Australian Government
Cotton Research and Development Corporation

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Part 1 - Summary Details

CRDC Project Number: RRDP1713

Project Title: More Profit from Nitrogen: Optimising Nitrogen and Water Interactions in Cotton

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CRDC Research Program: 1 Farmers

Final Report Executive Summary

Organic matter in soil can supply more than 50% of the nitrogen (N) to cotton crops, but this pool of N supply is dynamic and difficult to predict. Soil bacteria are responsible for mineralising soil organic N and hydrolysing dissolved urea to ammonium. Most plants can take up both ammonium and nitrate forms. However, nitrate is susceptible to leaching and can be denitrified into inert and greenhouse gases. Filterable organic N (dissolved organic nitrogen, DON) is the most readily available form for microbial mineralisation and can also leach. The type and timing of N fertiliser and irrigation may regulate N supply and loss, as the severity of soil drying between irrigation events regulates microbial activity. The 'Optimising nitrogen and water interactions in cotton' project investigated how ammonium, nitrate and organic N in soil is affected by urea and DMPP-treated urea fertilisers during wetting and drying cycles of irrigated cotton. DMPP urea is an enhanced efficiency fertiliser that slows the conversion of ammonium to nitrate in soils.

The main objectives of this research were to: (1) investigate how N fertiliser formulations; namely: urea and DMPP-treated urea, and wet/dry cycles affect within-season patterns of soil N supply, (2) identify how well a rapid soil test based on water extraction and measurement of dissolved organic N or potassium chloride-extractable inorganic N species can inform predictions of soil mineralisable N, and (3) suggest how currently available nutrient management DSSs can be improved by improved knowledge of within-season patterns of soil N supply.

The research was conducted in soils established to overhead irrigated cotton on commercial farms over the 2016/17 and 2017/18 seasons in the Darling Downs of south-east Queensland. Soil was sampled after key irrigation or rainfall events, and at critical cotton growth stages. Soil was sampled from outside and inside root exclusion tubes that were placed in the soil to a depth of 300 mm at the beginning of each season,

to monitor the plant-available pools of soil and fertiliser N in the presence and absence of roots, respectively. Novel, low-cost, rapid methods were used to measure nitrate, ammonium and total dissolved N (mineral N and DON). The results were compared with conventional N testing methods for their ability to predict crop N availability.

The main findings about patterns of within-season soil and fertiliser N supply from the field studies were:

- Background soil N mineralisation rates were low and uniform throughout the cotton season,
- Cotton roots actively take up inorganic N well before flowering (<30 days post-emergence),
- DMPP-treated urea inhibits the conversion of hydrolysed urea to ammonium (NH_4^+), as well as inhibiting nitrification,
- N-priming' (the increase in plant-available N in excess of N supplied by fertiliser application and background mineralisation), recorded in urea-fertilised plots within 60 days after fertiliser application was due to the displacement of soil organic matter (SOM), including dissolved organic N (DON), from organo-mineral complexes in the soil by NH_4^+ derived from the urea fertiliser,
- Ammonium derived from urea fertiliser 'fixed' to organo-mineral complexes (the difference between soil 2M KCl-extractable NH_4^+-N and water-extractable 2M KCl NH_4^+-N) only became available for plant uptake in the 2016/17 season 115 days after fertiliser application, and
- A rapid water extraction soil test for total dissolved N is a much more sensitive indicator of N supply than conventional soil inorganic N methods within the first 60 days after fertiliser application.

The main findings from the fertiliser leaching trial conducted from May 2018 to July 2018 were:

- The displacement of SOM from organo-mineral complexes in the soil by ammonium derived from urea fertiliser requires high soil temperatures for the urease enzyme to rapidly hydrolyse urea to produce high concentrations of ammonium. Below 20°C, the rate of hydrolysis is too slow for any significant SOM displacement to occur, and
- High concentrations of nitrate derived from the fertiliser calcium nitrate are not associated with any increase in dissolved organic matter (DOM) in soil leachate.

Key findings from this study, which may improve nutrient management DSSs are:

- The use of DMPP-coated urea slows the rate of release of ammonium and nitrate substantially within 60 days after fertiliser application, and may compromise early root development,
- DMPP-coated urea could be used as a strategy to reduce nitrate loss by growers applying fertiliser to soils above a temperature of 20°C,
- An N-priming effect associated with the banded application of ammonia-based fertiliser may contribute substantial amounts of previously 'chemically/microbially protected' N to the soil mineral N supply,
- The N-priming effect is of significance only when ammonia-based fertiliser is banded into soil at temperatures of above 20°C, and
- Overhead irrigation may provide a more uniform release of mineralised N from soil organic matter over the growing season by avoiding more intense wet/dry cycles associated with flood irrigation.

This research provides growers with information on how the supply of soil and fertiliser N can be better synchronised with crop demand. Better synchronisation of supply and demand will reduce fertiliser use, improve N use efficiency and help sustain productive and environmentally resilient cropping systems.