand trends of long-term P supply throughout the soil profile. The research is investigating long term depletion rates of deep soil P reserves under different soil management strategies in irrigated farming systems.

The findings will aid in the development of informed N and P management strategies to increase efficient and effective N and P use by farmers.

The Research Questions

- What is the current status of N fertiliser knowledge from previous research in irrigated Australian cotton systems?
- What is the significance of ammonia volatilisation as an N loss pathway in furrow irrigated cotton systems?
- How does the interaction of irrigation management and N fertiliser timing affect N use efficiency in cotton?
- How does irrigation management affect mineralisation of N from soil organic matter in furrow irrigated cotton systems?
- How does the method of in-crop N fertiliser application affect N use efficiency in cotton?
- Is there long term P stratification or decline in cotton farming systems?
- How much P is being taken up by cotton plants from surface and subsoil layers?
- Is the response of P affected by varied irrigation and N management?
- Does P movement in runoff pose a risk to on-farm dams in cotton farms?



Methodology

The project is undertaking a literature review of previous research into N fertiliser use efficiency in parallel with in-field research:

1. A core trial site is located at the Australian Cotton Research Institute (ACRI), Narrabri, NSW, consisting of a fully replicated and randomised plot design subject to a range of N application strategies including:
 - Product and form of application (solid granular urea and dissolved solutions of UAN, urea and ammonia);
 - Timing of application (all applied in-crop vs varying amounts pre-plant : in-crop);
 - Rate of application (Zero N, Optimal N, High N (optimal + 100 kg N/ha));
 - Use of enhanced efficiency fertiliser (EEF) products (including urease inhibitor and nitrification inhibitor); and
 - Irrigation schedule (initially focus on 50 or 70 mm deficits).
2. A single summer campaign to measure ammonia volatilisation from in-crop applied N fertiliser, using open path laser concentration sensors, is also be undertaken.
3. In-crop N mineralisation is assessed through mineral N analysis of soils collected by sequential in-season soil coring inside and outside of root exclusion tubes.
4. N losses in selected irrigation and in-crop N management treatments is being studied in greater depth using ¹⁵N mini plots at the core site.

5. Two satellite site experiments, established on commercial farms near Gunnedah and Moree in 2017, have incorporated replicated and randomised treatments from the core site, selected through discussions with local grower groups.
6. Evaluations are undertaken at each of the experiment sites on N plant uptake, cotton lint yield, N content in irrigation runoff, and residual N soil under the various scenarios.

The P component of the project also includes a literature review of nutrition research in cotton farming systems followed by in-field P research:

1. Historical samples from several long-term cotton trials are analysed for $\text{CaCl}_2\text{-P}$, Colwell-P, BSES-P and PBI to assess the development of soil P stratification and/or P decline over time.
2. P utilization, from various depths in the soil at different growth stages, are being investigated using P-isotopes.
3. Irrigation and N management interactions, and their implications for improving P use efficiency, are being investigated in field experiments quantifying P uptake response.
4. Irrigation water samples are monitored for total and reactive P to quantify cotton farming system practices that minimise the risk of P loss.

Project Achievements

- A paddock-scale (8 ha) irrigated cotton core site trial was conducted at ACRI in years 1 & 2 with 15-24 treatments imposed, including irrigation scheduling and N fertiliser product/application type/application timing treatments.
- Comprehensive measurements of the treatment effects on soil, water, and plant properties were made both throughout the season, and of cotton lint and seed yield and N uptake at harvest.
- Successful use of individual-plot N-fertigation systems has allowed side-by-side comparisons of water-run N application with broadcast and side-dress treatments.
- Two replicated and randomised on-farm experiments have been established in year 2 near Moree and Gunnedah (NSW) with treatments imposed and in-season soil, plant and irrigation water sampling underway. Lint and seed yield measurements will be made within the plots, both by hand sampling and with commercial pickers. Both trials are investigating the potential benefits of using of a nitrification inhibitor directly injected with anhydrous ammonia when applied at a range of N rates pre-plant.
- Soil P status has been assessed in archived samples from 5 long-term cotton tillage and rotation trials. Samples collected from both the beginning and end (or most recent sampling where the trials are on-going) of each trial were analysed according to outlined methodology.
- N and P uptake within the ACRI core site trials is also being assessed, as is N and P in irrigation water inflow and runoff from all the imposed treatments.

Initial Outcomes

- Irrigating to a 70 mm deficit (9 irrigations) increased lint yield and fertiliser N use efficiency, compared to irrigating to a 50 mm deficit (12 irrigations), despite the plants in the 50 mm deficit being taller and of greater biomass.
- A more-than-adequate supply of N from soil + fertiliser meant that varying the N application timing or N fertiliser product used did not affect lint yield or NUEf, despite the plants in plots where more of the fertiliser N was applied early having taller plants.
- N loss in tail drain runoff was substantial from the water-run treatments, ranging from 23–31% of the fertiliser N applied as either ammonia, UAN or urea, compared to just 5–6% when urea was either broadcast or side-dressed prior to irrigation.
- Excess soil + fertiliser N remained in the soil profile as nitrate after picking, but had leached to between 30 cm and 60 cm depth.
- Soil P levels at four of the five long-term sites was adequate for continued cotton production without P deficiency, but over the years of the trials showed a declining trend towards lower levels at all depths to 60 cm.
- At the other long-term site, initial soil P indicated possible P deficiency for cotton, so fertiliser P was used during the trial, which had increased soil P by the conclusion of that trial.
- Crop rotation treatments at the P-deficient site appeared to affect final soil P levels, with legume-rotations showing the highest soil P increase.

Extending the outcomes

The project is providing a number of opportunities for the industry to connect with the ongoing findings outcomes. These include:

- Presentations at cotton industry and scientific conferences, including the *Australian Association of Cotton Scientist Conference*.
- Presentations at cotton industry grower workshops such as the *2018 CottonInfo Optimising Irrigation and Nitrogen Researchers Tour*.
- Field days/farm walks at the trial sites.
- Support of two PhD positions through the University of Queensland and the University of Melbourne.
- Regular article contributions to the Spotlight on Cotton R&D magazine and CottonInfo e-newsletter.
- Updating of CottonINFO resource materials for growers.
- Scientific journal articles will focus on the key research questions in years 3-4.



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www.crdc.com.au/more-profit-nitrogen

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