Enhancing efficiency fertilisers - preliminary results from two trials

Kaidy Morgan and Mikaela Tiller
Hart Field-Site Group

Key findings

- High starting soil N and below average growing season rainfall (Decile 3) limited treatment effects in the first season of this trial.
- There were no differences observed between inhibitor products or nitrogen rates for any of the in-season observations carried out.
- The dual inhibitor product applied at 75% and 100% of standard fertiliser rate outperformed the untreated control for grain protein (%), however did not differ from plots that were treated with standard urea (no inhibitor).

Introduction

Additional nitrogen (N) is required in many Australian cereal systems to meet water limited yield potential, however significant losses through gas, leaching and immobilisation are often experienced. The percentage of applied N taken up by the plant in dryland cropping systems in Australia is roughly 35-40%, therefore there is a need to minimise losses to increase nitrogen use efficiency (Suter and Pandey, 2025). Research into the use of enhancing efficiency fertilisers (EEF) has been increasing, targeting inhibiting enzymes related to the N transformation biochemical process. Each EEF impacts the N cycle by slowing one of the N transformation process (Figure 1). Coated urea controls and slows down the release of N in response to soil conditions. Urease and nitrification inhibitors slow the rate at which urea hydrolysis and nitrification occur. A dual inhibitor is a combination of a urease and nitrification inhibitor, consequently slowing down both processes.

Two plot trials were conducted at Hart, SA in 2025 to evaluate the efficacy of urea with or without inhibitors at various rates on wheat (*Triticum aestivum,* cv. Calibre). The first, a GRDC funded EEF trial, investigates N fertiliser efficiencies with and without inhibitor coatings at various rates. The second, a small Hart-funded extension to this work, tests the efficacy of efficiency fertilisers when applied at two timings.

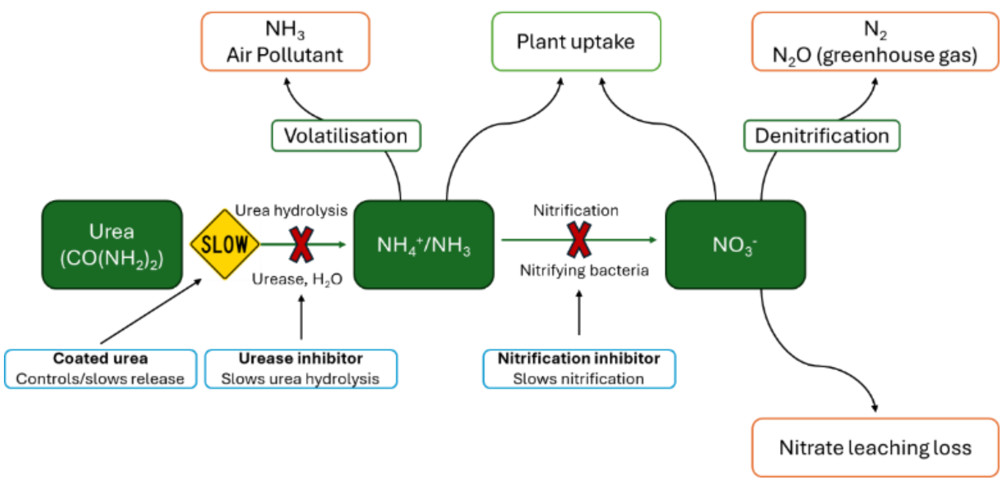

Figure 1. N pathways after application of urea and location of impact of the different EEFs and the impacted loss pathways. Adapted from Suter and Pandey, 2025.

Methodology

Trial design and treatments

Two trials were established at the Hart field site on a clay loam soil type using a small-plot knife-point press wheel seeder, with three replicates of each treatment (Table 1).

Table 1. Trial details for 2025 enhancing efficiencies fertiliser at Hart, SA.

Plot size	1.75 x 10 m	**Previous crop**	Bale awnless wheat
Location	Hart, SA	**Soil N**	120.4 kg N/ha
Seeding date	May 23, 2025	**Fertiliser**	Seeding: MAP (10:22)
Time of harvest	December 5, 2025		Zn 1% @ 80 kg/ha
GSR*	Decile 3 (223 mm)		Trial 1: August 22, 2025
			Trial 2 Timing 1: July 30, 2025
			Trial 2 Timing 2: August 22, 2025

**GSR = Growing season rainfall*

Trial 1: Enhancing efficiencies fertiliser agronomy

At one application timing, five nitrogen treatments were applied: urea, urea with urease inhibitor, urea with nitrification inhibitor, urea with dual inhibitor, and a controlled release fertiliser. Starting with an untreated control (UTC), treatment rates increased in 25% increments up to 100% of optimal target nitrogen. Urea without an inhibitor was also applied at 150% of the standard rate (Table 2). Nitrogen rates were determined by starting soil N and seasonal conditions. Treatments were top dressed at mid-tillering and received 20.8 mm of rainfall in the week post-application.

Table 2. Treatment list and rates for 2025 enhancing efficiencies fertiliser agronomy 15N at Hart, SA.

Nitrogen applied (% of standard rate)	Rate (kg N/ha)
UTC	0
25	5.3
50	18.5
75	31.8
100	45.0
150	71.5

Within the 75% treatment plots across all nitrogen types, a 1.38 x 1.38 m microplot was established. The microplots were treated with the same fertiliser and rate as the main plot, however, were applied with isotopically labelled ^{15}N to allow tracing of fertiliser-derived N in plant and soil DNA.

Trial 2: Enhancing efficiencies fertiliser timing

At two application timings, three nitrogen treatments were applied: standard granular urea, urea with a urease inhibitor, and urea with a dual inhibitor at 75% of the standard nitrogen target (31.8 kg N/ha).

Timing 1 was applied at a rain event and Timing 2 aimed for an application timing up to 10 days prior to a rain event. Timing 1 was applied after a cumulative 26.8 mm of rainfall had been received over the previous five days. Post-application conditions included an additional 20.8 mm of rainfall recorded during the week after application. Timing 2 was applied four days prior to receiving a cumulative 24.6 mm of rainfall across five days.

Site management and environmental conditions

Throughout the growing season the trial was managed through the application of pesticides to ensure an insect, weed and disease-free canopy.

Pre-sowing soil testing at the trial site indicated high background N (85.2 kg N/ha at 0-70 cm), likely as a result of dry conditions and following a failed wheaten hay crop in 2024. Despite being typically highly N responsive, high background N in 2025 implied that there would only be small benefits of additional N, unless growing season rainfall exceeded Decile 3 (Hart Field-Site Group, 2025).

The 2025 growing season was characterised by below average rainfall (Decile 3, 223 mm) which should be considered when interpreting grain yield and quality data. The trial was not subject to stress from any other external or environmental factors.

Assessments

Trial 1: Enhancing efficiencies fertiliser agronomy 15N

To measure baseline soil N, soil cores were taken across the site prior to seeding, sampled to a depth of 100 cm and sectioned by depths of 0-10 cm, 10-40 cm, 40-70 cm and 70-100 cm for analysis. Post harvest cores were taken per plot and sectioned by depths of 0-15 cm, 15-35 cm, 35-55 cm and 55-75 cm (data yet to be received).

Plant establishment counts (plants/m^2) were conducted at the first application timing approximately six weeks after emergence. Normalised difference vegetation index (NDVI) was assessed prior to N application (August 22) and again at two, four and six weeks after nitrogen application utilising a handheld Greenseeker. At flag leaf and anthesis, ground calibration cuts for dry matter were taken and NDVI readings were done separately in this area (UTC, 75% and 100% treatments only). Harvest index cuts were also taken prior to harvest. Wheat was harvested using a small-plot harvester and grain yield (t/ha), protein (%) and screenings (%) were assessed post-harvest. Within the ^{15}N microplots plant counts, anthesis ground cuts, harvest index and post-harvest soil N were conducted (data not yet available).

Trial 2: Enhancing efficiencies fertiliser timing

Baseline soil N was measured following the same method as Trial 1. In-season soil samples were conducted the day of application and approximately seven weeks after Timing 1 (T1) and four weeks after Timing 2 (T2) on September 19. Wheat was harvested using a small-plot harvester and grain yield (t/ha), screenings (%), protein (%), and test weight (kg/hL) were assessed post-harvest.

Photo. View of the Enhancing Efficiency Fertlisers trial at Hart in 2025.

Results and discussion

Trial 1: Enhancing efficiencies fertiliser agronomy

High starting soil N and below average growing season rainfall (Decile 3) limited treatment effects in the first season of this trial. There were no differences noticed between inhibitor products or nitrogen rates for any of the in-season observations, with all treatments performing similarly to the untreated control (Table 3).

Table 3. In-season observations for the Enhancing Efficiency Fertiliser trial at Hart, 2025.

	Biomass g/m^2	**NDVI 1**	**NDVI 2**	**NDVI 3**	**NDVI 4**
Untreated control	373.8	0.31	0.41	0.52	0.51
Urea @ 25%	317.5	0.34	0.42	0.52	0.52
Urea @ 50%	345.3	0.32	0.44	0.49	0.54
Urea @ 75%	357.1	0.33	0.44	0.57	0.53
Urea @ 100%	378.6	0.30	0.41	0.47	0.54
Urea @ 150%	348.1	0.32	0.43	0.54	0.55
CRF @ 25%	357.7	0.33	0.42	0.50	0.53
CRF @ 50%	348.7	0.31	0.40	0.54	0.54
CRF @ 75%	344.9	0.30	0.43	0.48	0.56
CRF @ 100%	367.5	0.35	0.41	0.52	0.56
Urea + Dual @ 25%	356.1	0.34	0.41	0.49	0.54
Urea + Dual @ 50%	400.0	0.32	0.41	0.51	0.54
Urea + Dual @ 75%	344.6	0.31	0.41	0.51	0.55
Urea + Dual @ 100%	320.7	0.28	0.39	0.52	0.51
Urea + Nitrification @ 25%	315.0	0.32	0.42	0.49	0.54
Urea + Nitrification @ 50%	352.3	0.33	0.41	0.48	0.54
Urea + Nitrification @ 75%	341.2	0.31	0.41	0.51	0.54
Urea + Nitrification @ 100%	348.4	0.33	0.43	0.54	0.52
Urea + Urease @ 25%	360.1	0.31	0.39	0.49	0.49
Urea + Urease @ 50%	344.5	0.32	0.40	0.52	0.53
Urea + Urease @ 75%	350.9	0.34	0.43	0.55	0.54
Urea + Urease @ 100%	380.4	0.32	0.47	0.55	0.58
P-value	**NS**	**NS**	**NS**	**NS**	**NS**

The dual inhibitor product applied at 75% and 100% of standard fertiliser rate outperformed the untreated control for grain protein (%), however remained similar to plots that were treated with standard urea (no inhibitor) (Table 4). There were no differences in any other quality parameters tested.

Table 4. Yield and grain quality data for enhancing efficiency fertiliser agronomy trial at Hart, 2025. Shaded values indicate best performing treatments. Any difference between two means greater than the Bonferroni critical difference value is significant at α = 0.05 after Bonferroni correction.

Treatment	Yield (t/ha)	Protein (%)	Screenings (%)	Test weight (kg/hL)
Untreated control	1.52	11.3[a-d]	7.3	77.1
Urea @ 25%	1.59	11.1[ab]	7.3	77.4
Urea @ 50%	1.63	12.0[a-f]	7.4	77.0
Urea @ 75%	1.48	12.7[f]	8.8	76.1
Urea @ 100%	1.55	12.4[def]	8.5	76.7
Urea @ 150%	1.68	12.5[def]	8.1	76.5
CRF @ 25%	1.56	11.0[a]	7.2	77.1
CRF @ 50%	1.63	11.6[a-f]	7.8	76.6
CRF @ 75%	1.58	11.7[a-f]	8.0	76.7
CRF @ 100%	1.63	11.3[a-d]	7.7	77.3
Urea + Dual @ 25%	1.61	11.1[abc]	7.6	77.1
Urea + Dual @ 50%	1.63	11.4[a-e]	7.4	77.3
Urea + Dual @ 75%	1.49	12.6[ef]	8.8	76.4
Urea + Dual @ 100%	1.52	12.7[a-d]	8.3	76.1
Urea + Nitrification @ 25%	1.51	11.5[a-f]	8.0	76.3
Urea + Nitrification @ 50%	1.52	11.9[a-f]	8.2	76.4
Urea + Nitrification @ 75%	1.46	12.2[a-f]	8.7	75.9
Urea + Nitrification @ 100%	1.64	12.2[a-f]	8.1	76.6
Urea + Urease @ 25%	1.50	11.3[a-d]	7.8	77.0
Urea + Urease @ 50%	1.60	11.7[a-f]	7.8	77.0
Urea + Urease @ 75%	1.53	12.3[b-f]	8.3	76.7
Urea + Urease @ 100%	1.71	12.3[c-f]	7.7	76.5
P-value	**NS**	**<0.001**	**NS**	**NS**
Bonferroni CD		**1.3**		

At the time of compiling this article, grain and biomass data from the ^{15}N-labelled microplots was not yet available. Differences between inhibitor products may be identified once this data is analysed, however conditions in 2025 were not favourable to test the effectiveness of enhancing efficiency fertilisers due to dry conditions and reduced N requirements.

This trial will continue in 2026, where it is anticipated that treatment effects may become clear if favourable growing season conditions are experienced.

Trial 2: Enhancing efficiencies fertiliser timing

Application timing or the use of inhibitors did not affect any parameters measured in 2025 (data not shown). Additionally, over one season, there was no effect of application treatment on soil nitrogen (0-30 cm) for any of the four tests carried out.

Table 5. Soil nitrogen (0-30 cm) results for the enhancing efficiency fertilisers trial at Hart, 2025.

Application timing (T) & fertiliser product applied	Pre- T1 (soil N kg/ha)	Pre-T2 (soil N kg/ha)	Post-T2 (soil N kg/ha)	Post-harvest (soil N kg/ha)
T1 dual	76.81	80.93	73.59	39.55
T1 urea	62.34	85.94	47.52	52.75
T1 urease	109.75	89.57	46.7	54.04
T2 dual	117.82	72.04	51.57	50.17
T2 urea	88.75	61.27	62.17	62.33
T2 urease	88.44	50.09	80.66	73.17

Summary

Limited differences were observed in 2025 for both the enhancing efficiencies fertiliser agronomy (Trial 1) and the enhancing efficiencies fertiliser timing (Trial 2) trials at Hart. Limited biomass production and adverse growing season conditions likely impacted potential results of nitrogen treatments. Both trials will be repeated in 2026.

Acknowledgments

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC. The authors would like to thank them and for their continued support (GRDC Project UOM2404-007RTX). Hart also acknowledge the collaboration of The University of Melbourne as the team who lead this national project.

The Hart Field-Site Group would also like to acknowledge the generous support of our sponsors who provide funding that allows us to conduct the enhancing efficiencies fertiliser timing trial in 2025. Proceeds from Hart's ongoing commercial crop also support Hart's research and extension program. We would like to thank the various organisations who provided product and seed to conduct this trial.

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