Legume-based crop rotation impacts productivity and nitrogen use efficiency in south-eastern Australia

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Background

Need for crop diversification for sustainable farming systems.

Monoculture systems:

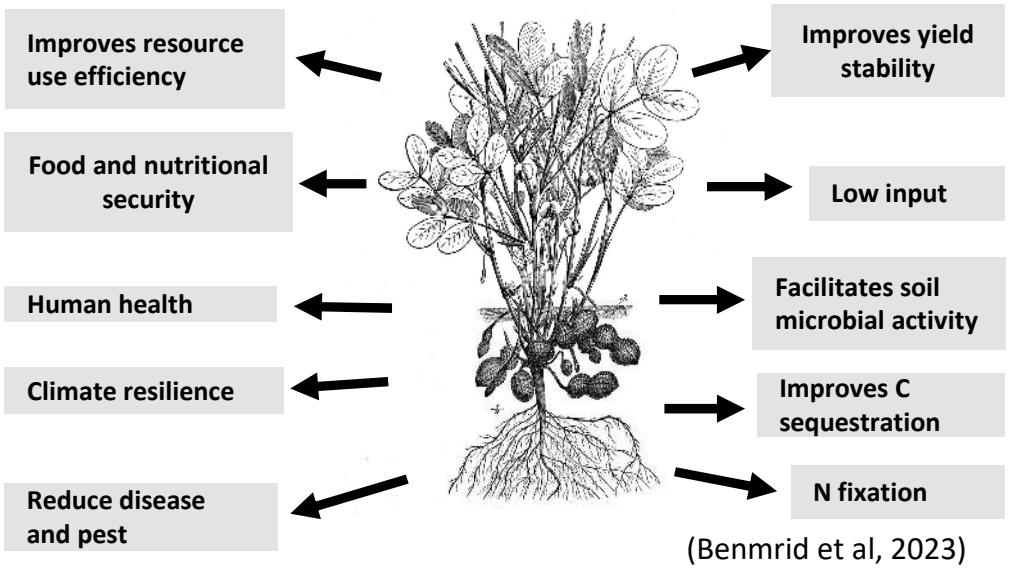
Advantage

- High yielding and profitable in the short term.

Disadvantage

- High external input
- Vulnerable to risks (climate, pest)
- Soil resource depletion
- High carbon emission

Why integrating legumes matter?



(Benmrid et al, 2023)

Example (Southern Australia)

- Pea and lupin contribute 60-110 kg N ha^{-1} (Park et al., 2010)
- Reduce leaf and root diseases (Jensen et al., 2020)

Research questions

Do legume-based crop rotation systems improve crop yield in the long-term ?

Do they improve resource use (water and nitrogen) use efficiency?

By how much they can potentially increase SOC and N stock in the soil?

Objectives

To predict long-term contribution of legume-based crop rotation through changes in:

1. Crop yields and profitability of farming systems.
2. Soil attributes(SOC and N).
3. Resource use efficiency (water and nitrogen).

Methods

A modelling study based on the long-term trial at CSIRO, Boorowa Agricultural Research Station (BARS), NSW, Australia.

Modelling scenarios

Four crop rotation scenarios

1. Canola-wheat-wheat (Intensive)
2. Faba bean-barley-oat-canola-lupin-wheat (Diversified 1)
3. Faba bean-canola-wheat-barley-faba bean-wheat (Diversified 2)
4. Lucerne-lucerne-lucerne-canola-wheat-wheat (Pasture-based)

Based on long-term Farming system trial

Model Calibrate and evaluate

Soil N levels
(0, 50, 100,200, 300 kg N-No_3/ha)

Climate
- Long-term (1980-2020)

Agro-ecologies
Boorowa, Cootamundra, Condobolin, and Ardlethan

APSIM Classic

Yield

Gross margin

Soil
(SOC and N)

Resource use efficiency
(nutrients, water, labour)

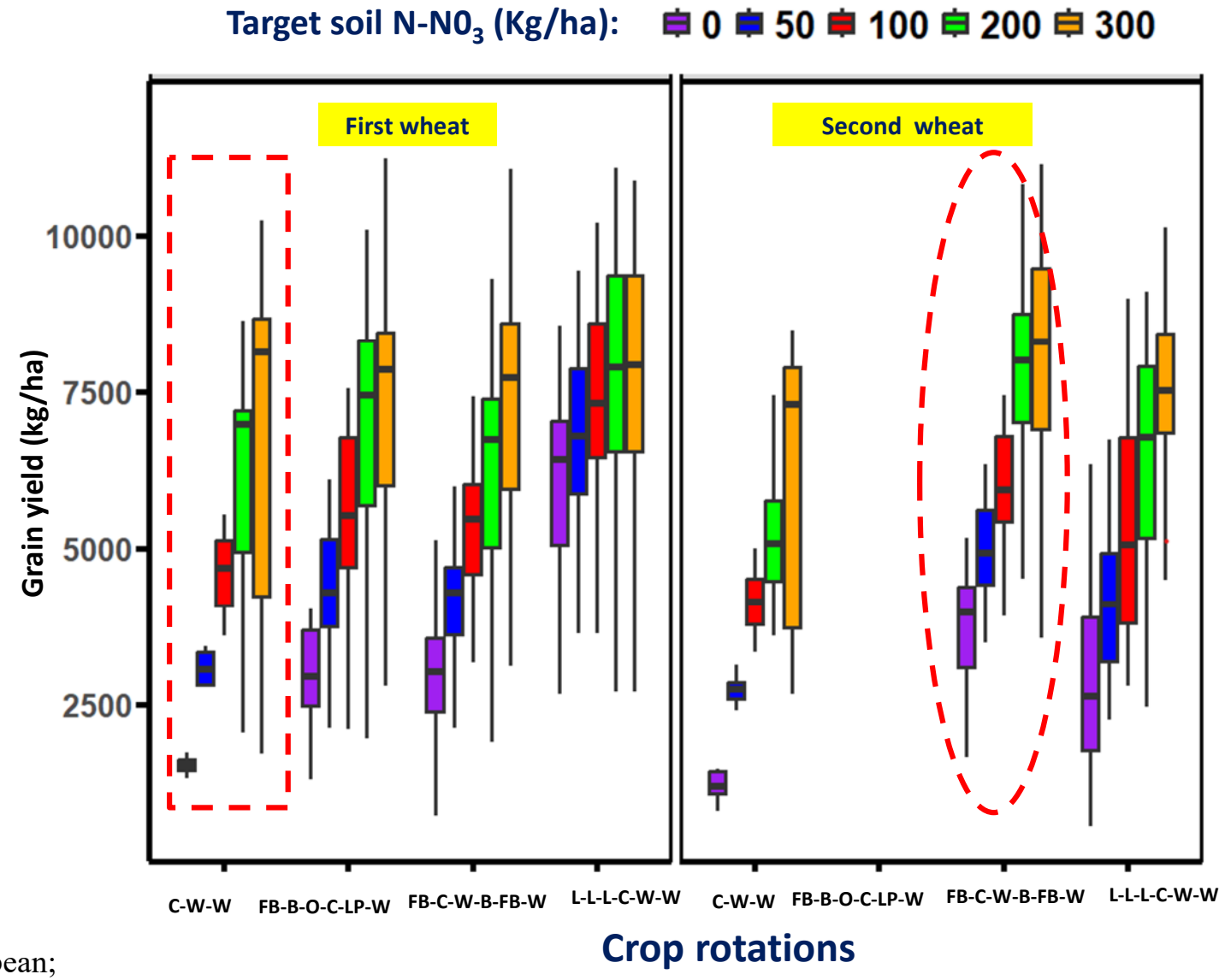
GHGs

Findings

- Focus: Boorowa site
- Crop yields, considering wheat as a benchmark
- Soil organic carbon
- Nitrogen fertiliser use efficiency
- Profit

Impact of six-year rotation on wheat yield

- Only the intensive C-W-W, first year wheat with 300kg/ha out yielded the 1st yr wheat crops following lucerne.



C, canola; W, wheat; L, lucerne; FB, faba bean; B, barley; LP, lupin; O, oats.

Impact of rotation on soil organic carbon

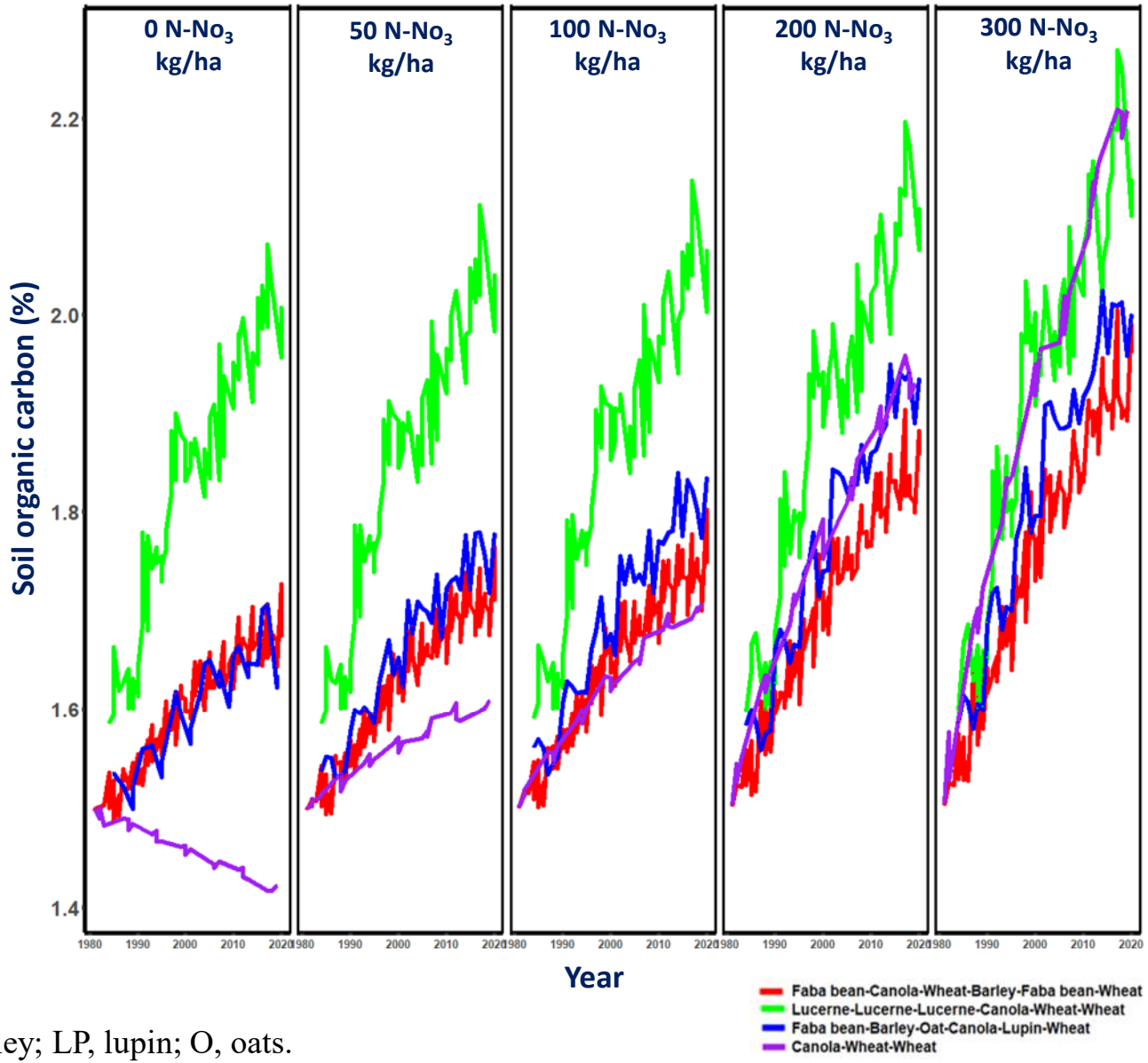
- At low N (< 200 N-No3 kg/ha),

L-L-L-C-W-W > FB-B-O-C-LP-W > FB-C-W-B-FB-W > C-W-W.

- At higher N,

L-L-L-C-W-W > C-W-W > FB-B-O-C-LP-W > FB-C-W-B-FB-W.

- The difference narrowed with increased N.



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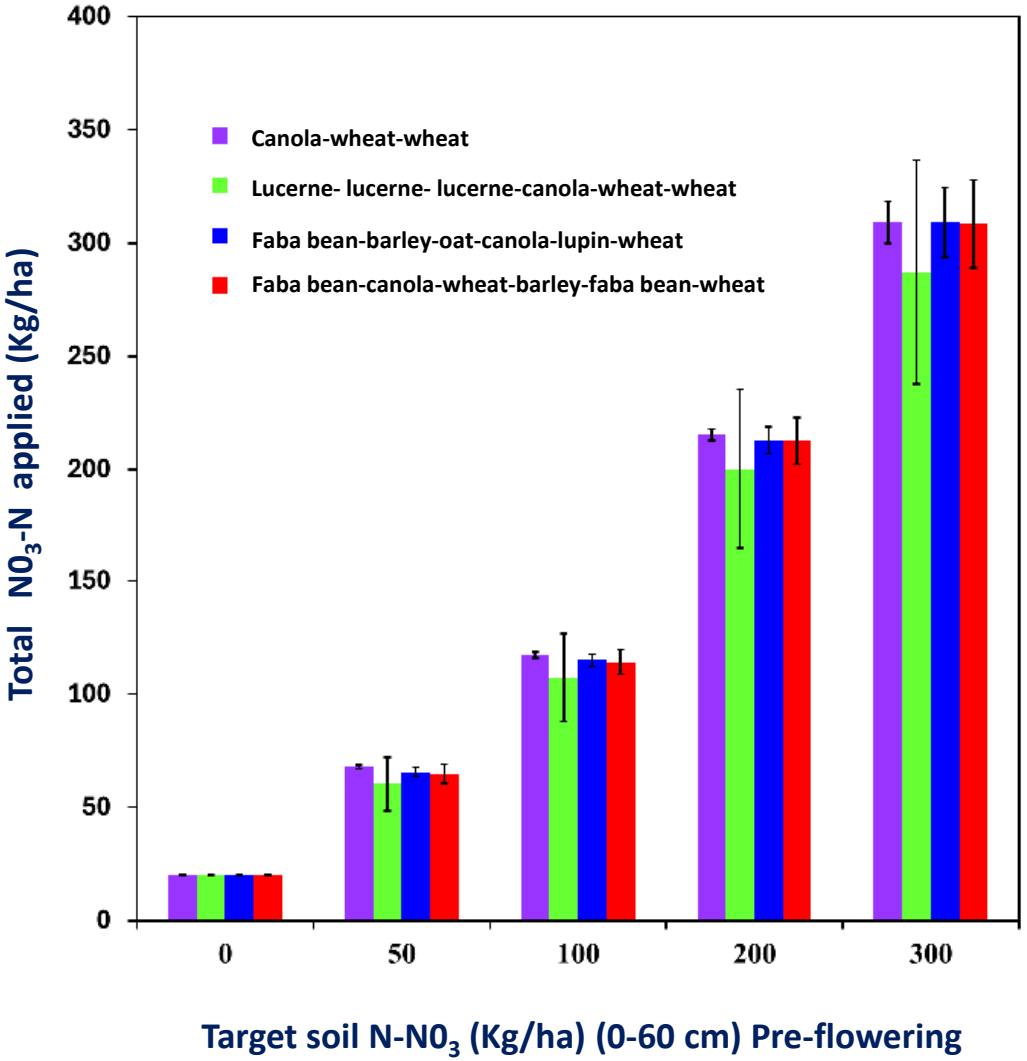
Fertiliser use efficiency

- Fertiliser requirement,

L-L-L-C-W-W < FB-C-W-B-FB-W < FB-B-O-C-LP-W < C-W-W



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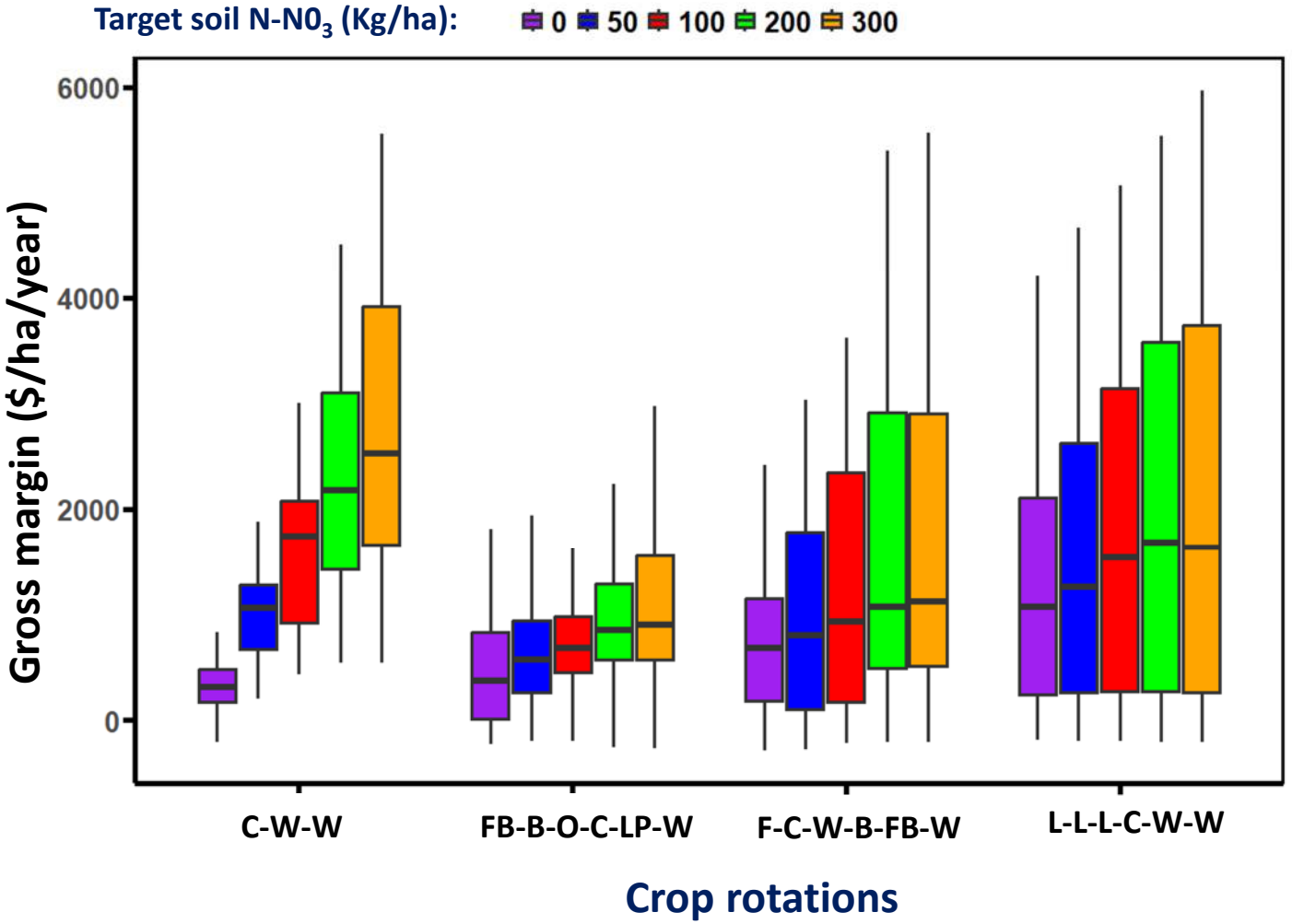
Gross margin

(Gross benefit (GB): Yield * grain price; Cost (C): production cost for each; crop; Gross margin: GB-C)

- L-L-L-C-W-W crop rotation was found to be more profitable for low N inputs (< 100 N-$N0_3$ (Kg/ha).
- C-W-W gave higher profit for high N levels (> 100 N-$N0_3$ (Kg/ha).
- FB-B-O-C-LP-W was least profitable.



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Conclusion

Integrating legumes into a crop rotation can improve or maintain stable crop yields in the long term by maximizing resource use efficiency, including nitrogen fertilizer and rainfall.

Including legumes such as lucerne and faba bean in a crop rotation significantly increases soil carbon levels.

Integrating legumes reduces the amount of nitrogen fertilizer needed, compared to intensive production system over the long term.

Thanks!

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