

# Nitrogen decisions – how to get them more right more often

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## Keywords

nitrogen decisions, partial N balance, profit, risk

## GRDC project code

CSP2303-015BGX

## Take home messages

- Mean N rate averaged over multiple years explains a large proportion of variation in mean yield and gross margin, and many different decision-making systems can get this rate 'right'
- Analytical systems (for example, Yield Prophet Lite) have lower shadow cost compared to less analytical systems (for example, N banks, replacement) making them marginally more profitable
- Gross margin is maximised when multi-year partial N balance is neutral to positive (0–100kg/ha more fertiliser N applied than removed in grain, over the life of the experiment)
- Cereal grain protein and partial N balance are excellent benchmarks to evaluate N decision-making over the short and long term.

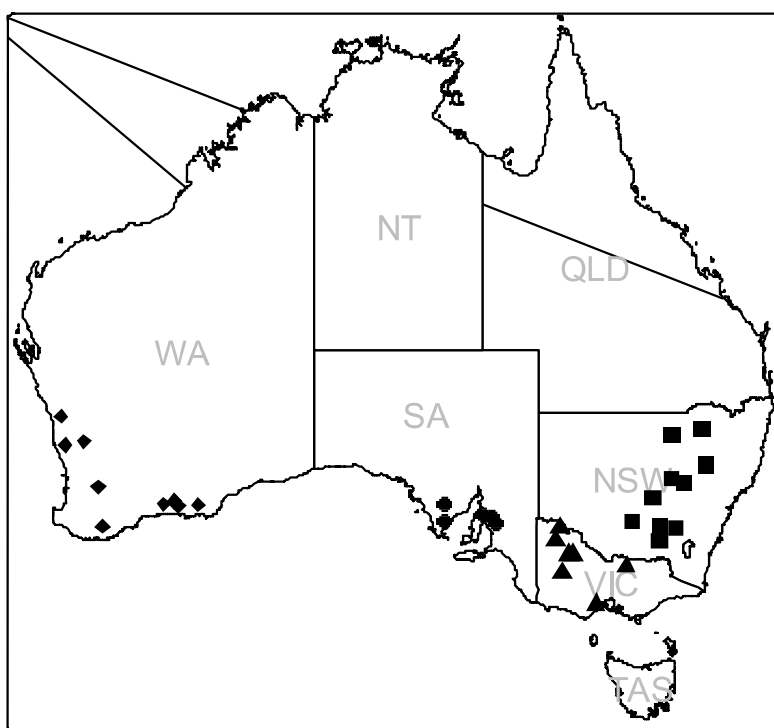
## Background

GRDC RiskWi\$e aims to help growers make better decisions – decisions that are more right more often. To help improve N fertiliser decision-making, the initiative has established a national network of coordinated field experiments that evaluate the production, profit and risk profile of different N fertiliser strategies. These experiments differ from most past N experiments because they evaluate decision-making processes or systems rather than fixed N rates, and the treatments are applied to the same plots year after year, allowing effects to accumulate and long term performance of different decision-making processes to be evaluated over multiple years. Analysis of the large national dataset reveals key messages on how to get the most out of N fertiliser applications.

## Method

Thirty-three small-plot field experiments evaluating N management decisions have been established across grain growing regions in all mainland states except QLD (Figure 1, Table 1). Action research groups nominated the treatments evaluated in experiments based on the preferences of local growers and advisers (Table 2). A set of common core treatments were included at a subset of sites to allow combined analysis for this paper (Figure 2). In total, there were 62 site × year combinations analysed across 2018–2025 seasons which included wheat, barley, canola, lentil, faba bean and sorghum grain crops, as well as legume brown manure crops.

Several criteria were used to evaluate the performance of the different treatments, including grain yield, gross margin, shadow cost and partial N balance. Gross margin is calculated using 5-year average commodity prices and variable costs from the SAGIT Gross Margin Guide (<https://sagit.com.au/2024-farm-gross-margin-guide/>) and takes into account a quality premium or deduction for both wheat and canola based on protein and oil content, respectively. Shadow cost is calculated as the difference in gross margin between a particular treatment and the treatment with the highest gross margin in that site/year. Partial N balance is calculated as N fertiliser and legume N input minus grain N offtake.



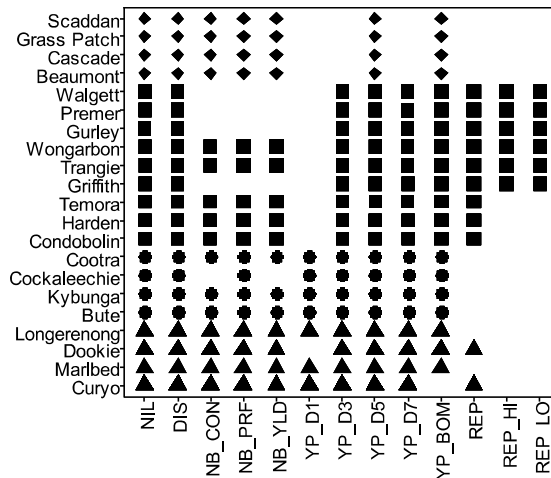
**Figure 1.** Map of all 33 small-plot field sites in the national network of N decision experiments.

**Table 1.** Details of the 21 sites in the national network of N decision experiments used in this analysis.

| Experiment code | State | Year start | Site         | Organisation                                    |
|-----------------|-------|------------|--------------|---|
| 01VIC18CUR      | VIC   | 2018       | Curyo        | Birchip Cropping Group                          |
| 02VIC22MAR      | VIC   | 2022       | Marlbed      | Birchip Cropping Group                          |
| 04VIC22DOO      | VIC   | 2022       | Dookie       | University of Melbourne                         |
| 06VIC22LON      | VIC   | 2022       | Longerenong  | Birchip Cropping Group                          |
| 09SA22BUT       | SA    | 2022       | Bute         | Northern Sustainable Soils, Trengove Consulting |
| 10SA22KYB       | SA    | 2022       | Kybunga      | Hart Field Site Group                           |
| 11SA22COC       | SA    | 2022       | Cockaleechee | EP Ag Research                                  |
| 12SA22COO       | SA    | 2022       | Cootra       | EP Ag Research                                  |
| 13NSW22CON      | NSW   | 2022       | Condobolin   | Central West Farming Systems                    |
| 14NSW22HAR      | NSW   | 2022       | Harden       | FarmLink Research                               |
| 15NSW22TEM      | NSW   | 2022       | Temora       | FarmLink Research                               |
| 17NSW23GRI      | NSW   | 2023       | Griffith     | Ag Grow Agronomy                                |
| 18NSW23TRA      | NSW   | 2023       | Trangie      | Grain Orana Alliance                            |
| 19NSW23WON      | NSW   | 2023       | Wongarbon    | Grain Orana Alliance                            |
| 20NSW23GUR      | NSW   | 2023       | Gurley       | Agricultural Marketing and Production Systems   |
| 21NSW23PRE      | NSW   | 2023       | Premer       | Agricultural Marketing and Production Systems   |
| 22NSW23WAL      | NSW   | 2023       | Walgett      | Agricultural Marketing and Production Systems   |
| 26aWA24BEA      | WA    | 2024       | Beaumont     | South East Premium Wheat Growers Association    |
| 26bWA24CAS      | WA    | 2024       | Cascade      | South East Premium Wheat Growers Association    |
| 26cWA24GRA      | WA    | 2024       | Grass Patch  | South East Premium Wheat Growers Association    |
| 26dWA24SCA      | WA    | 2024       | Scaddan      | South East Premium Wheat Growers Association    |

**Table 2.** The 13 core treatments in the national network of N decision experiments included in this analysis.

| Code   | Name                      | Description   |
|--------|---------------------------|---|
| NIL    | Nil N                     | Nil N control. Starter fertiliser at sowing only.   |
| DIS    | District Practice         | Rate may be determined by current grower decision-making, local district practice, or the national average rate (45kg N/ha).  |
| NB_CON | N Bank Conservative       | N bank target (soil N + fertiliser N) is 25kg N/ha less than the environment economic optimum rate.   |
| NB_PRF | N Bank Optimal Profit     | Environment economic optimum N bank target. The N bank maintains a base level of fertility (soil N + fertiliser N) and is predicted by the relationship between annual rainfall and minimum N required to achieve economic yield. |
| NB_YLD | N Bank Optimal Yield      | N bank target (soil N + fertiliser N) is 25kg N/ha more than the environment economic optimum rate.   |
| YP_D1  | Yield Prophet 100% (D1)   | Sufficient N applied to meet water limited potential yield assuming a decile 1 season finish (equivalent to Yield Prophet 100% probability).  |
| YP_D3  | Yield Prophet 75% (D2–D3) | Sufficient N applied to meet water limited potential yield assuming a decile 2–3 season finish (equivalent to Yield Prophet 75% probability).   |
| YP_D5  | Yield Prophet 50% (D5)    | Sufficient N applied to meet water limited potential yield assuming a decile 5 season finish (equivalent to Yield Prophet 50% probability).   |
| YP_D7  | Yield Prophet 25% (D7–D8) | Sufficient N applied to meet water limited potential yield assuming a decile 7–8 season finish (equivalent to Yield Prophet 25% probability).   |
| YP_BOM | Yield Prophet BOM         | Sufficient N applied to meet water limited potential yield assuming whichever YP treatment is most likely based on the BOM 3-month forecast (that is, decile 1, 3, 5 or 7).   |
| REP    | Replacement               | Apply N fertiliser equal to grain N offtake from previous season. Assume 40 kg/t N for wheat, 35 kg/t N for barley, 80 kg/t N for canola.   |
| REP_HI | Replacement +30%          | Apply N fertiliser equal to grain N offtake from previous season plus 30%.  |
| REP_LO | Replacement – 30%         | Apply N fertiliser equal to grain N offtake from previous season minus 30%.   |

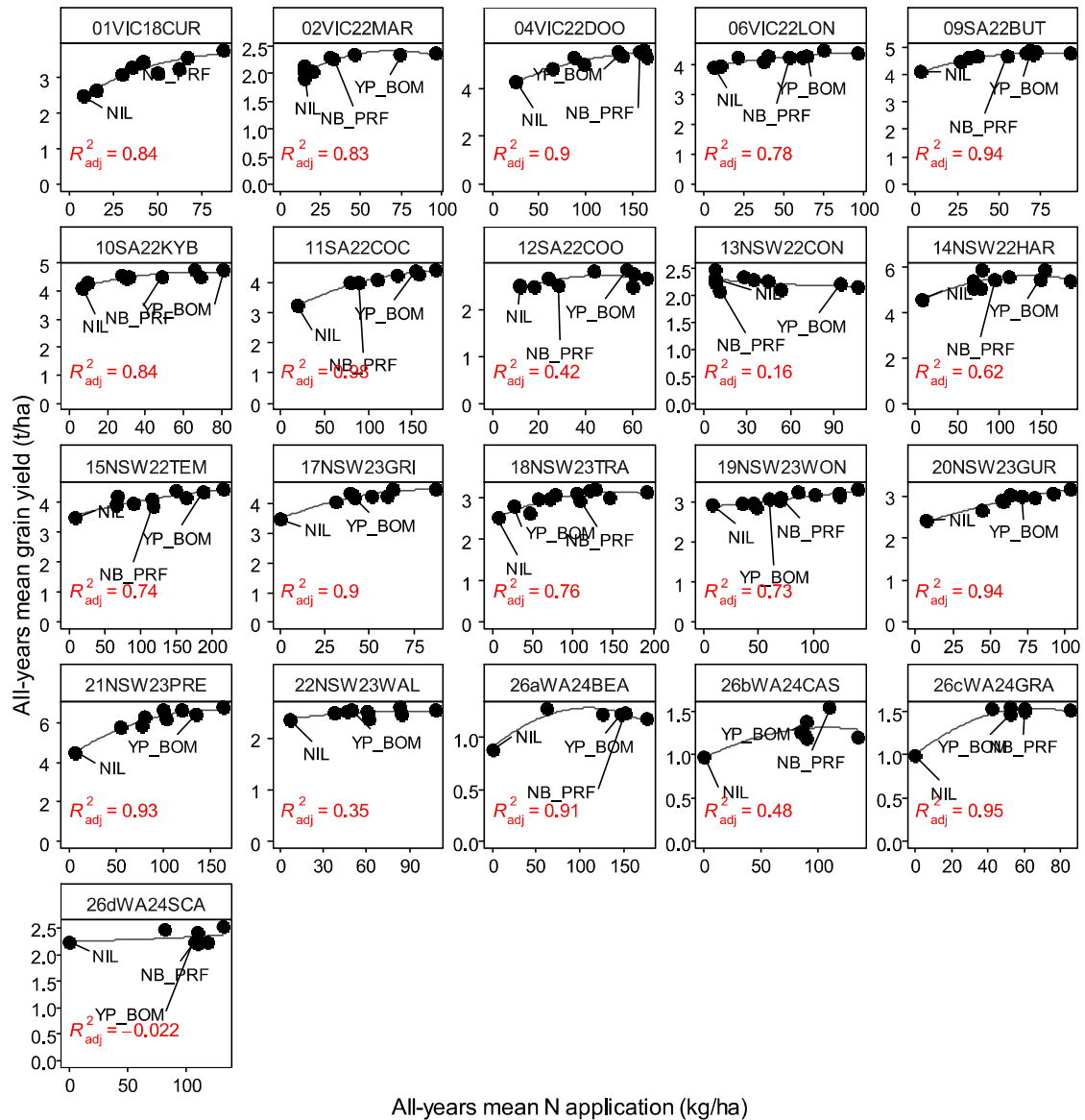


**Figure 2.** Common treatments that have been included in the analysis. Field sites were located in WA (diamond), NSW (square), SA (circle) and VIC (triangle).

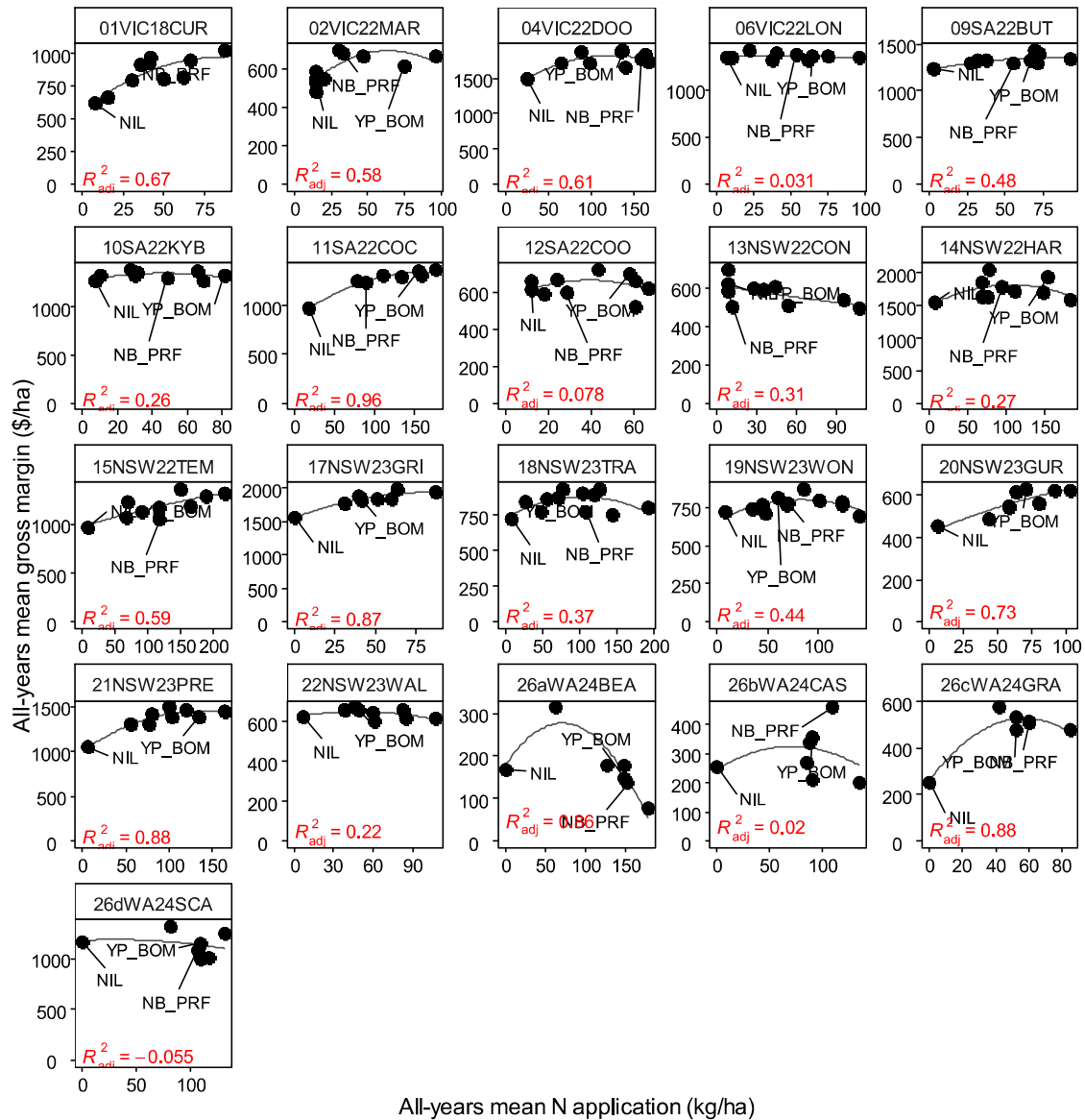
## Results and discussion

### Yield and gross margin

At most sites, long term N rate explained a large proportion of variation in yield (Figure 3), indicating that long term rate is more important than how much N is applied in a single year. This is also true for gross margin (Figure 4), but the relationships are generally weaker and flatter, for example, at Longerenong, which has high soil organic matter. Many different decision-making systems do a reasonable job of estimating the ‘right’ N rate over the long term. Sites that did not have a good relationship between long term N rate and yield have not been responsive to N fertiliser for the duration of the experiment, and include sites like Condobolin, which has large reserves of soil mineral N. Newer sites that only have results for 1–2 years (for example, Cascade, Scaddan) also tend to have a weaker relationship between N rate, yield and gross margin.



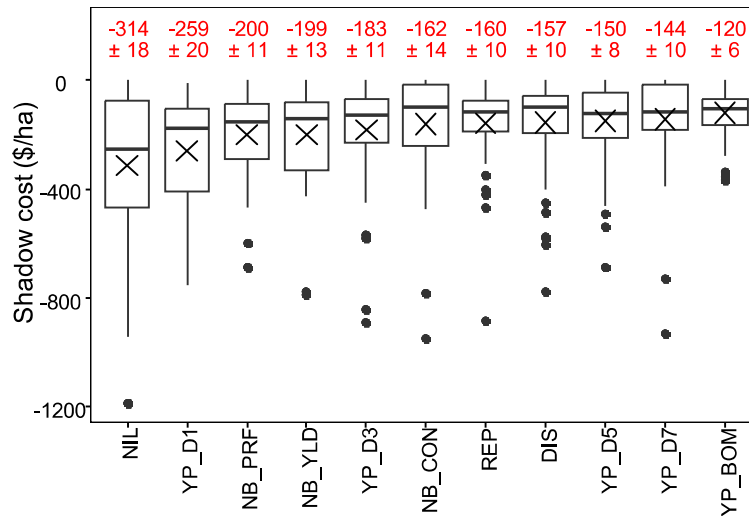
**Figure 3.** The relationship between mean N application rate and grain yield at the 21 sites used in the analysis.



**Figure 4.** The relationship between mean N application rate and gross margin at the 21 sites used in the analysis.

### Shadow cost

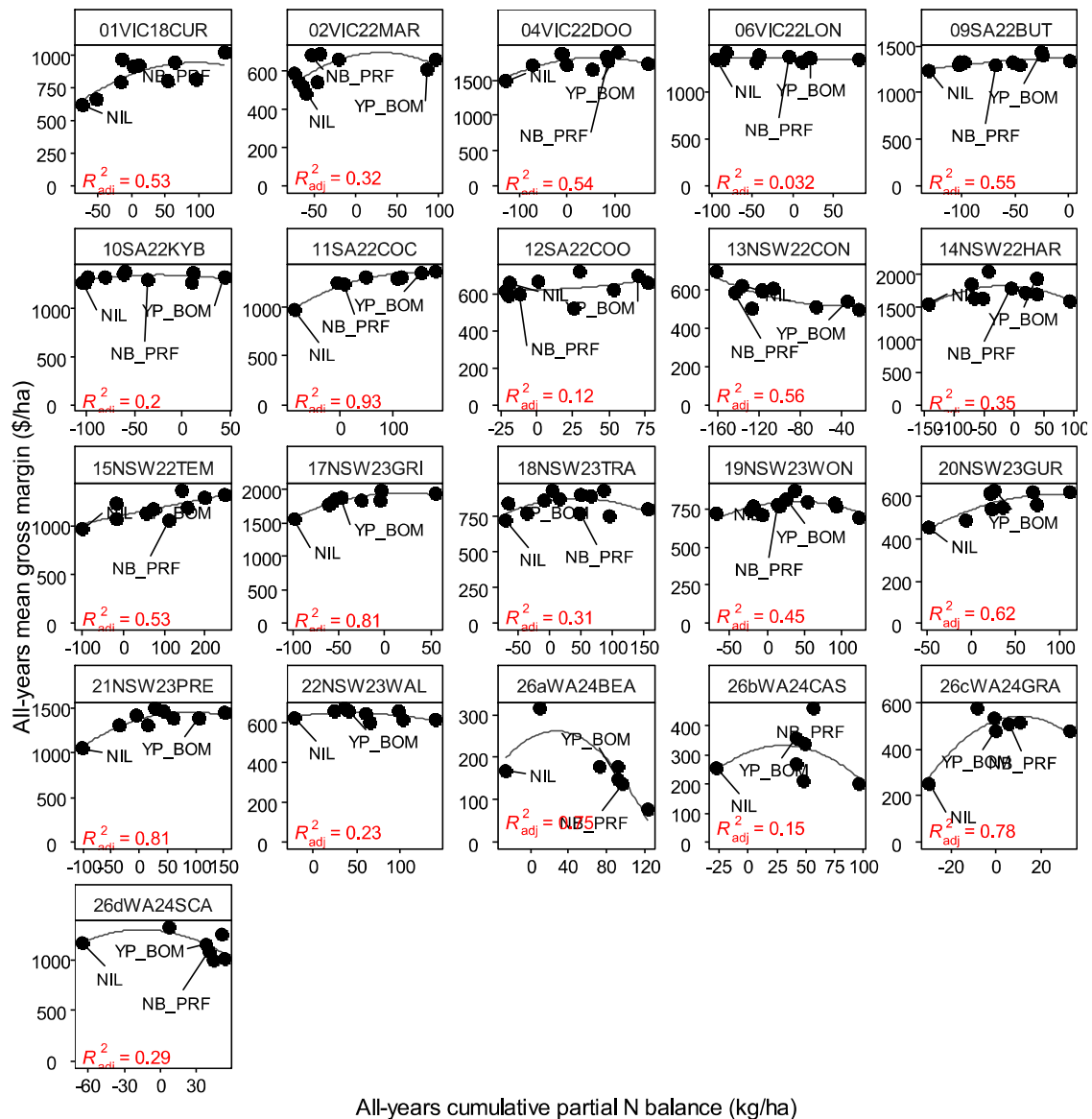
Whilst long term N rate explains a large proportion of variation in yield and profit, more analytical and seasonally responsive decision-making systems like YP\_BOM, YP\_D5 and YP\_D7 have lower mean shadow cost and narrower distribution of shadow cost (Figure 5), indicating that these systems are more right more often. YP\_BOM has marginal advantage over less analytical systems like NB\_PRF (\$80/ha each year) and REP (\$40/ha each year).



**Figure 5.** Shadow cost of each treatment. All-years mean shadow cost is indicated by the × symbol. Shadow cost is calculated as the difference between the gross margin of a particular treatment compared to the best treatment in that site-year.

### Partial N balance

Gross margin was maximised at a level of N fertilisation that delivers a small positive partial N balance (0–100 kg/ha more N being applied than is removed in grain over the life of the experiment) at 17 out of 21 sites (Figure 6). At sites where this was not the case, this was sometimes due to very high levels of soil organic matter and mineral N (for example, Condobolin, Longerenong) or other sources of N in the system (for example, brown manure Kybunga, grain legume Cootra).



**Figure 6.** The relationship between cumulative partial N balance and gross margin at the 21 sites used in the analysis.

## Conclusion

Many different decision-making systems can derive fertiliser rates that allow optimum long term gross margin to be achieved. However, more analytical systems, such as Yield Prophet Lite, have lower shadow cost making them marginally more profitable. At sites that are N responsive, highest profit is achieved when partial N balance is 0–100 kg/ha (0–100 kg/ha more fertiliser N applied over the life of the experiment than kg/ha N taken off in grain). This is a good benchmark for growers to review their decision-making processes over the long term.

## Acknowledgements

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 for their continued support. The authors would also like to acknowledge all

members of the RiskWi\$e project who have contributed to these experiments or provided administrative support.

### **Useful resources**

<https://research.csiro.au/riskwise/>

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### **Date published**

February 2026