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# Nitrous oxide emissions and Carbon balance of different N management systems

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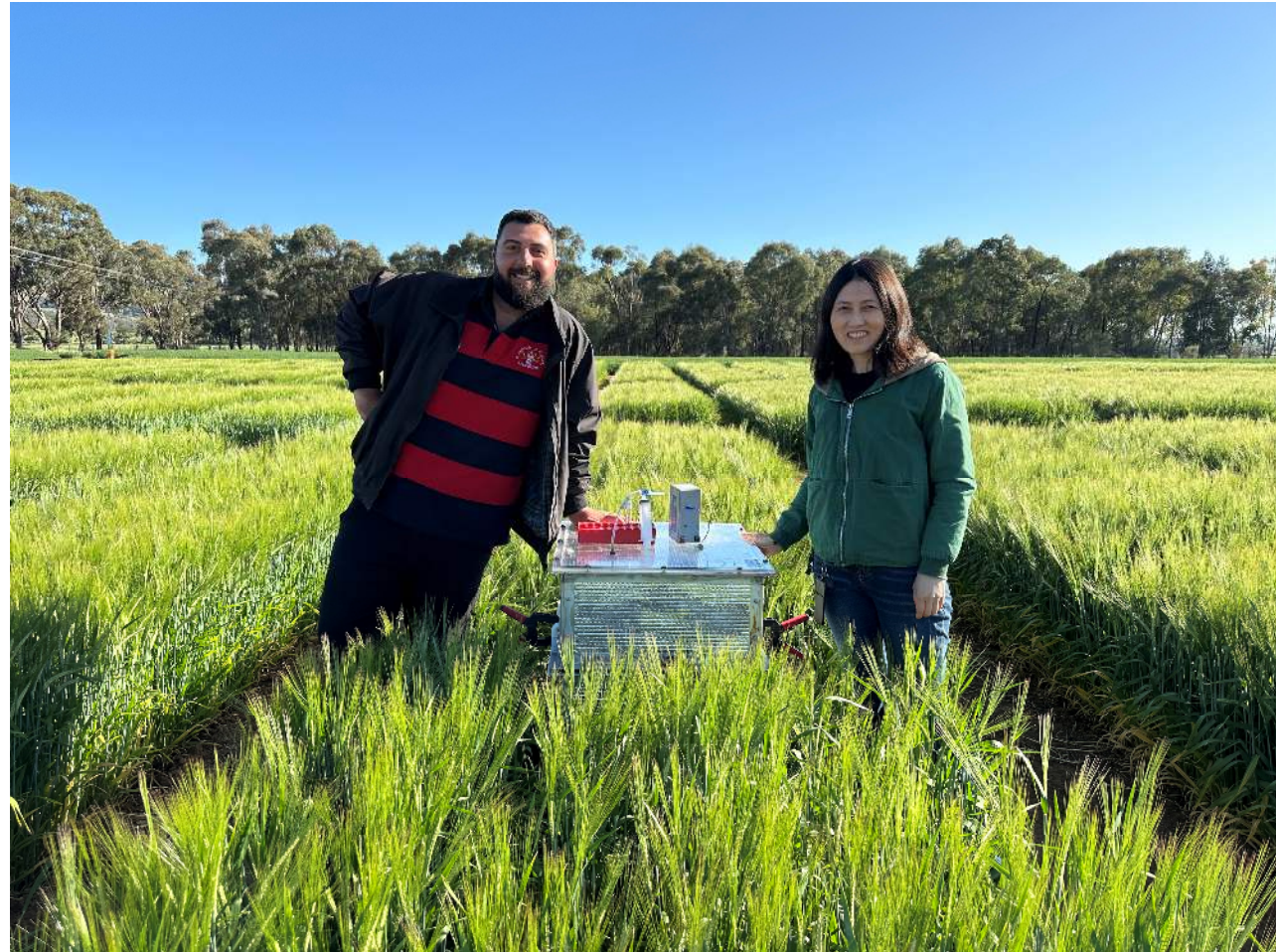




# Acknowledgements

Crop Agronomy Group at the University of Melbourne

(<https://safes.unimelb.edu.au/research/crop-agronomy#people>)





# Wheat yield gap caused by under fertilisation of N

## Australian national wheat yields

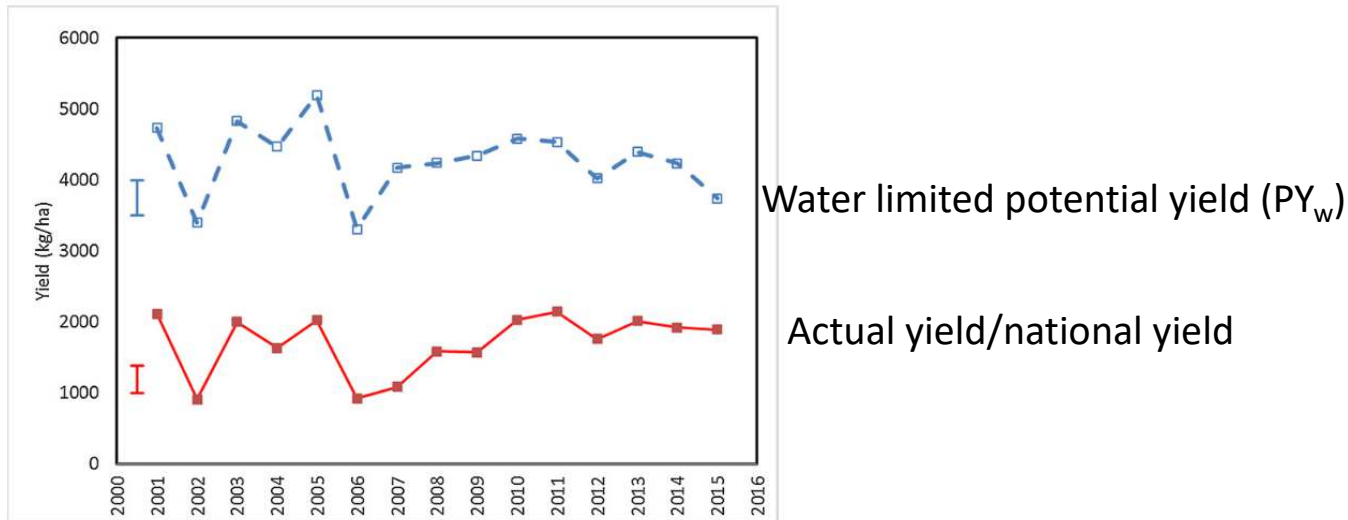


Fig. Hochman and Horan, 2018, Field Crops Research 228 (2018) 20–30)

- Under fertilisation of N (national average = 45 kg N ha<sup>-1</sup>) is the single biggest factor contributing to this yield gap
- Significant decline in total soil N and SCO in continuous cropping (Angus and Grace, 2017; Kirkegaard et al. 2023)



# Why don't growers apply more N fertiliser

- It is difficult to match N supply to crop demand in dryland cropping
- Fertiliser N is expensive and the single biggest variable cost for growers
- Fertiliser N not taken by the current season crop (~66%) is considered as a lost cost and potentially environmentally degrading

Table: % N recovery in wheat (2013) and Barley (2014) with the application of ~ 100 kg N/ha (Smith et al.,2019).

Year	Total Plant	Soil	Soil plus Plant
2013	57 ± 9	34 ± 4	91 ± 10
2014	49 ± 6	42 ± 5	91 ± 6

- **So, all the N not taken by the current season crop is not a lost cost or environmentally degrading.**

(Ray et al., 2015; Smith et al., 2019; Barton et al., 2022; Vonk et al., 2022)



# N management should be strategic rather than tactical

Growers should have a sound strategy to fertilise the soil not the crop to close the yield gap

## Proposed strategies

**N bank (NB) target strategy: Disregards seasonal forecast of N requirements**

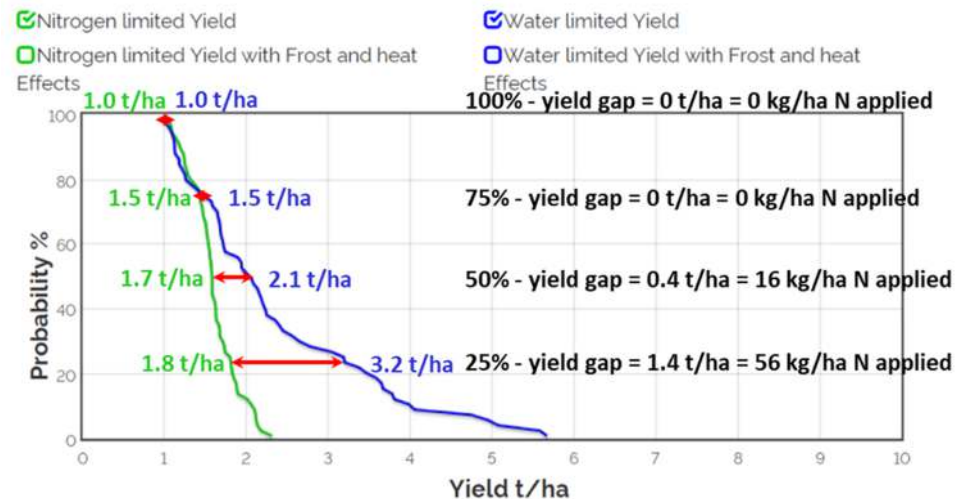
Fertiliser-N rate = A target N rate for the environment – soil mineral N measured before sowing

**Yield Prophet® (YP) strategy:**

Relies on yield forecast using historical data.

Applies 40 kg N/ha per tonne extra wheat yield

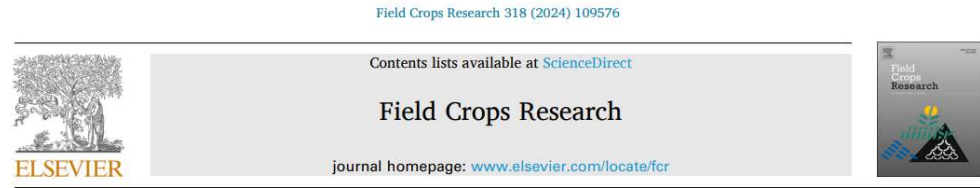
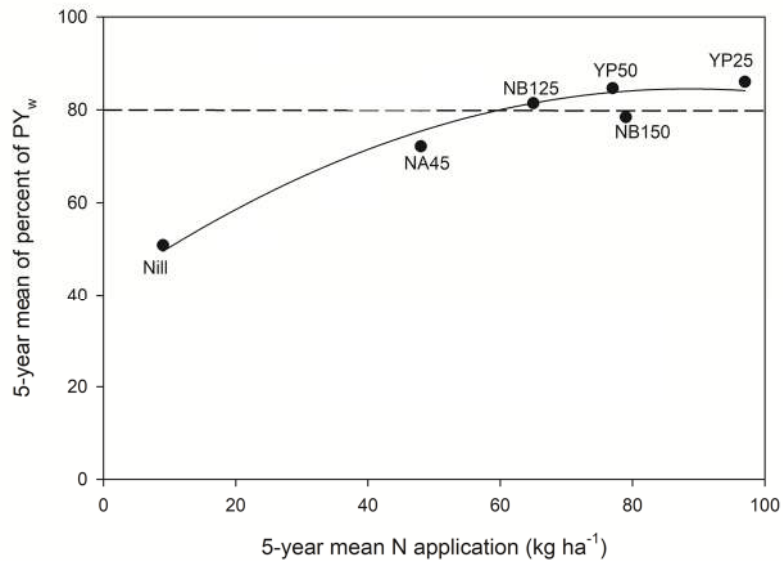
Grain Yield Outcome





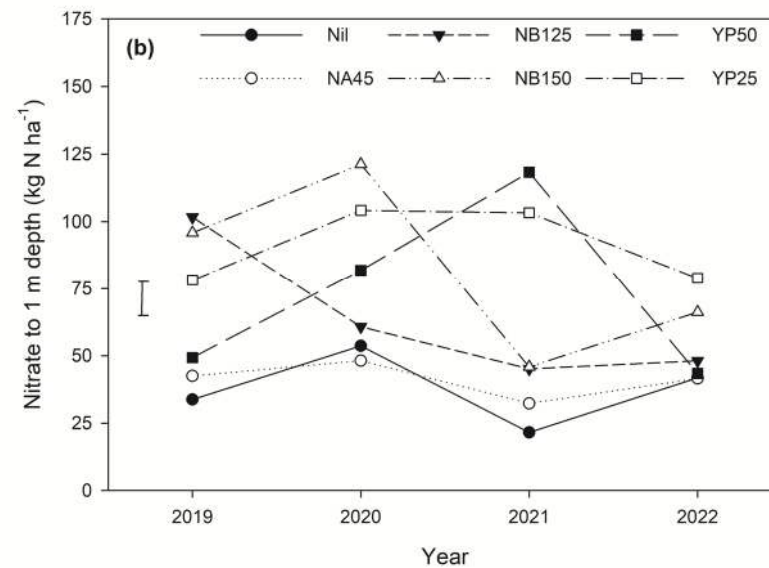
# N bank and YP systems can close yield gap

Experiment in Curyo VIC – low rainfall (357 mm)



A comparison of nitrogen fertiliser decision making systems to profitably close grain yield gaps in semi-arid environments

Arjun Pandey<sup>a,\*</sup>, James Hunt<sup>b,e,\*\*</sup>, James Murray<sup>c</sup>, Kate Maddern<sup>c</sup>, Xiaojuan Wang<sup>b</sup>, Caixian Tang<sup>d</sup>, Kate Finger<sup>c</sup>





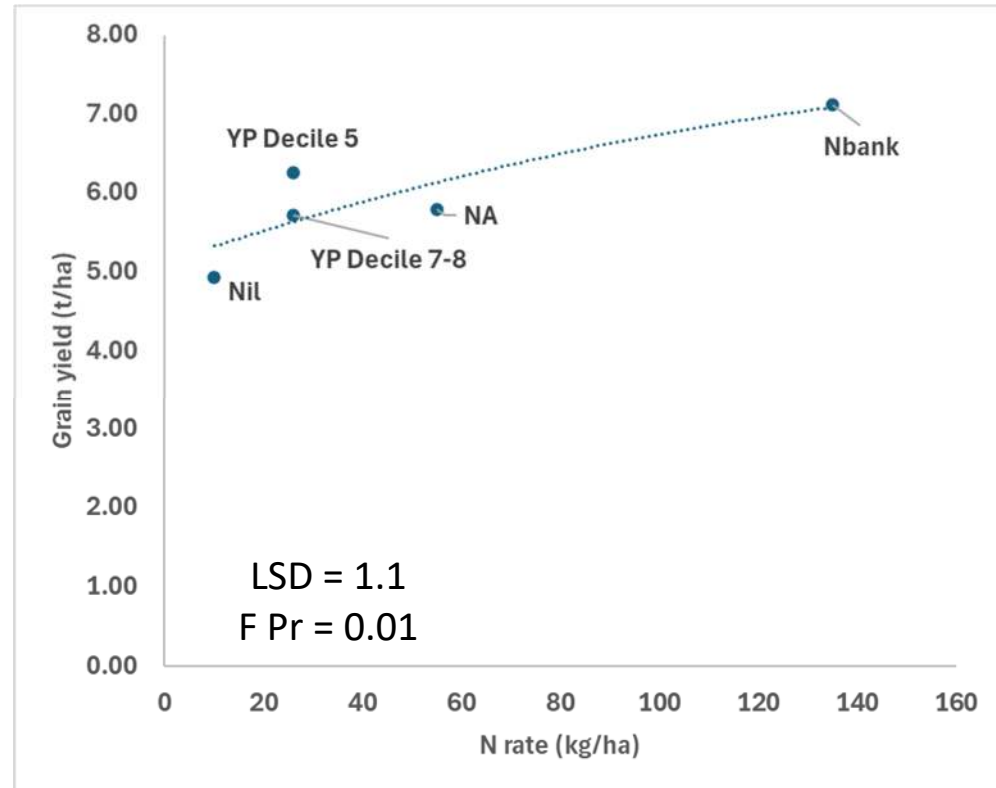
# Experiment in Dookie Campus VIC - 2023

Dookie – medium rainfall (553 mm)

N bank target = 275 kg N/ha

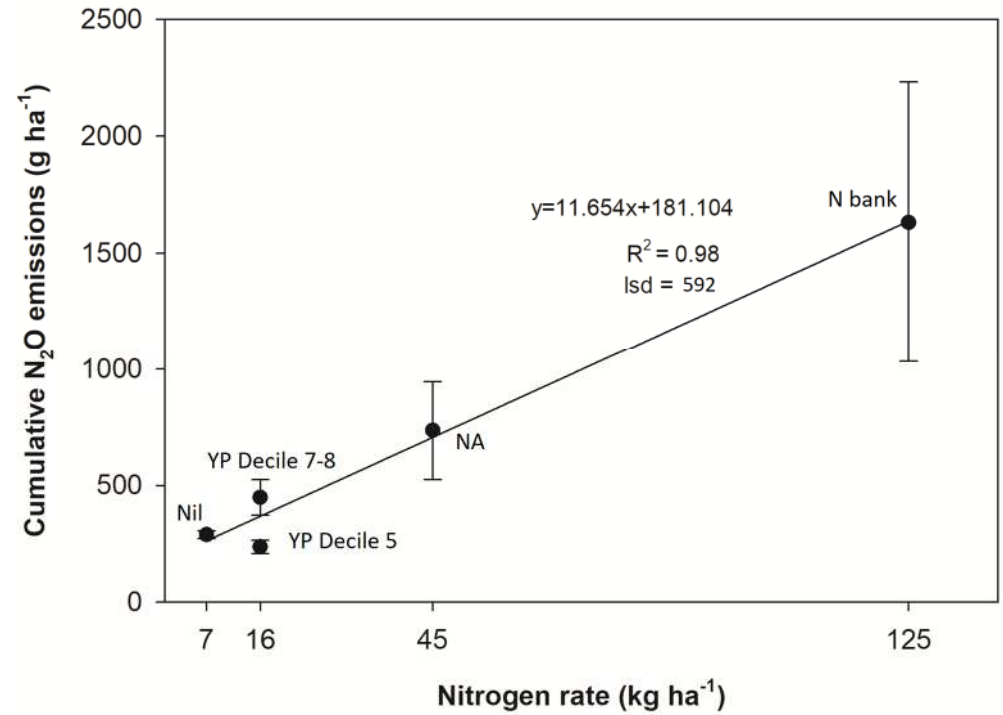
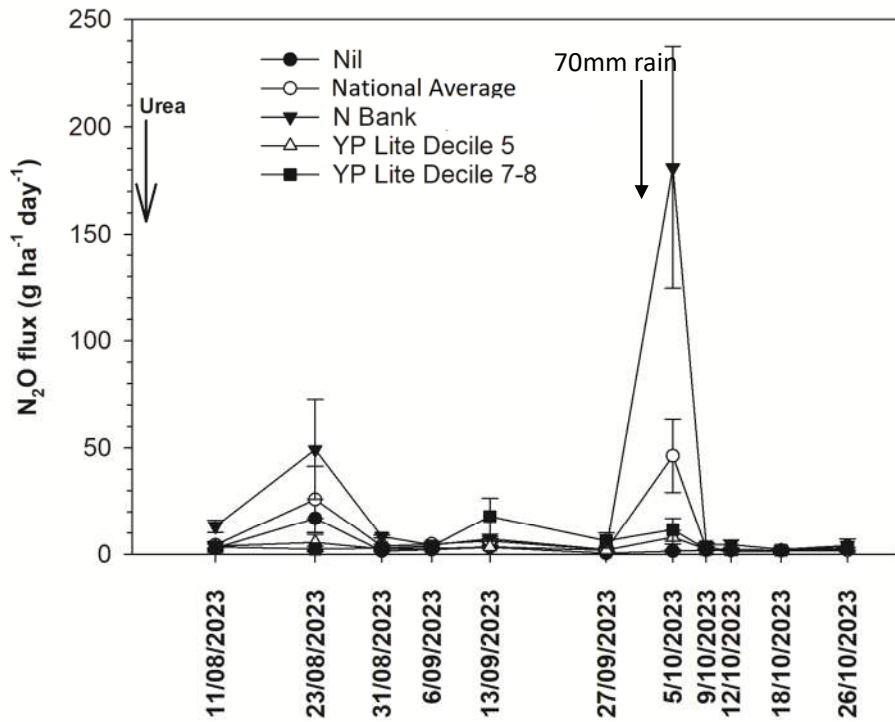
Wheat in 2023

Treatment	Fertiliser N rate (kg/ha)
Nil	10
National Average	55
YP Decile5	26
YP Decile7-8	26
N bank	135



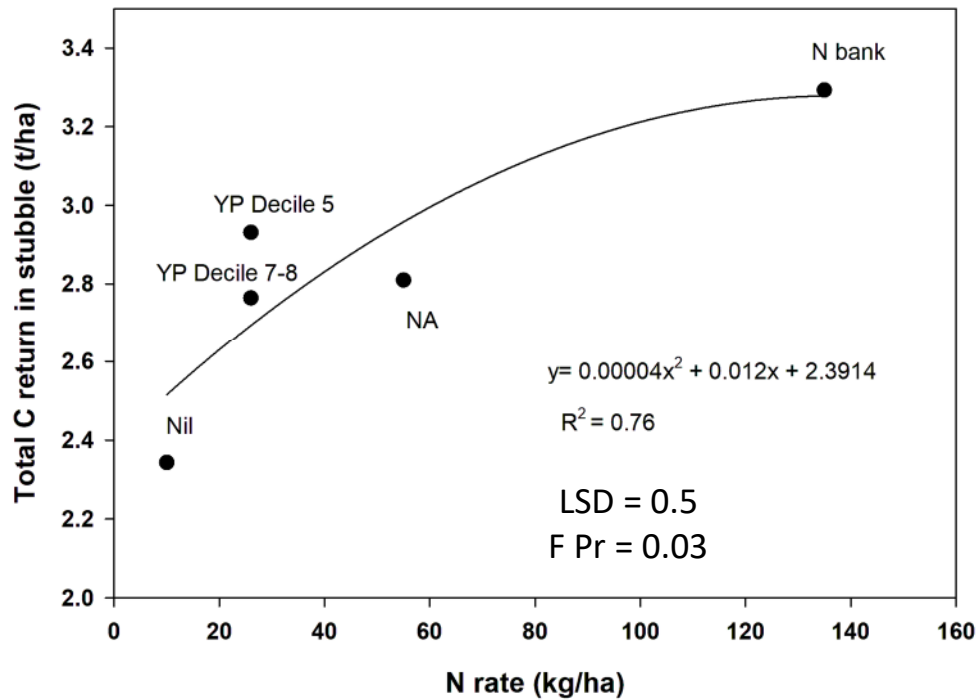


# N<sub>2</sub>O emissions in 2023 season

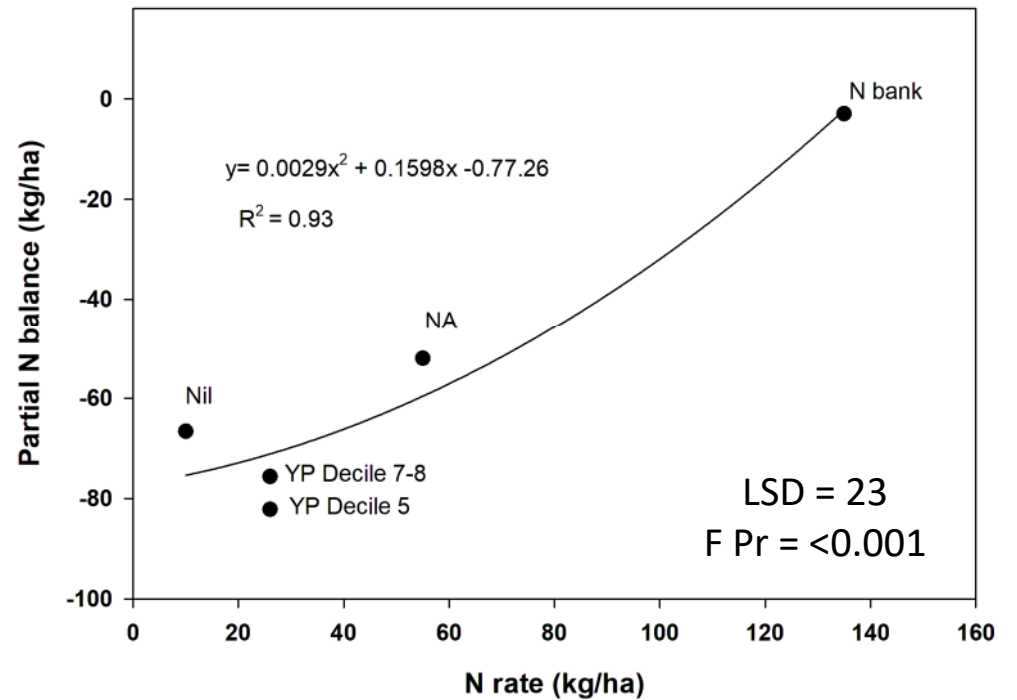




# N bank led to higher C return and near neutral N balance



Extra 0.5 t atmospheric CO<sub>2</sub>-C was assimilated in N bank compared to NA



N bank maintained near neutral partial N balance



## Broader view

**SOM has C:N ratio of 12:1 (Kirkby et al. 2011, 2013)**

**Assumptions: All the grain uptake of soil N (Total N exported in grain – Total fertiliser-N applied) came from SOM mineralisation**

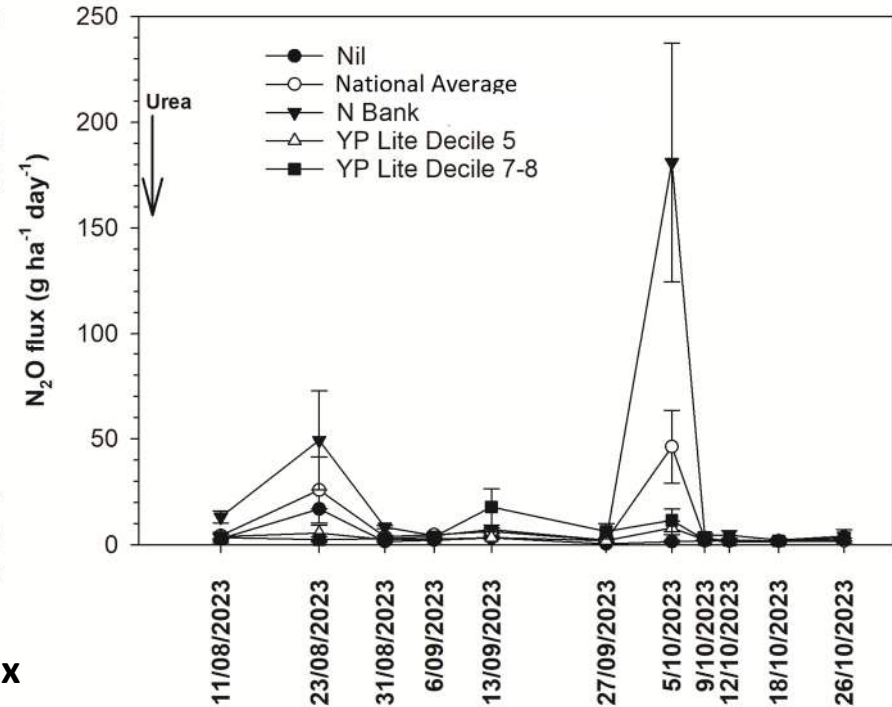
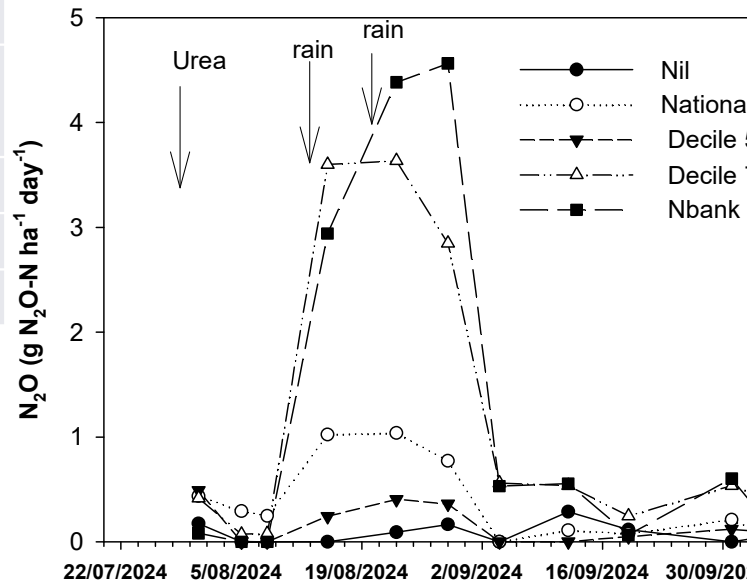
Treatment	N rate (kg/ha)	PNB (kg/ha)	C loss (kg/ha)	N <sub>2</sub> O (kg/ha)	CO <sub>2</sub> -e GHGs balance (kg/ha)
Nil	10	-67	800	0.4	897
National Average	55	-52	625	0.8	833
YP Decile5	26	-82	987	0.3	1066
YP Decile7-8	26	-76	908	0.5	1046
N bank	135	-3	35	1.7	489

**Even though N bank had more than double N<sub>2</sub>O emissions compared to National Average its CO<sub>2</sub>-e GHGs balance is almost half**



# 2024 season vs 2023 season

Treatments	N rate in 2024 (kg/ha)
Nil	10
National Average	55
YP Decile 5	4
YP Decile 7-8	104
N bank	162



In dry years, unused N does not contribute to massive N<sub>2</sub>O flux



## Conclusions

- N bank system can close yield gaps in Australian dryland cropping.
- Unlike the national average N rate, N bank system is unlikely to deplete soil organic matter due to their near neutral partial N balance and higher organic C return.
- N bank results in high N<sub>2</sub>O emissions but fixation of C in photosynthates and reduction in CO<sub>2</sub> emissions from SOM mineralisation makes the system environmentally sustainable.
- Risk of N<sub>2</sub>O emissions in dry years when crop uses less N is low, so the residual N may benefit SOM build up and the following season crop N uptake.



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# Thank you

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