GRDC EEF project early learnings

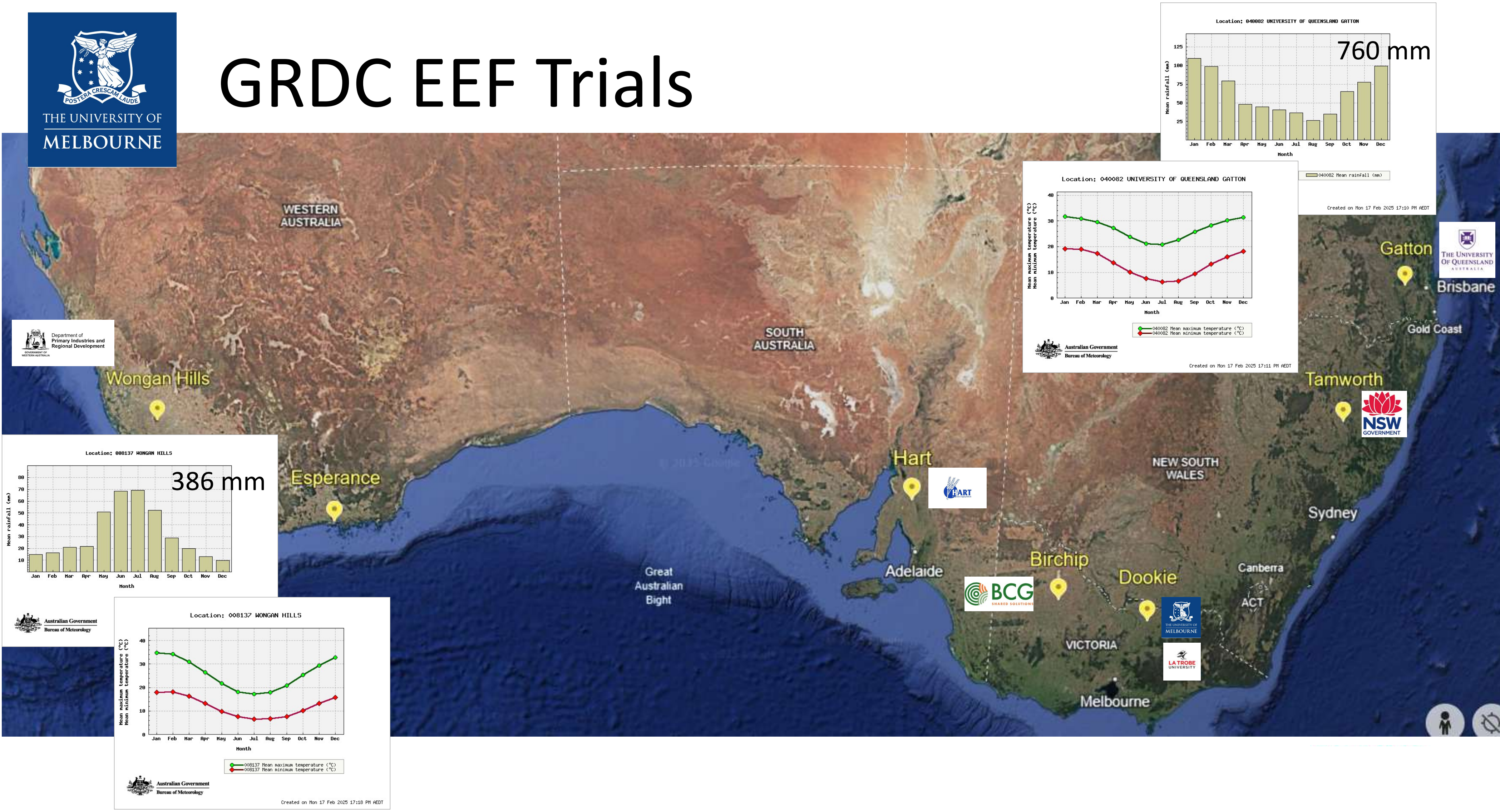
Prof Helen Suter, Dr Arjun Pandey, Prof Mike Bell and Dr Weijin Wang

Enhanced efficiency nitrogen fertilisers in the grains industry: an opportunity to reduce GHG emissions and increase NUE (2024-2028) (UOM2404-007RTX)

Project aims

- Understand the role of Enhanced Efficiency Fertiliser (EEF) technologies within the Australian grains industry to;
  - Maximise Nitrogen Use Efficiency (NUE)
  - Optimise crop production
  - Reduce environmental impacts (e.g., Greenhouse Gas Emissions (N_2O)) from N fertiliser use
  - Provide growers with knowledge to help with decision making for their conditions
  - Ensure growers are prepared for pressure from markets, consumers and government to reduce GHG and other environmental footprints

GRDC EEF Trials



GRDC EEF TRIALS

FIELD TRIALS

Agronomic N trials (2-3 years)

- EEFs compared with Urea
- Placement and timing

Fate of applied fertiliser N

- 2-3 years using ^{15}N labelled urea and EEFs
- Plant and soil

N_2O emissions

- 2 years (Dookie, Tamworth and Gatton)

Dookie Campus trial site

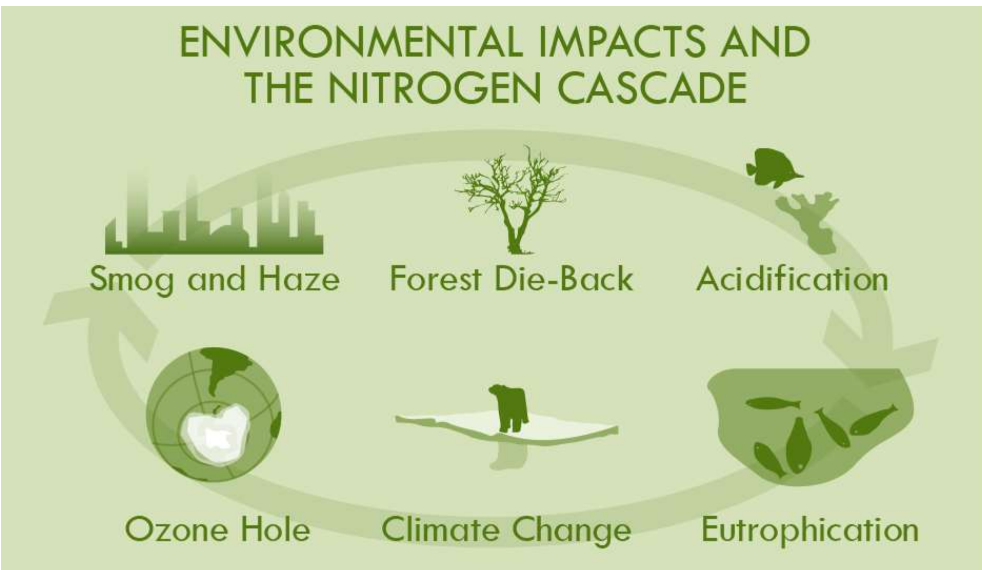
MECHANISTIC STUDIES

- Soil-fertiliser-climate interactions; $N_2O:N_2$ emissions

ECONOMIC MODELLING

EEF OUTCOMES MODELS AND PROJECTIONS

Environmental impacts from Nitrogen



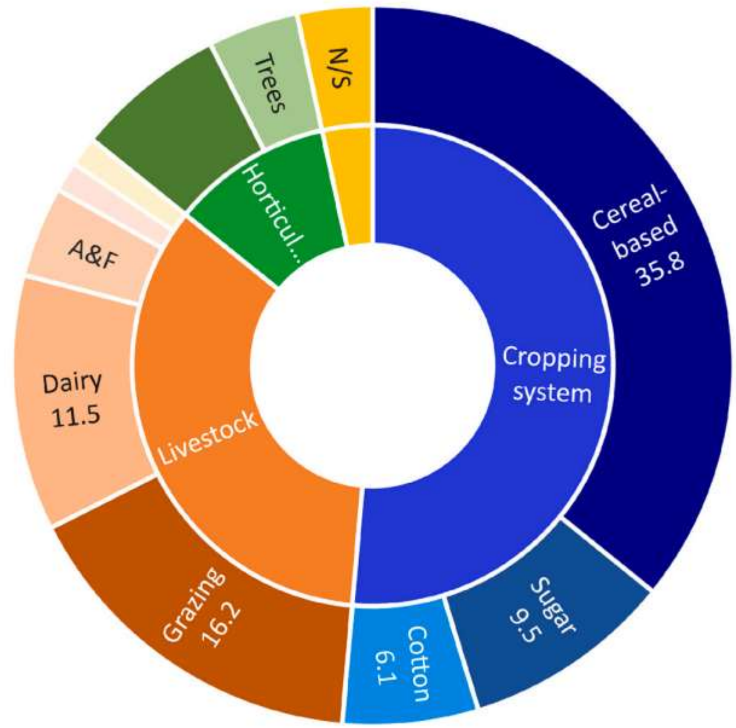


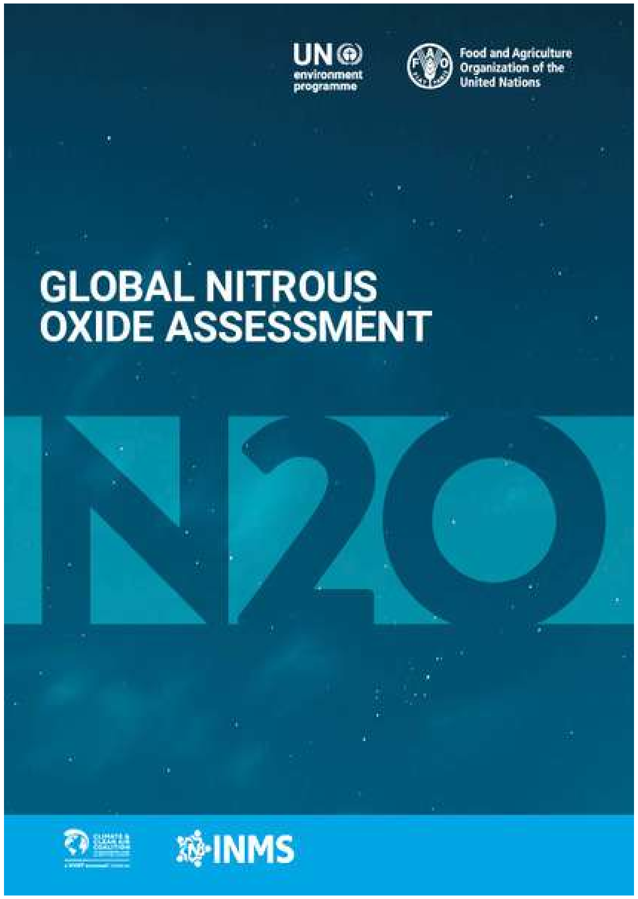
Fig. 1. Published N_2O emissions data by agricultural sector. 51.4 % of emissions are from the crop sector (blue), 34.5 % from livestock (orange), 10.8 % from horticulture (green), and 3.4 % do not have a specified source (yellow). A&F = abattoirs and feedlots; N/S = not stated.

N_2O impact

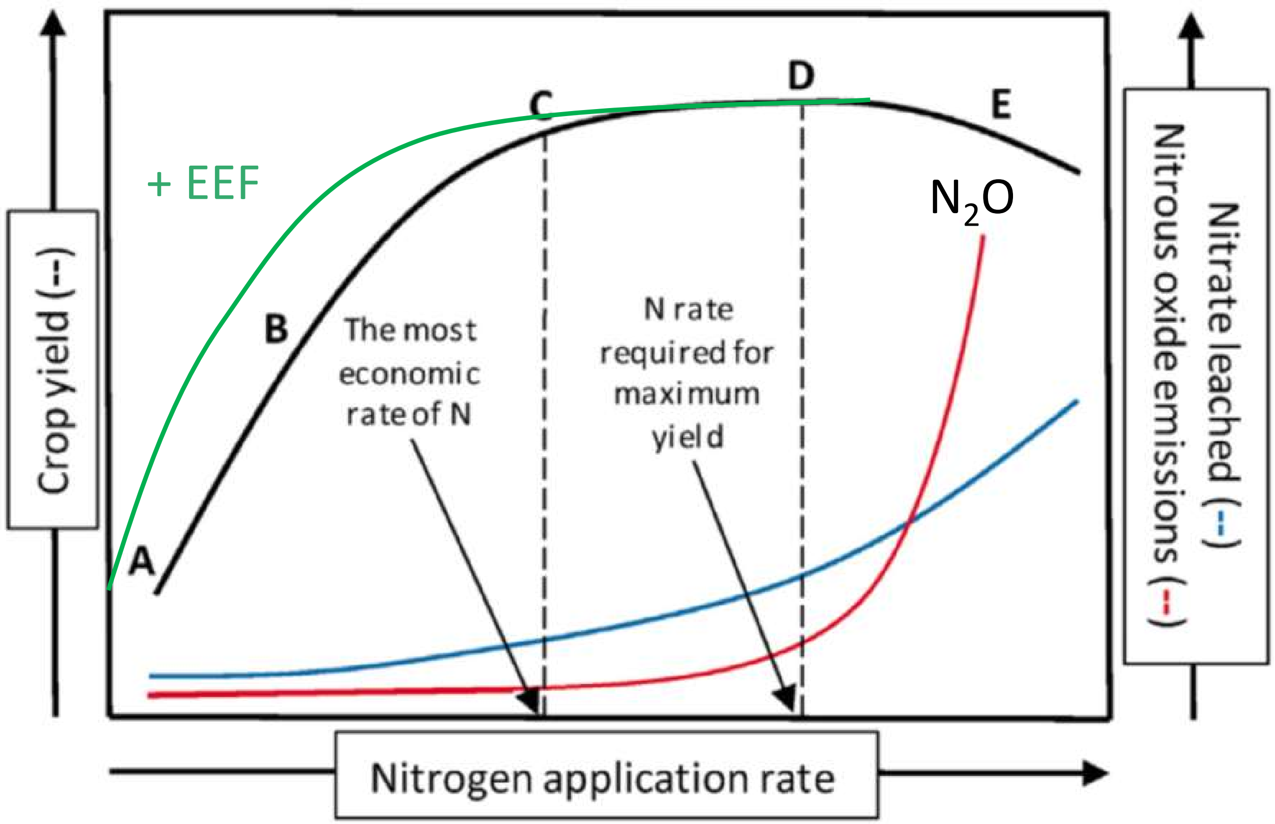
- "urgent action on N_2O is critical to achieving climate goals, and without a serious reduction in emissions, there is no viable path to limiting warming to 1.5°C in the context of sustainable development.."

- "currently the most significant ozone-layer depleting substance being emitted into the atmosphere."

- "A sustainable nitrogen management approach not only reduces nitrous oxide emissions but also prevents the release of other harmful nitrogen compounds,.."



Reduce N inputs



Modified from Antille and Murphy, 2021, Environmental and Sustainability indicators

2024 season experiment Dookie – Wheat

Five fertiliser products were tested

- Urea
- Nitrification inhibitor
- Urease inhibitor
- CRF-Polymer coated
- Dual inhibitor

Experiment 1 (N response)

➢ **4 × N rates % of optimum** (+ 0N and Y_{max})
- 25
- 50
- 75
- 100

Y_{max} = 150

Experiment 2 (Placement × Timing)

➢ **One N rate at 75% of the optimum**
- 2 × placement (surface and deep)
- 2 × timing (sowing and GS30)

Experiment 3 (^{15}N recovery)

➢ **One N rate at 75% of the optimum**
- ^{15}N (at 10 atom% ^{15}N enrichment)

2024 season experiment Dookie – Wheat

Measurements

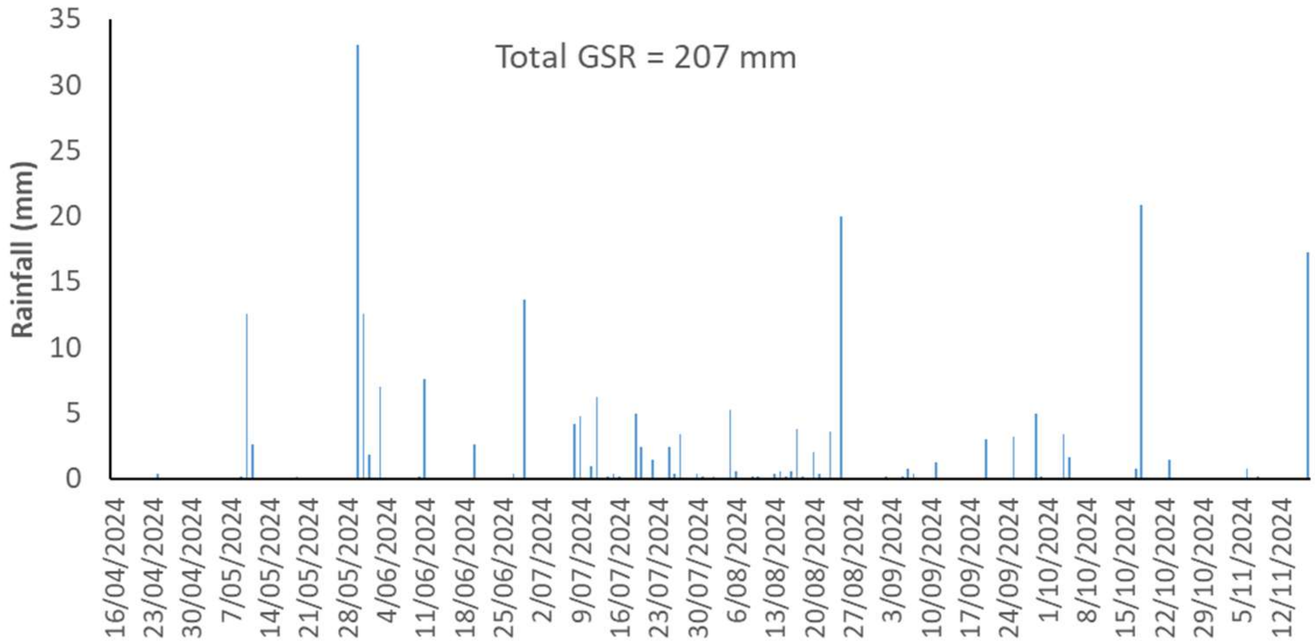
Response, yield and quality

- NDVI
- Maturity biomass cut
- Machine harvest
- Plant N and grain protein

Fate of fertiliser N

- In-season ^{15}N in mineral N
- End of season soil mineral N
- End of season ^{15}N in soil and plants

2024 Growing season Rain – Dookie



Median GSR for Dookie is 325mm

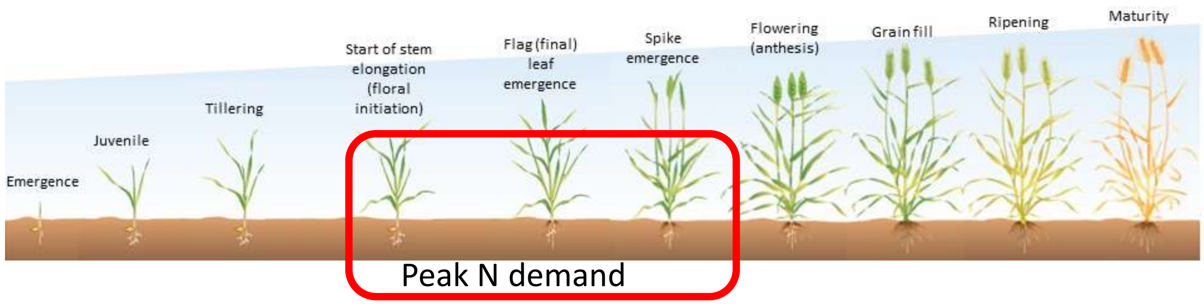
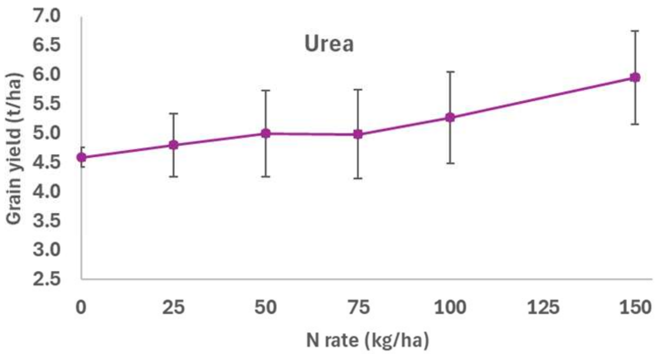


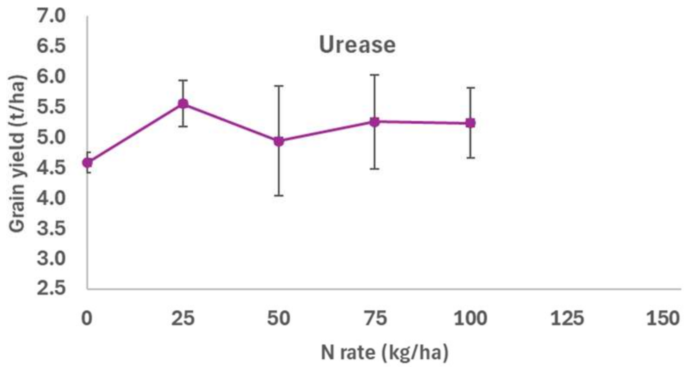
Figure: James Hunt

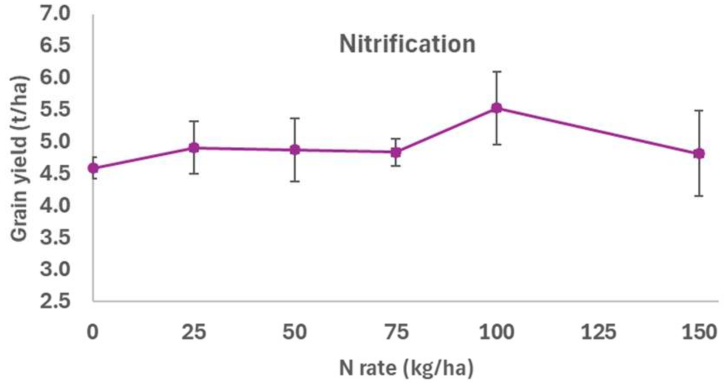
2024 season experiment Dookie – Wheat

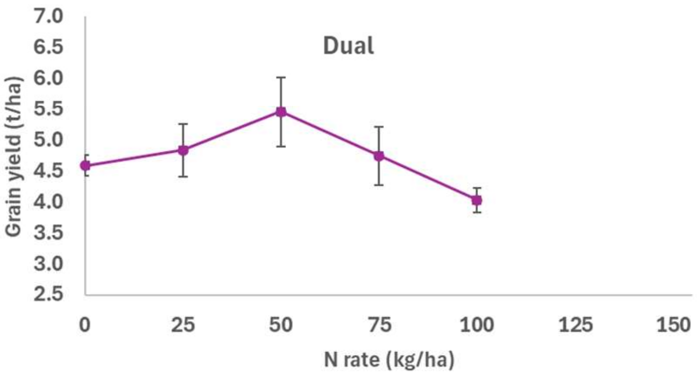
Measurements: Experiment 1 (N response)

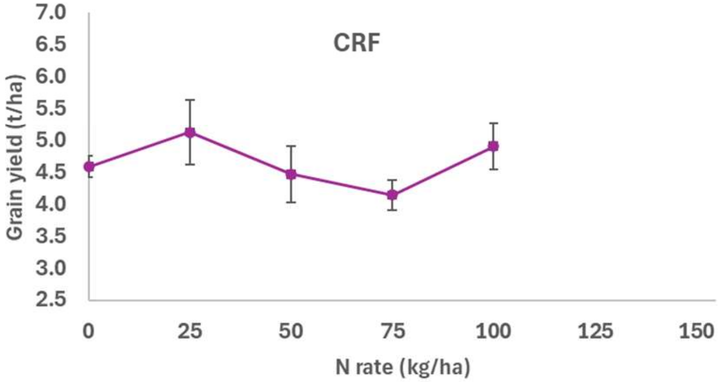
- Yield (t/ha)









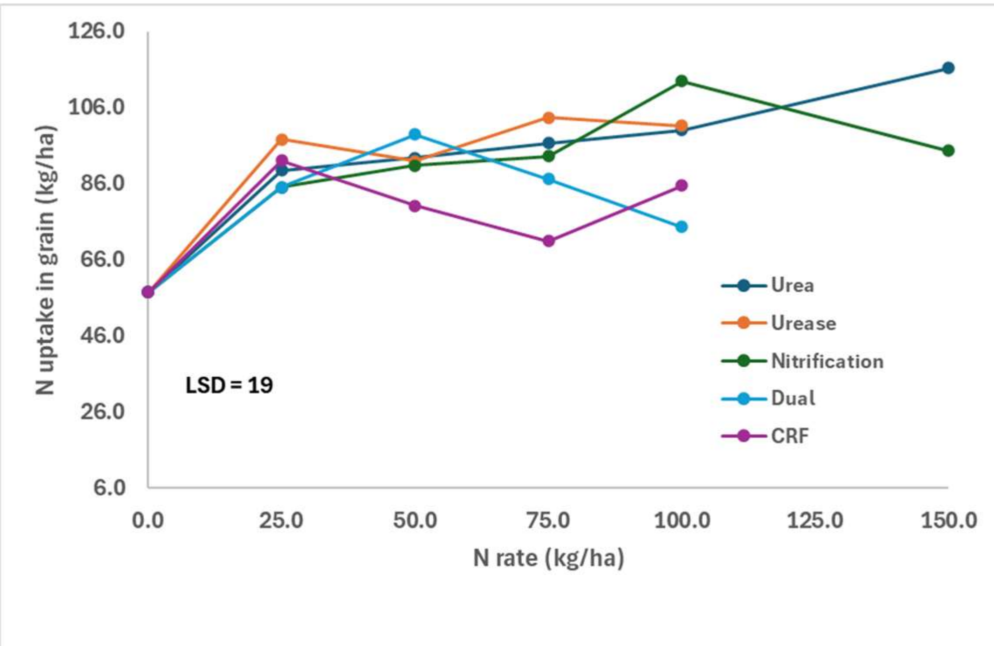


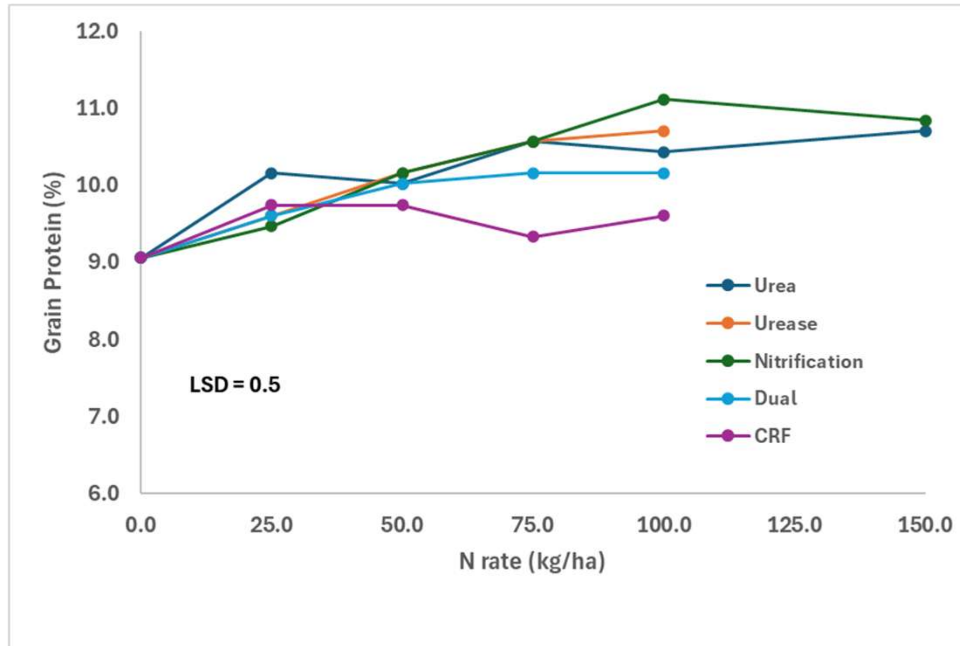
- No significant yield response to N rates (LSD = 0.7)

2024 season experiment Dookie – Wheat

Measurements: Experiment 1 (N response)

- N uptake in grains and grain protein %

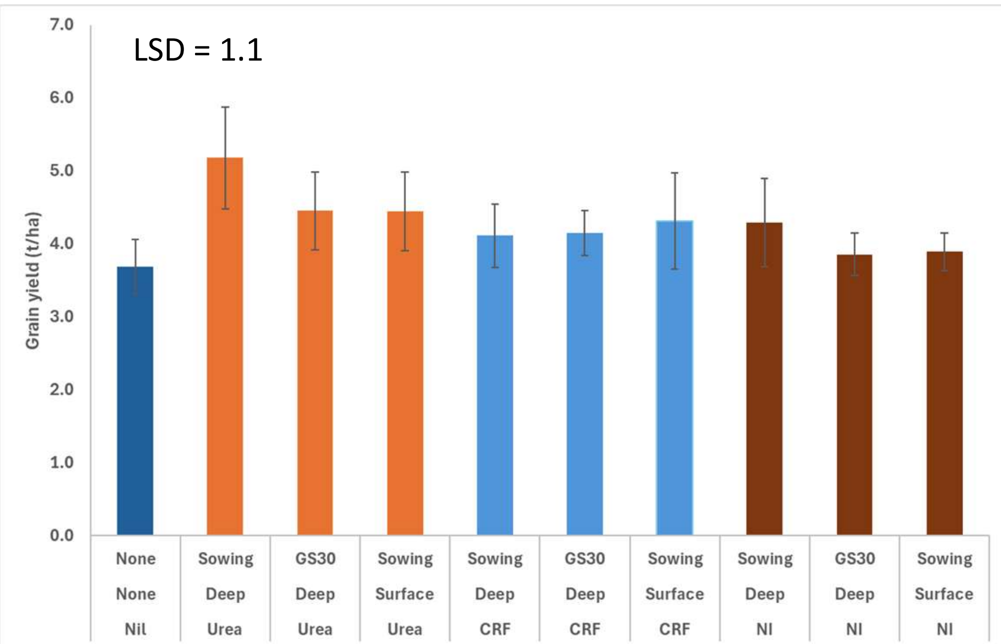


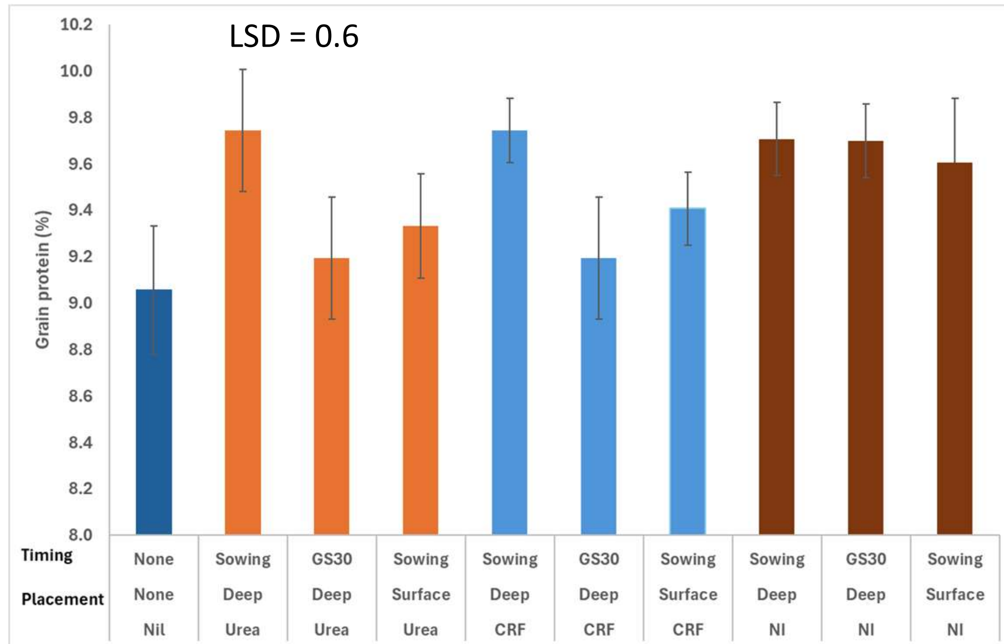


2024 season experiment Dookie – Wheat

Measurements: Experiment 2 (Placement × Timing)

- Yield (t/ha)
- Grain protein (%)





- No significant yield response to the placement and timing of N products (LSD = 0.7)

2024 season experiment Dookie – Wheat

Measurements: Experiment 3 (^{15}N recovery, N applied @75kg/ha))

- End of season ^{15}N in soil and plants

Product type	Proportion of fert-N in plant (Ndff%)	Recovery of fert-N in grain (%)	Recovery of fert-N in straw (%)	Total recovery of fert-N in plant (%)
Urea	20±4	22±5	1.1±0.4	23±4
Urease inhibitor	25±3	22±1	1.1±0.3	23±2
Nitrification inhibitor	22±3	19±1	1.4±0.3	20±2
Dual inhibitor	27±3	23±3	1.4±0.4	24±4

- Partial soil analysis for ^{15}N recovery is showing >70% total fertiliser N recovery in plant and soil (most likely >80% in EEFs)

Summary- 2024 season experiment Dookie

- No significant yield response to N input due to dry growing season
- No yield or grain quality advantage from any of the EEF types
- Placement or timing of EEF application did not provide yield advantage
- Compared to urea, significantly higher proportion of the total plant N came from EEFs

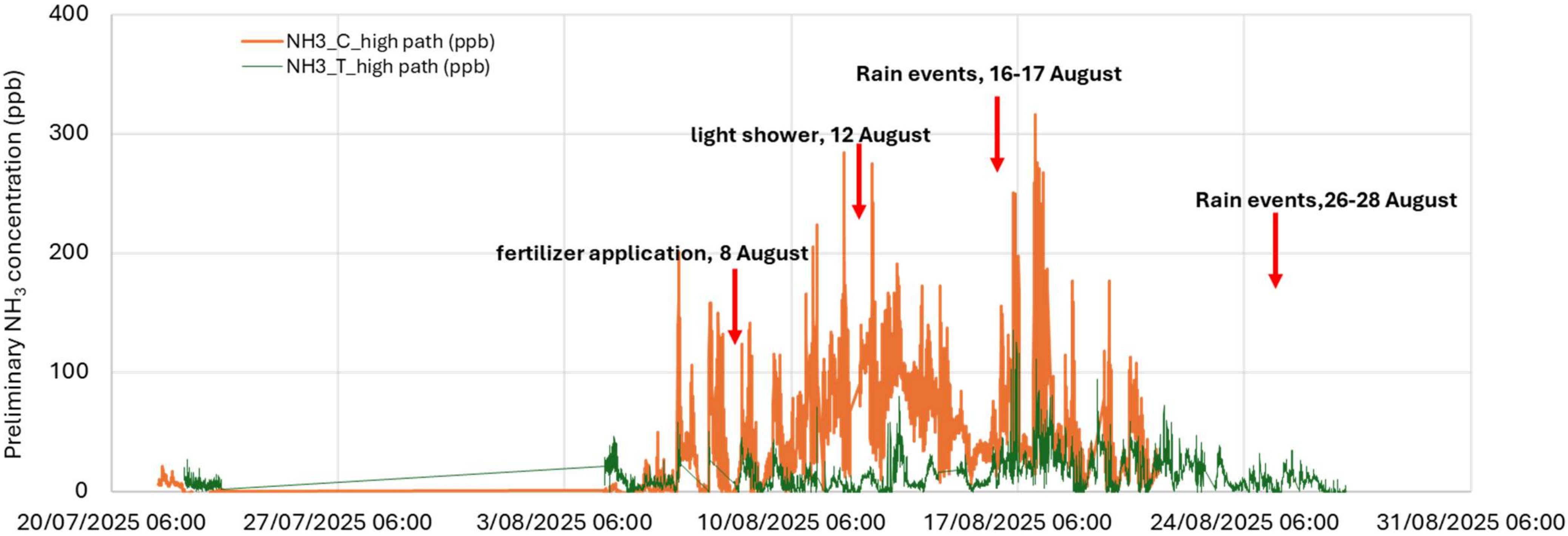
2025 season experiment Dookie – Wheat

Five fertiliser products were tested

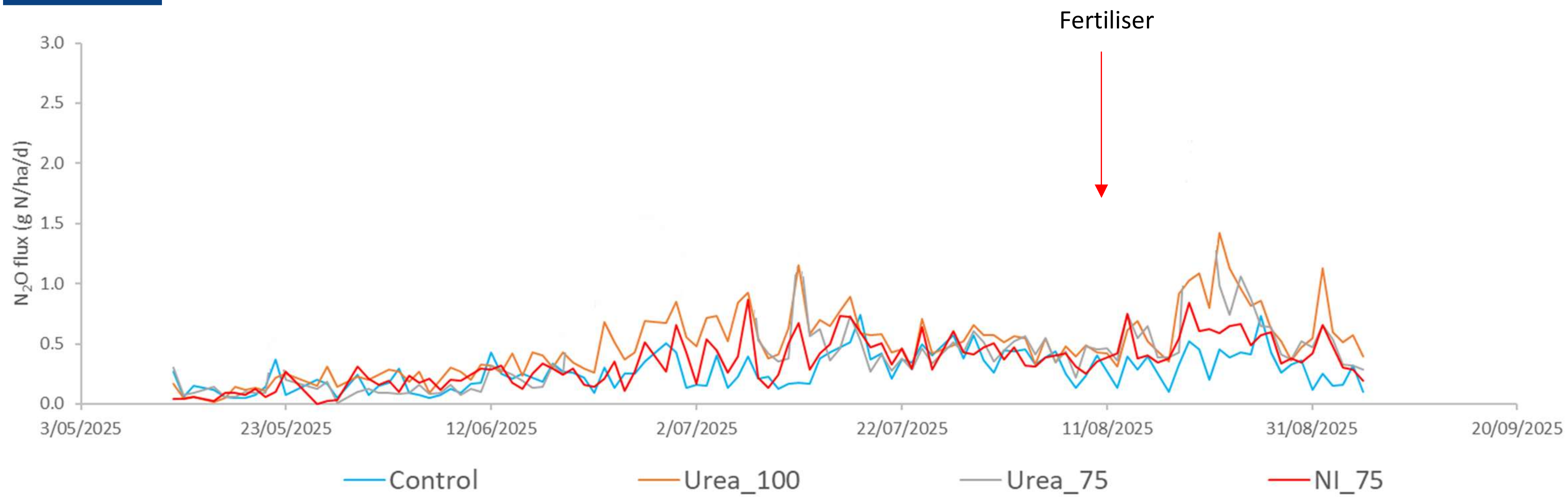
- Urea
- Nitrification inhibitor
- Urease inhibitor
- CRF-Polymer coated
- Dual inhibitor

➢ Experiment 1 (N response)
➢ Experiment 2 (Placement × Timing)
➢ Experiment 3 (^{15}N recovery)
➢ **N_2O emissions**
➢ **NH_3 volatilisation**

2025 season experiment Dookie – Wheat



2025 season experiment Dookie – Wheat



Thanks to Dr David Riches

Treatments at Gatton site - Summer Crop Sorghum

5 × fertiliser products

- Urea
- Nitrification inhibitor
- Urease inhibitor
- CRF-Polymer coated
- Dual inhibitor

2 × Application methods

- Surface broadcast
- Subsurface banded

4 × N rates (plus 0N and Y_{max})

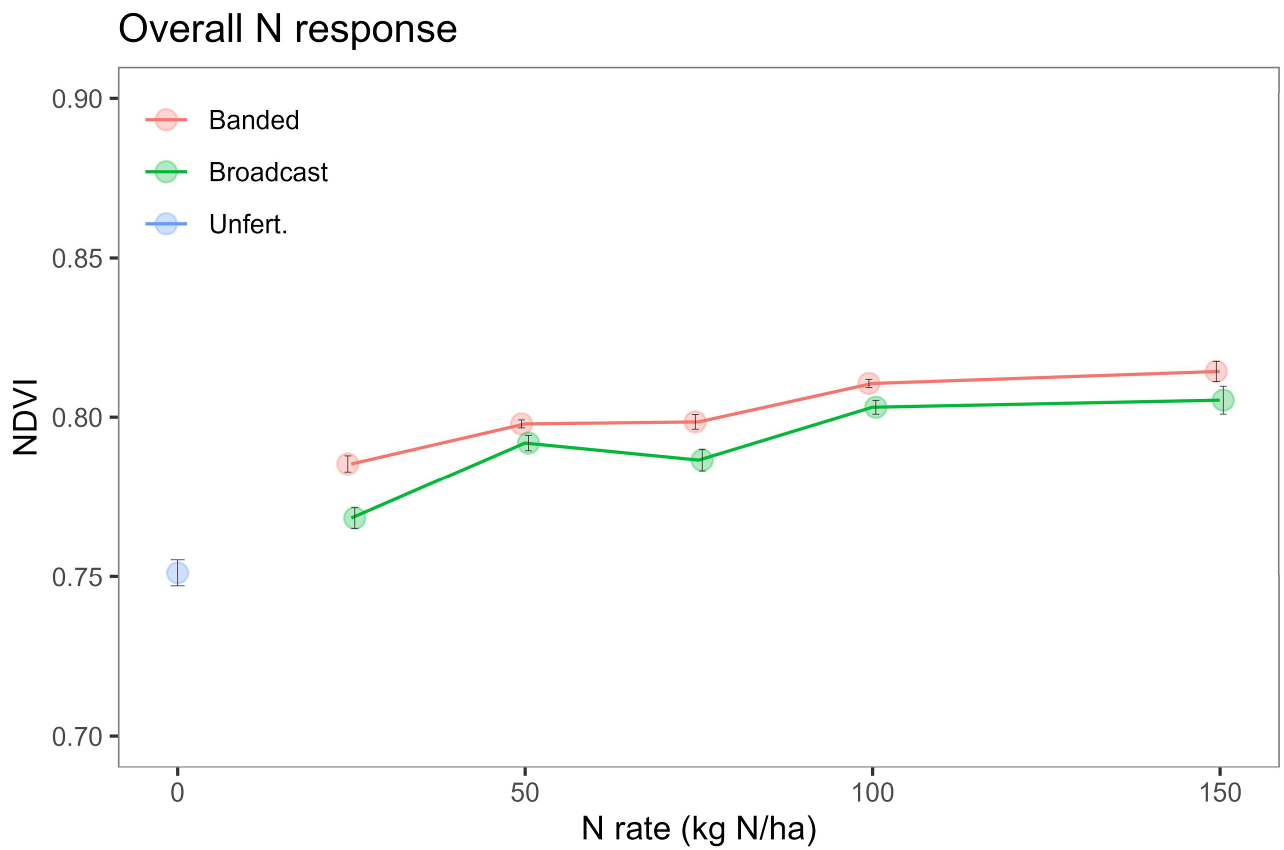
- 25
- 50
- 75
- 100

2 × N isotopes

- ^{14}N
- ^{15}N (at 10%)

Thanks to Prof Mike Bell, UQ

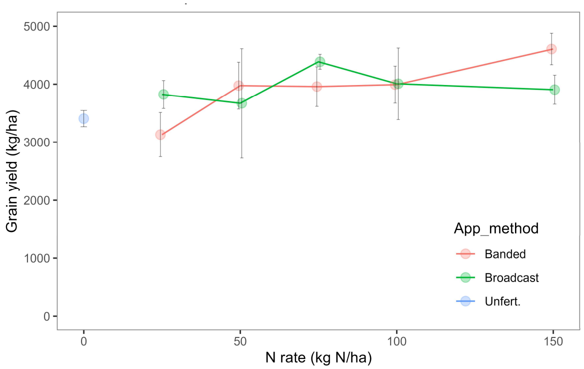
Canopy development retarded for N rates <50 kg N/ha, irrespective of product



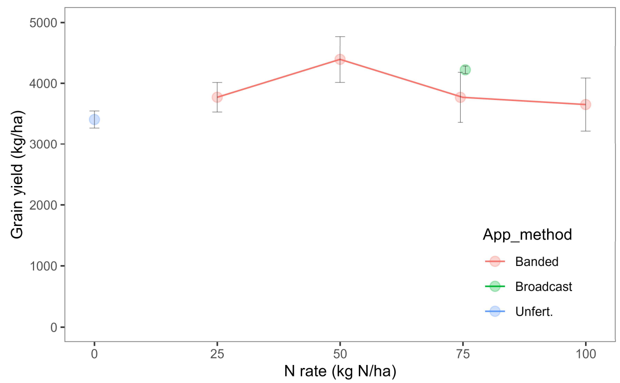
Drone imagery and data provided by:

Grain yield N rate responses for N urea and EEF products, either banded or broadcast

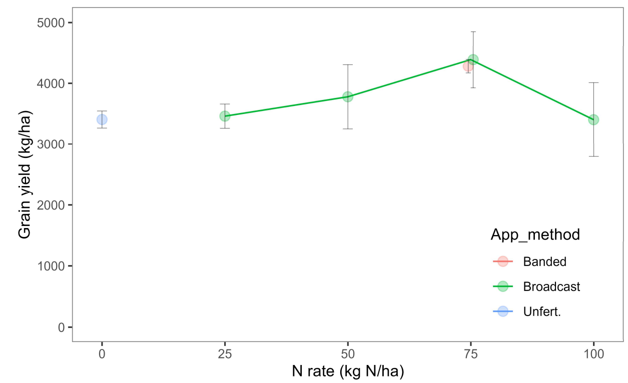
Urea



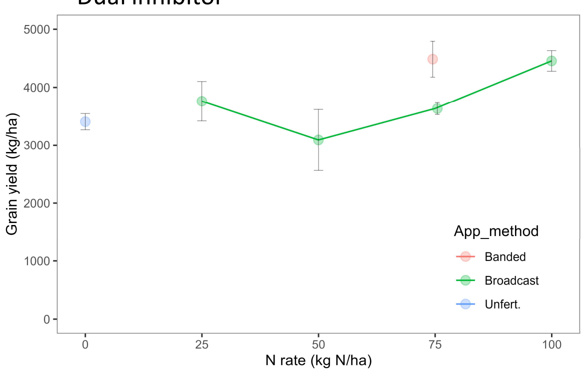
Nitrification inhibitor



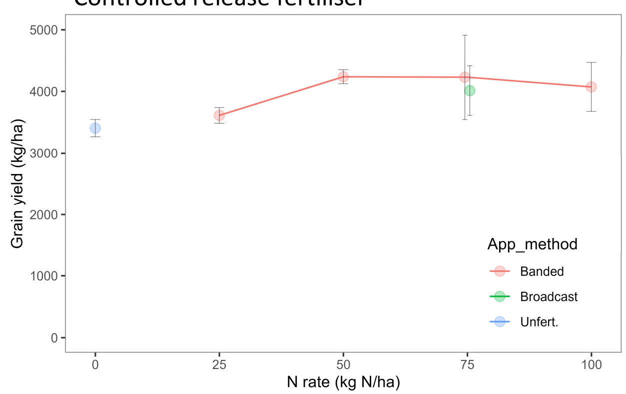
Urease inhibitor



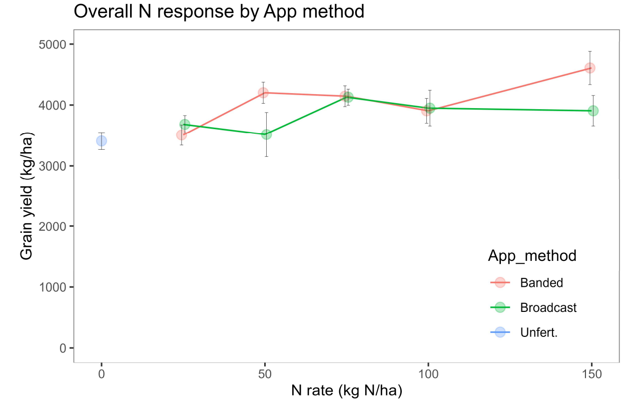
Dual inhibitor



Controlled release fertiliser

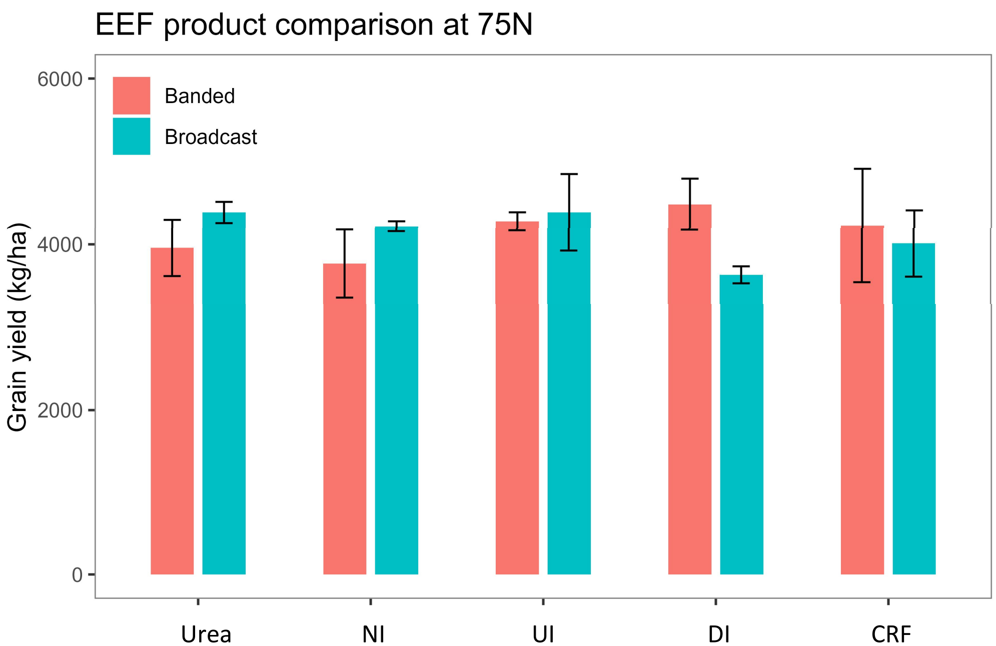


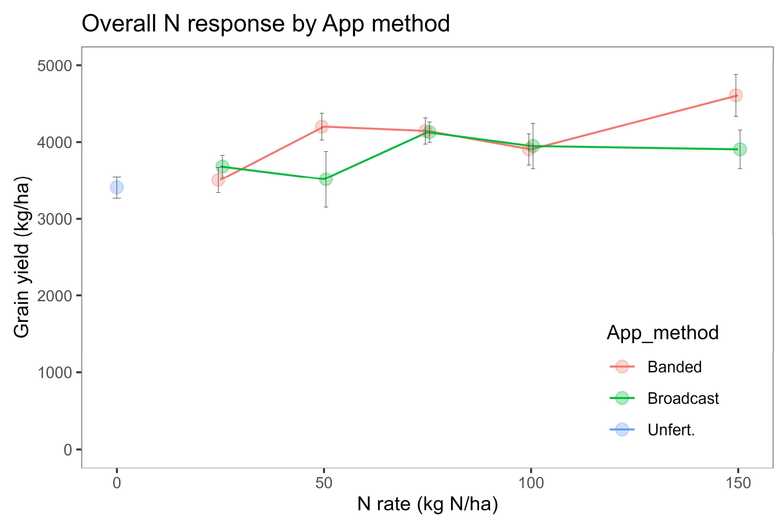
Overall N response by App method



- Sorghum yield in 2024/25 season was below average due to very wet, overcast growing season
- Yields generally low, but N responses maximised at N rates of 50-75 kg N/ha

Product comparison for grain yield





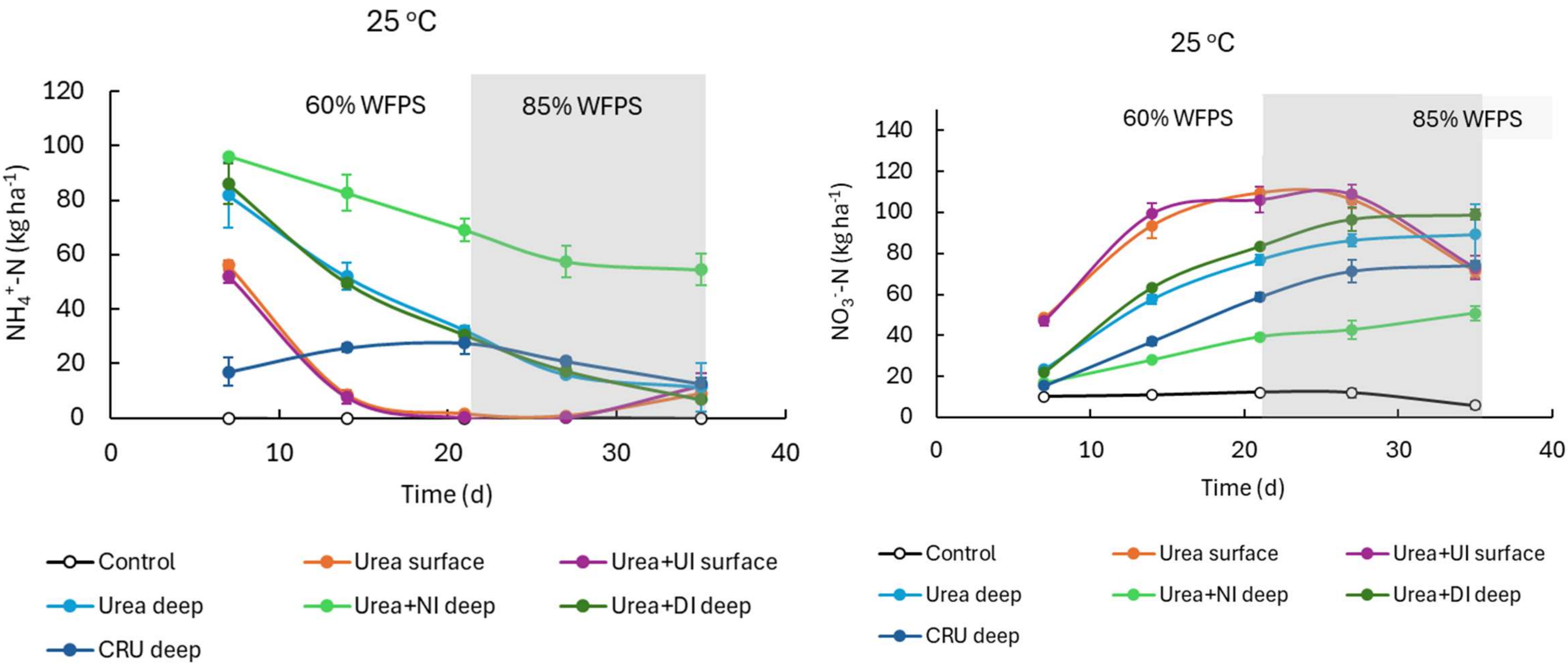
No significant effects of product or application method.
All yields low in very wet season

Summary - Gatton Experiment

- A disappointing season due to extremely wet conditions for >2 months
- N accumulation responded to N rate but not product and was generally low for summer sorghum (Waterlogging, low radiation?)
- No apparent differences between urea and EEF products, regardless of application strategy
- Crop N balance and residual fertiliser N in the soil at harvest from ^{15}N plots will be informative

Mechanistic study

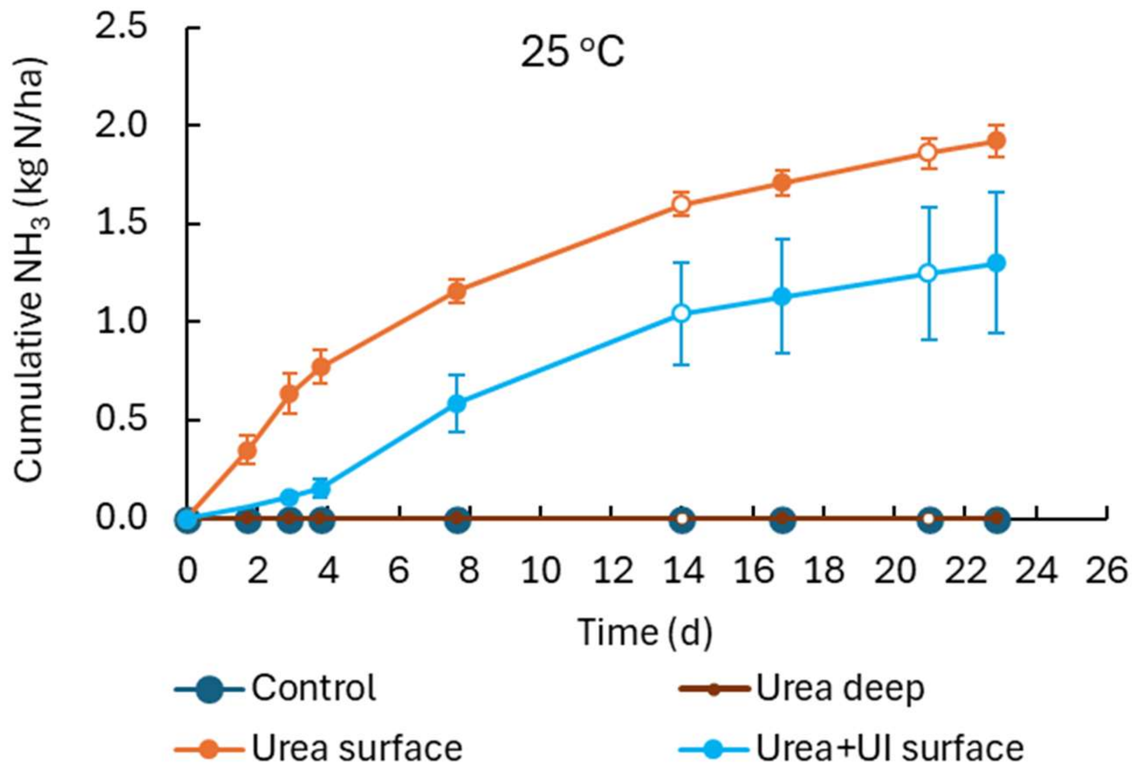
Thanks to Principal Scientist Dr. Weijin Wang



Deep placement was at 4.5-5 cm

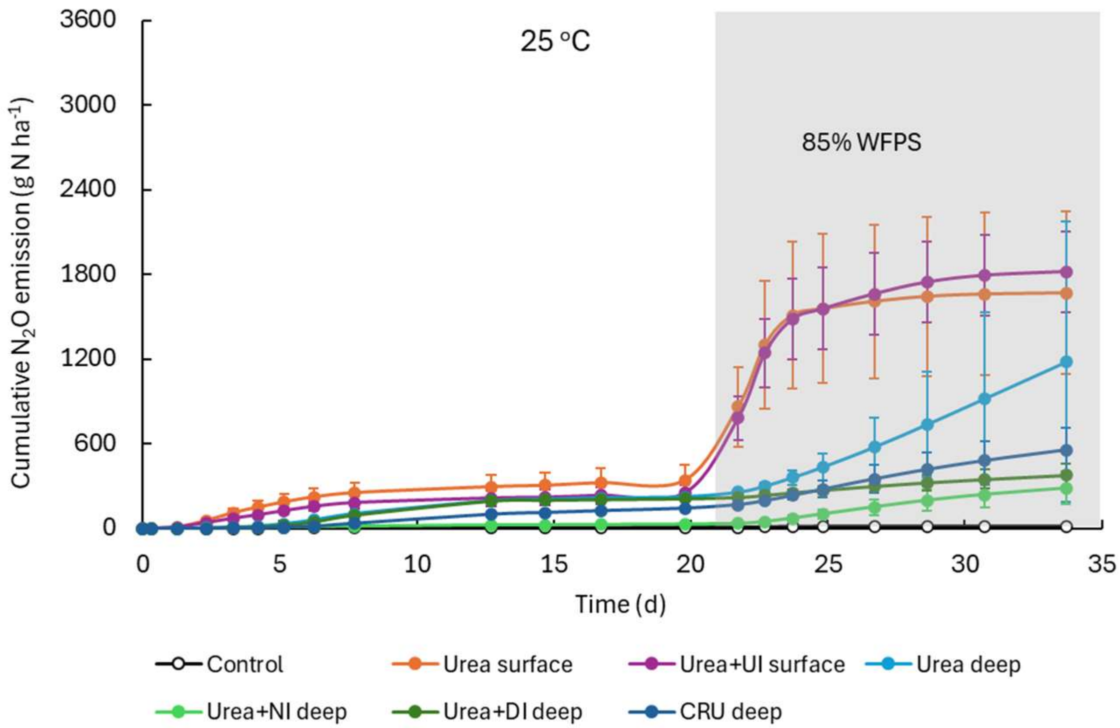
Mechanistic study

NH_3volatilisation



Mechanistic study

Cumulative N_2O emissions



Summary - Mechanistic study

- Nitrification inhibitor maintained highest level of NH_4^+ and the lowest level of NO_3^-.

- Urease inhibitor reduced NH_3 loss compared to surface applied urea but deep placement of urea (~5cm) performed better.

- Nitrification inhibitor, dual inhibitor and CRF reduced N_2O emissions.

Contacts:
Prof. Helen Suter, helencs@unimelb.edu.au; 0438 456 602
Dr Arjun Pandey, arjun.pandey@unimelb.edu.au; 0458810668