Comparing nitrogen management strategies to inform risk–reward, Griffith NSW

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Take home message

- Pre-sowing soil tests in 2025 showed that mineral N levels were highest where higher N fertiliser rates had been applied in previous years, showing N management decisions do influence soil N carryover
- In the pulse phase of the rotation, the extra soil N did not translate into increased yield or quality for lentils in 2025. As such there was no additional economic return in 2025 in the lentil phase from increased residual nitrogen. The results reinforce that pulse crops are unlikely to benefit from high soil N, especially when nodulation and fixation are effective
- After 3 seasons, whilst many strategies are still running down the nitrogen balance, the Manure and High Risk Seasonally Responsive (assuming a decile 7–8 finish) treatments had the highest positive N balances. These 2 treatments also had the highest average nitrogen applied after 3 years. Replacement +30% and Moderate Risk Seasonally Responsive (assuming a decile 5 finish) treatments are emerging as being decision making systems that strike a good balance between profit, risk, and sustainability
- Overall, the third-year results demonstrate that N management benefits are strongly crop and phase dependent.

Background

This project is part of 'RiskWi$e' (the National Risk Management Initiative) which includes a network of small plot and paddock scale trials across a range of production environments and systems nationally, all of which are aiming to quantify the risks and rewards of different nitrogen (N) management strategies and decisions over multiple years.

As part of the NSW Action Research Group (ARG), Ag Grow Agronomy set up a nitrogen systems trial in 2023 at the Ag Grow Agronomy research farm "Ridge Top" near Beelbangera, 16km NE of Griffith, to test the performance of different nitrogen management decision making strategies over a four-year period.

As N was identified by growers as a priority area for risk–reward decision making, the project was designed to compare a variety of decision-making approaches to inform annual N fertiliser applications including the use of tools like Yield Prophet to target pessimistic or optimistic seasonal conditions, longer-term strategic approaches like N banking or replacement strategies.

The trial compares the yield, grain quality, and profitability of the different N management approaches, with the aim of providing information on: whether fertiliser N not used by crops in the year of application carries over to subsequent seasons; what the consequences of

excessive N fertiliser are for crop productivity; and the effect of different N fertiliser strategies on legume productivity, N fixation and economic outcomes.

The Griffith trial consists of 12 N treatments, driven by growers and grower experience with their N management strategies, with all N applied at sowing unless otherwise stated, and include:

1. *Nil* (Control): no N fertiliser applied (Phosphorus applied with superphosphate)
2. *Grower Practice* (DIS): rate determined by current grower decision making, based on a combination of soil test data, attitude to risk, historical results and seasonal forecast. Option for extra fertiliser to be applied as topdressed N if season allows
3. *Low Risk* Seasonally Responsive (YP_D3): sufficient N applied to meet water limited potential yield assuming a decile 2–3 season finish (equivalent to Yield Prophet 75%)
4. *Moderate Risk* Seasonally Responsive (YP_D5): sufficient N applied to meet water limited potential yield assuming a decile 5 season finish (equivalent to Yield Prophet 50%)
5. *High Risk* Seasonally Responsive (YP_D7): sufficient N applied to meet water limited potential yield assuming a decile 7–8 season finish (equivalent to Yield Prophet 25%)
6. *Climate Forecast* (YP_BOM): sufficient N applied to meet water limited potential yield assuming whichever of treatments 3–5 is most likely based on BOM 3-month forecast
7. *8% Gross Income* (FIN): apply as much N fertiliser as can be purchased with 8% of gross income from the previous season at current market value of urea
8. *Replacement* (REP): apply N fertiliser equal to grain N offtake from previous season
9. *Replacement +30%* (REP_HI): apply N fertiliser equal to grain N offtake from previous season plus 30%
10. *Replacement -30%* (REP_LO): apply N fertiliser equal to grain N offtake from previous season minus 30%
11. *Manure* (MAN): proportion of N supplied through addition of manure of known N content. 3 t/ha Manure applied in year 1, plus N rate applied as per treatment 4 every year including year 1
12. *Enhanced Fertiliser* (EEF): N fertiliser is supplied with coatings to reduce losses. Rate of N applied as per treatment 4

Crop rotation has been canola (2023), wheat (2024), and lentils (2025). Canola is planned for 2026.

This trial will not only provide useful data on these approaches but also provide a platform to explore how models and other tools can inform N fertiliser decisions to balance the long-term risks and rewards.

Impacts of treatments on soil N

Soil tests are undertaken annually pre-sowing on treatments 1 to 5 for nitrogen and soil moisture, at depths of 0–10cm, 10–40cm, 40–70cm and 70–100cm. In 2025 soil tests were undertaken on 26th February.

Figure 1 shows an estimate of the total mineral nitrogen available (0–100cm) for plant uptake for each treatment at sampling and the total N applied in 2024. The 2024 N rate applied accounts for most of the variation in 2025 soil mineral N. The Nil treatment had significantly lower pre-

sowing soil mineral N available than all other treatments tested, except the low-risk treatment (YP_D3).

In previous year's nitrogen rates for each treatment were calculated from these soil test results. Given lentils were sown in 2025, no nitrogen was applied to any treatment in 2025.

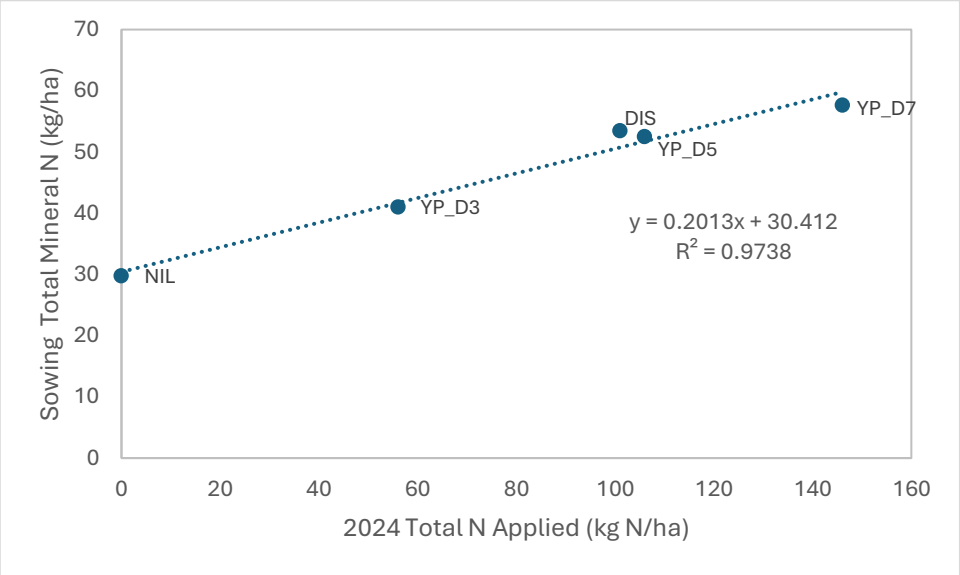

Figure 1. 2025 pre-sowing soil total mineral N (kg N/ha) (0–100cm), February 2025.

2025 Crop performance

As part of the rotation the trial was sown to GIA Thunder lentils at 40 kg/ha on 29 April 2025 with 120 kg/ha superphosphate. The trial was rolled 27 May 2025, with appropriate pest, disease and weed control undertaken on the trial post-emergence.

Grain yield & quality

The average grain yield of the trial was 3.2 t/ha, with yield ranging from 2.96 to 3.40 t/ha between treatments. Lentil yield did not respond to the varying pre-sow soil mineral N levels in 2025. There were also no differences in seed size of the lentils between treatments in 2025, with an average thousand seed weight of 34.8 g.

Partial N balance 2025

Partial N balance was calculated using total fertiliser N minus the grain N export plus the N fixation. There were no differences between treatments in terms of the partial balance for nitrogen in 2025, Table 1.

Table 1. 2025 Partial N Balance (kg/ha) for Griffith N Systems trial.

Trt No.	TREATMENT	Partial N supply (kg/ha)	N export (kg/ha)	N fixation (kg/ha)	Partial N balance (kg/ha)
1	Nil (Control)	*30*	128	200	72
2	Grower Practice (DIS)	*53*	114	178	64
3	Low Risk (YP_D3)	*41*	119	186	67
4	Med Risk (YP_D5)	*53*	117	183	66
5	High Risk (YP_D7)	*58*	126	197	71
6	Climate Forecast (YP_BOM)		127	198	71
7	8% Gross Income (FIN)		122	190	69
8	Replacement (REP)		119	186	67
9	Replacement+30% (REP_HI)		131	204	73
10	Replacement-30% (REP_LO)		120	188	68
11	Manure (MAN)		125	196	70
12	Enhanced Fertiliser (EEF)		124	194	70
		mean	***123***	***192***	***69***
		MSD (p=0.05)			***ns***

Note: N BALANCE CALCULATIONS
Partial N supply (kg/ha) - Calculated as sowing total mineral N (kg/ha) + fertiliser total N (kg/ha)
Partial N balance (kg/ha)- Calculated as fertiliser total N (kg/ha) - grain/hay N export (kg/ha) + N fixation (kg/ha)
N export (kg/ha) - Grain N export calculated from grain N percentage of yield
*N fixation (kg/ha) - Calculated from grain or biomass yield as per [Peoples et al 2017]. Grain legume N fixation (kg/ha) = grain yield (t/ha) * 60 (kg/t).*

2023–2025 results

Cumulative partial N balance and gross margin

The relationship between cumulative partial balance of nitrogen and gross margin after 3 years is shown in figure 2.

The cumulative partial balance of N is calculated from the total N applied minus N removed in the grain after 3 years. After 3 years the manure (MAN) treatment and the high risk (YP_D7) treatment had the highest positive nitrogen balance with 84 and 79 kg N/ha, respectively.

All other treatments, except replacement + 30% (REP_HI) and medium risk (YP_D5), had a negative N balance. These treatments have continued to run down the nitrogen. The Nil treatment had the greatest negative balance, with a deficit of 77 kg N/ha. The replacement treatment (REP) was close to zero after 3 years.

After 3 years the mean gross margin shows all treatments have returned a profit over the Nil control treatment, with not a big difference in profit between any of the strategies. Profit remains driven by grain yield and the cost of nitrogen applied, with no nitrogen applied to the pulse phase of the rotation.

The manure (MAN) treatment after 3 years has returned the highest profit, followed by the replacement + 30% (REP_HI) treatment.

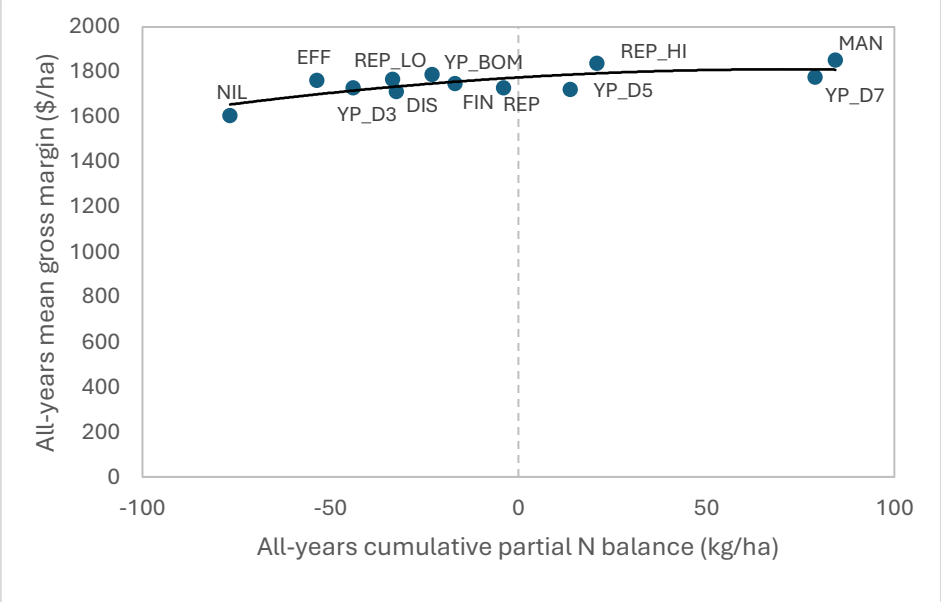

Figure 2. Relationship between cumulative partial balance of nitrogen and mean gross margin after 3 years (2023–2025).

Note: Costs used are actual on-farm costs, with treatment costs above the standard paddock costs and attributed to the actual N treatment only.

Discussion

This trial was established to quantify the agronomic risks and rewards of different nitrogen management decision making strategies across multiple seasons. By the third year, the system was in a pulse phase (lentils, 2025), providing an opportunity to assess whether legacy N strategies influenced crop performance, soil N dynamics, or in-season crop growth.

Despite clear differences in pre-sowing soil N status this did not translate into any agronomic benefits or detriment in the lentil phase. Pre-sowing soil tests in 2025 showed that total mineral N (kg N/ha) was highest in treatments that had received greater N inputs in previous years, indicating that N strategies did affect residual soil N supply and excess N applied in 2023 and 2024 has carried over. However, this increased soil N availability did not result in measurable differences in crop growth or yield outcomes.

In 2025, there were no yield benefits from any of the N treatments. Grain yield, seed size and overall crop performance were the same across all treatments, regardless of how much background N had been applied in previous years. This indicates that under the conditions experienced in the 2025 season, lentils were not limited by nitrogen and did not respond to either current or historical N inputs. As a pulse crop, lentils can meet much of their N requirements through nitrogen fixation, reducing their dependence on soil N. As such the higher starting soil N did not improve crop growth or grain yield, as expected.

From a risk–reward perspective, the higher background N increased soil mineral N levels going into the lentil crop. However, the extra N did not improve yield, seed size or crop vigour, meaning there was no economic return in the lentil phase of the rotation. Despite this, after 3 years, the cumulative partial gross margin remains driven by grain yield, with all treatments returning a profit over the Nil control treatment.

Overall, after 3 years there is not a lot of difference in profit between any of the N management strategies. However, replacement + 30% (REP_HI) and medium risk (YP_D5) are showing good

levels of profit and a small positive N balance, which is a good compromise between profit and sustainability.

For previous individual year's results and more detailed background of this project, treatments and set up please refer to our website: https://www.aggrowagronomy.com.au/research-projects/

ZONE 3 – central west & northern Riverina

As well as the Griffith N systems trial, as part of zone 3 in NSW covering the central west & northern Riverina, Central West Farming Systems (CWFS) have been conducting a long-term nitrogen management trial at The Fettell Centre in Condobolin since 2022 as part of the GRDC RiskWi$e initiative. This N Banking trial also compares a range of nitrogen decision making strategies including traditional replacement rates, seasonally responsive approaches using decision support tools, fixed soil nitrogen bank targets, and legume-based rotations. Results from Condobolin contribute locally relevant data to the national RiskWi$e network and support growers in making nitrogen decisions that balance input risk with water limited yield potential. https://cwfs.org.au/projects/riskwise/

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