More Profit from Nitrogen

Optimising nutrient management for improved productivity and fruit quality in mangoes

Mango Grower Project Update- November 2017

Led by the Northern Territory Government Department of Primary Industry and Resources (NT DPIR), in partnership with Queensland University of Technology (QUT), this five year project is one of ten national research projects collaborating under the umbrella of the *More Profit from Nitrogen Program* across the horticulture, cotton, dairy and sugar industries to seek improved nitrogen use efficiency (NUE).

The mango industry research is using an integrated approach to quantify plant nitrogen (N) demand and cycling through the soil-plant-atmosphere system of crops. The outcome for mango growers will be the development of scientifically supported NUE management strategies to increase the quantity and quality of mango yields, whilst effectively mitigating costly loss of N to the environment, improving overall productivity, profitability and providing good environmental management.

Whilst N is essential for mango tree development, fruit production and quality, prior to the commencement of this research, only limited data was available for Australian mango growing regions on the relative importance of soil N processes, total N loss from current management practices and profitable use of N in the plant.

The research is using a stable isotope of N, called ^{15}N, to quantify a plant's demand for N and the amount of N supplied by the soil. It is also looking into current practice to develop best management practices for optimising N fertiliser use, including the potential of enhanced efficiency fertilisers (EEF).

What is the research investigating?

The key questions being answered, using primarily field based research, are:

- What is the dynamic of N concentrations in the different parts of the tree crop plant-soil-atmosphere system across multiple seasons? Where does the applied N go, how can we reduce losses and use N to drive profitable outcomes for mango growers?
- What is the measured utilisation, availability and timing of N released from crop residues and soil organic matter mineralisation? What is the contribution of N mineralisation to the total N demands of mangoes?
- How does this impact overall mango nutrition? How does this differ between the regions and soils?
- What technologies can growers use to access better information regarding N dynamics and seasonal availability to inform their decisions for a better economic outcome?
- What is the cost effectiveness of EEFs for NT mango soils under a range of temperature and moisture conditions?

Figure 1 *Project team begins the soil sampling (L to R), QUT PhD student Raj Pandeya, with Project Scientist Dr Joanne Tilbrook (standing) and Senior Nutrition Scientist Dr Tony Asis (NT DPIR)*

What has been achieved in the first phase?

Project activities are underway, located in field sites at the NTDPIR's Coastal Plains Research Station (Darwin), Katherine Research Station (KRS) and nine participating commercial orchards across the Darwin and Katherine growing regions.

Almost 12 months since commencing, a highly skilled team has been recruited, field sampling has commenced and importantly there has been active engagement with growers to seek input and feedback. To date the team has worked with our generous participating mango growers to:

- ✓ Undertake sampling of mango soils that have then been analysed and used for laboratory based incubation experiments, including the performance of different EEFs;
- ✓ Complete and test initial methods to quantify whole tree biomass harvests and undertake a laboratory based grinding method of preparing mango plant tissue to the necessary particle sizes for analysis;

- ✓ Harvest twelve 1.5 year old ^{15}N isotope labelled mango trees to measure the above and below-ground biomass. This allowed the team to quantify the amount of N coming from both fertiliser and soil sources and therefore estimate the NUE of mango;
- ✓ Develop a method to introduce labelled N into mango xylem, the water transport system of trees. Commercially available tree injectors (active) were compared with solution filled syringes (passive) with the latter being most successful. The N labelling of mango tree tissues will provide information about N use and transport within trees and the surrounding soil.
- ✓ Collaborate with the University of New England (UNE) & Central Queensland University (CQU) in using remote sensing technologies to correlate paddock scale variability and production in Darwin mango orchards. The preliminary yield maps of 5 blocks (2 mango varieties) have been developed and are now being "ground-truthed" by participant growers. The project recently completed the sampling by picking, washing, scanning and weighing 11864 mangoes, or over 5,054 kg! Excitingly, remote sensing may be a real precision tool for mango growers in the not too distant future.
- ✓ Start of study to understand plant available N forms (nitrate and ammonium) in the feeder root zone of soil in mango orchards. Measurements were used to compare the availability of these forms of N in different locations within orchards; under the tree canopy and the canopy dripline, and in the interrow. This trial was commenced by Charles Sturt University Master's Student Maddison Clonan, and will be continued by the project team.

Figure 2 *NT DPIR Senior Technician Alan Niscioli removes soil from mango tree roots following whole tree extraction of 1.5 year old trees in labelled ^{15}N trial, Coastal Plains Research Station, Darwin.*

Figure 3 *QUT PhD student Raj Pandeya with soil tubes (for incubation) and soil pits (for characterisation) under mango trees, Coastal Plains Research Station, Darwin.*

Figure 4 *The Mango research team- More Profit from Nitrogen Project*

The team…

Dr Mila Bristow (NT DPIR)
Principal Research Scientist

Project role: Project Leader

Mila is the research leader of sustainable resource management within plant production systems for the Northern Territory Government. She has more than 20 years' experience working with industry to find solutions to widespread industry issues of best-practice, plant nutrition and suitable new varieties and products in northern Australian. Mila enjoys learning from her team and the mango producers participating in this project.

Dr Tony Asis (NT DPIR)
Senior Research Scientist

Project role: Senior Plant Nutrition Scientist

Tony has strong background on research in soil and plant nutrition, biomass recycling, use of stable isotopes in agriculture and greenhouse gas emission and inventory. In this project, he is responsible for managing the field trials and agronomic activities, co-developing 15N labelling and sampling methodologies for mango tree N recovery and conducting experiment on mango N management.

Dr Joanne Tilbrook (NT DPIR)
Project Scientist

Jo is a plant physiologist with a background in water transport in grape vines and improving salinity tolerance in cereals. For Jo, characterising nitrogen use in mango is new and interesting work.

Dr David Rowlings (QUT)
Senior Research Fellow

Project Role: Principal Soil Research Scientist

Dave is a soil scientist with extensive experience in conducting NUE and N cycling experiments from a range of tropical and subtropical agricultural systems, including tree crops, broad acre crops and pastures. In this project Dave leads the soil science questions and methodologies to understand N movement through soil pathways.

Raj Pandeya (QUT)
PhD Student

Project Role: PhD Student- Soil Nitrogen Interaction

Raj is based in Brisbane at QUT and has been undertaking periodic trips to the NT. Over the coming summer he will be staying in station accommodation at KRS as he undertakes his research.

Alan Niscioli (NT DPIR)
Senior Technician

Alan is the Senior Technician in the NT DPIR production horticulture team in Darwin where he leads the technical support for several mango projects. He combines his field, laboratory and analytical experience with excellent communications with our partners. Even when the mango season temperatures rise: Alan keeps going.

Dallas Anson (NT DPIR)
Technician

Dallas is the newest NT DPIR team member and is a new recruit to both NT and mango research. She brings many years of experience from horticulture and natural resource management. She is an eager learner and assists in all project activities.

How have we communicated the research progress and findings?

To extend the work of the research, a number of significant activities have been undertaken to date. Dr Mila Bristow met with growers and presented to the mango industry at the AMIA 11th Annual Mango Conference held at Bowen in May. The team also successfully submitted two papers to the XII International Mango Symposium held in Baise City, Guangxi, China in July. Dr Mila Bristow and Dr Tony Asis represented the team and presented to a large international audience. Tree Crops, Mango Matters and The Slice have all had articles published for growers on the project. Darwin and Katherine growers will have seen the NT DPIR team on their farms, at the mango pre-harvest meetings and at NT Farmers Association events.

Figure 5 *Mila Bristow presented NUE research at the XII International Mango Symposium held in Baise City, Guangxi, China*

Figure 6 *Red, light sandy clay mango soils, Katherine region.*

Figure 7 *QUT PhD student Raj Pandeya sieves a 'mango' soil from the Darwin Region*

What are the next activities of the research?

The xylem infusion trial

Dr Tony Asis and Dr Joanne Tilbrook (NT DPIR)

Understanding the turnover of nitrogen N from mango litter decomposition into the soil requires isotopically enriched (^{15}N) leaf litter. This is usually achieved through soil or foliar application of fertilisers, but for trees such as mango, the process is slow and a significant amount of expensive labelled N fertiliser is lost to the environment. A rapid labelling method to obtain direct and quantitative information on leaf uptake of nitrogen derived from fertiliser (Ndff) within a limited time is being developed.

In this study the team is testing a xylem infusion technique to rapidly create ^{15}N labelled mango litter. While there are risks to the tree; N toxicity, phloem death or infections, the risk mitigations in the methods are successful so far. Total leaf N of a tree is estimated and a calculated amount of labelled fertiliser in solution is infused into branch xylem over several hours. A week later the leaves are collected for processing and analysis. The pending data will indicate what quantity of labelled fertiliser is needed to generate litter with sufficient ^{15}N enrichment to follow soil N mineralisation and gas emissions as it decomposes.

Figure 8 *The leaves on this Kensington Pride mango at KRS are being labelled via infusions of ^{15}N fertiliser in solution into branch xylem tissue. After drying, the labelled leaf litter will be placed on soil under mango trees to decompose while soil N gas emissions and mineralisation are quantified.*

Figure 9 *QUT PhD student Raj Pandeya collecting leaf litter samples for analysis and installing a soil frame for the soil respiration experiments.*

Effects of tree pruning on N availability

Dr David Rowlings and Raj Pandeya (QUT)

QUT's David Rowlings and PhD student, Raj Pandeya, have recently set-up experiments for a PhD study at KRS for the upcoming wet season. Raj's experiments will use ^{15}N labelled mango leaves (produced as part of the xylem infusion trial) to trace the rate and

timing of decomposition and N recycling following tree pruning. The project's research findings to date suggest this may be one of the most important inputs of N in mango systems. Measurements include soil and litter respiration, soil mineralisation, deep soil water movement and leachate collection and ^{15}N recoveries in soil, litter and leachate.

Plant available nitrate and ammonium in the mango root zone

Dr Mila Bristow and Maddison Clonan (CSU Masters Student)

CSU's Maddison Clonan joined the NT DPIR project team to complete her 6-month research project as part of her Masters of Sustainable Agriculture. Maddie's project asked where is the spatial and temporal variation in soil nitrogen availability to plants in mango orchards of the Darwin region. She compared the availability of nitrate-N and ammonium-N in different locations within orchards. These locations (called microsites) were chosen by their different soil water availabilities; Under Canopy, under the canopy Drip Line and in the Inter Rows. In her 6 months, Maddie found:

- A decline in ammonium and nitrate availability across all microsites and major sites between the first and second measurement event (transition from wet into dry season). There was no significant difference between microsites.
- Overall, ammonium availability was higher than nitrate.

This study will be continued by the DPIR team to determine the seasonal patterns of soil available N under mangoes.

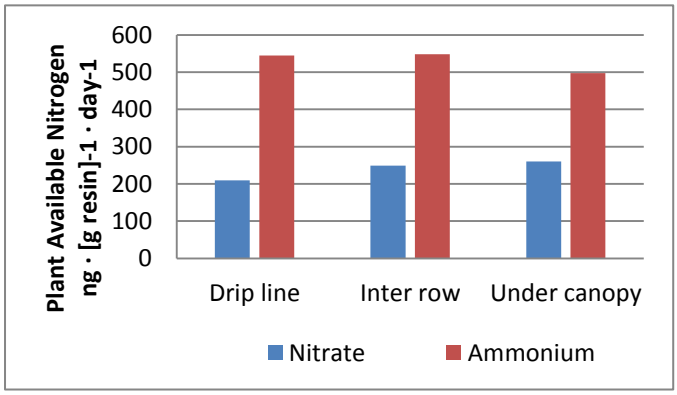

Figure 10 *Comparison of mean nitrate (NO3-N) and ammonium (NH4-N) between microsites from April to July 2017.*

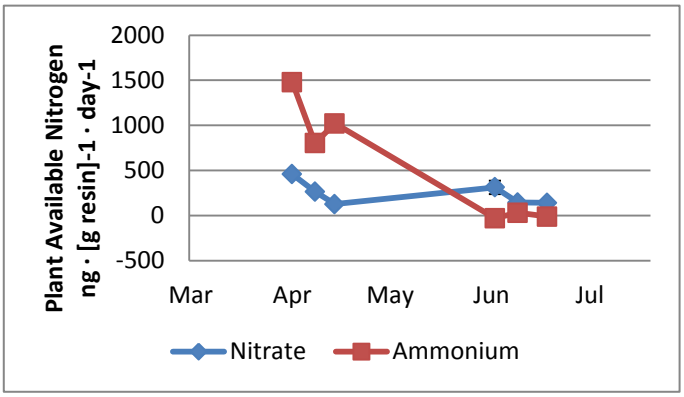

Figure 11 *Average ammonium and nitrate measurements from all sites in the Greater Darwin Region from April to July 2017.*

Ground-truthing the remote sensing production predictions: year 2

Dr Mila Bristow

This project, managed by Horticulture Innovation, in collaboration with UNE and CQU, has entered the final year of investigating the potential to map and measure mango orchard production variability using remote sensing technologies.

The NT DPIR team hand pick and measure each fruit, and collect a range of leaf, tree and soil measurements, to ground truth the yield information sensed from satellite imagery supplied by UNE. The sites are on commercial farms in the Darwin region. Results from this activity will be shared with producers and the mango industry in early 2018.

Figure 12 *Dr Mila Bristow (NT DPIR), Acacia Hills Mango Farm manager Martina Matzner and CQU's Nick Anderson with the NIR meter used to measure fruit maturity.*

For all grower inquiries on the project, contact:

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This project is supported through funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit program, the Northern Territory Government Department of Primary Industry and Resources, Queensland University of Technology's Institute for Future Environments and Hort Innovation Limited. In-kind support is also provided by the Australian Mango Industry Association Inc.

Australian Government
Department of Agriculture and Water Resources
Hort Innovation
NORTHERN TERRITORY GOVERNMENT
QUT Queensland University of Technology
AUSTRALIAN MANGOES