Department of
Primary Industries and
Regional Development
GOVERNMENT OF
WESTERN AUSTRALIA

Protect
Grow
Innovate

Continued improvement in WUE; Where do break crops & pastures fit?

Grains Industry Day 2023

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Introduction

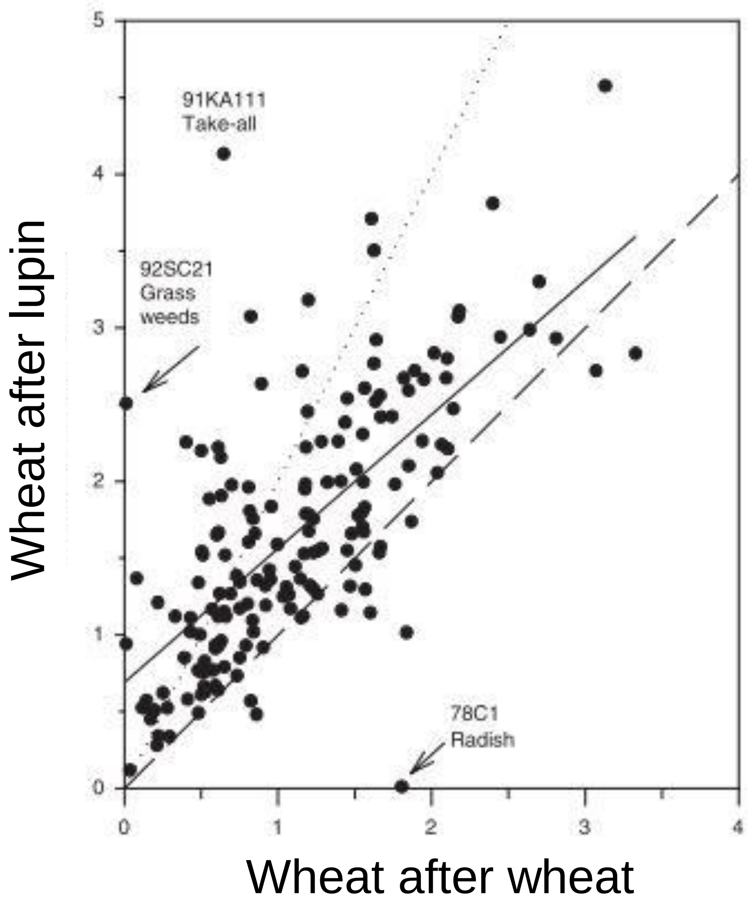
- Break crops and pastures are used to manipulate;
  - Weeds; rotation of chemicals and different techniques
  - Pathogens; non-host year
  - Nutrients; N and cycling of other elements
- Other legacy effects; soil water, soil biology
- Interactions between these biophysical variables

1) Angus, J, Kirkegaard, J, Hunt, J, Ryan, M, Ohlander, L, Peoples, M (2015) Break crops and rotations for wheat. *Crop and Pasture Science* **66, 523-552.10.1071/CP14252**
2) Kirkegaard, JA, Peoples, MB, Angus, JF, Unkovich, MJ (2011) Diversity and evolution of rainfed farming systems in southern Australia. In 'Rainfed Farming Systems.' (Eds P Tow, I Cooper, I Partridge, C Birch.) pp. 715-754. (Springer: Dordrecht, The Netherlands)
3) Kirkegaard, J, Christen, O, Krupinsky, J, Layzell, D (2008) Break crop benefits in temperate wheat production. *Field Crops Research* **107, 185-195.10.1016/j.fcr.2008.02.010**

Break crop effect on wheat yield…

- Traditionally small plot trials are reported as wheat/wheat vs break/wheat

- Many reports of yield increases, not always



1) Seymour, M, Kirkegaard, JA, Peoples, MB, White, PF, French, RJ (2012) Break-crop benefits to wheat in Western Australia; insights from over three decades of research. *Crop and Pasture Science* ***63, 1-16.10.1071/CP11320***
2) Lawes, R (2010) 'Using industry information to obtain insight into the use of crop rotations in the Western Australian wheat belt and quantifying their effect on wheat yields, The 15th ASA Conference; Food security from sustainable Agriculture. .' Lincoln, New Zealand, 15-18 November. (Australian society of Agronomy: Lincoln, New Zealand)

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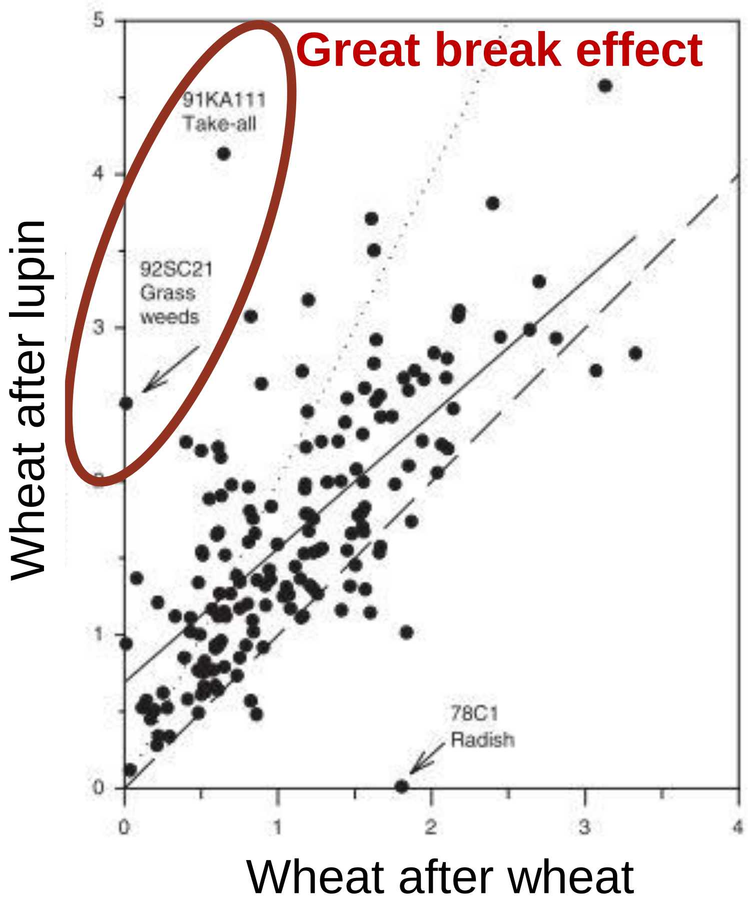

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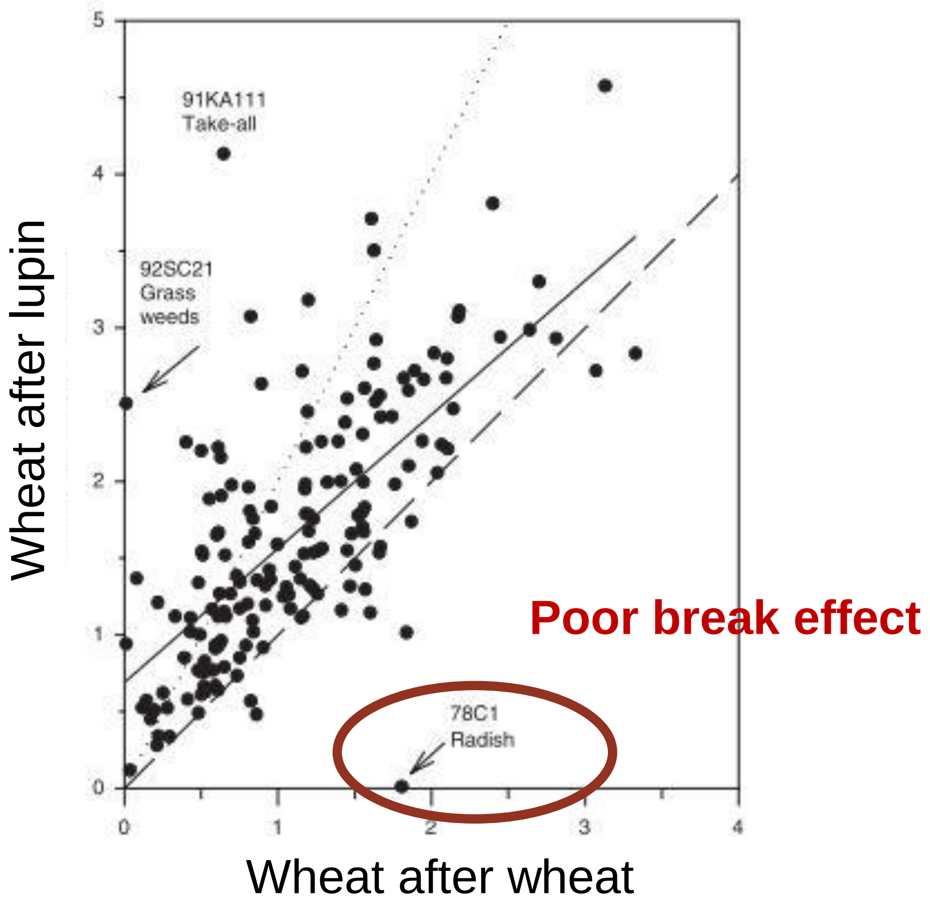
Break crop effect on wheat yield…

- Traditionally small plot trials are reported as wheat/wheat vs break/wheat
- Many reports of yield increases, not always
- Response depends on whether there was a production constraint ameliorated by the break
- Data reported from commercial paddocks can differ from small plot trials,

i.e. 600kg vs 200kg



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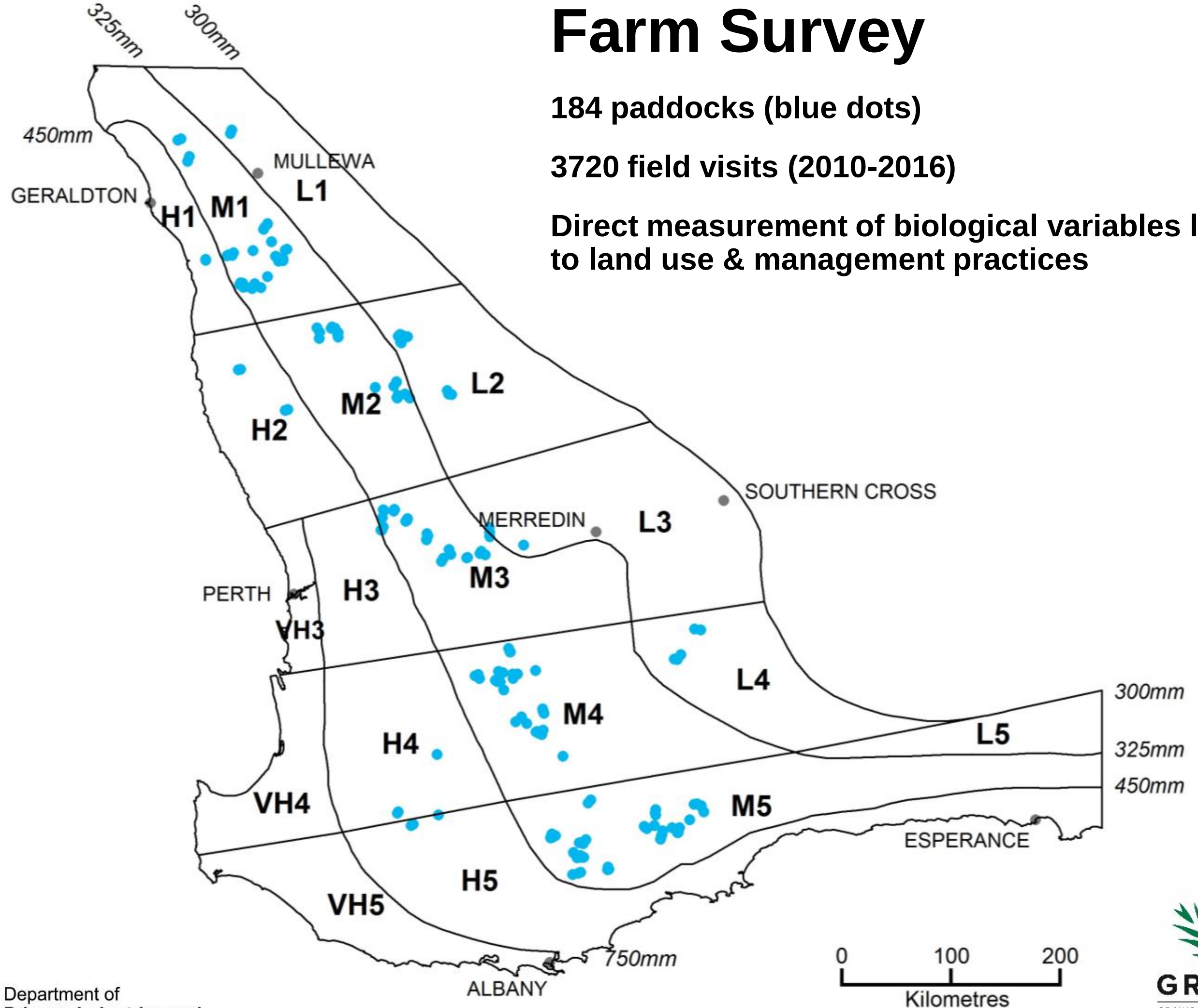
So we looked at commercial paddocks

Farm Survey

184 paddocks (blue dots)

3720 field visits (2010-2016)

Direct measurement of biological variables linked to land use & management practices



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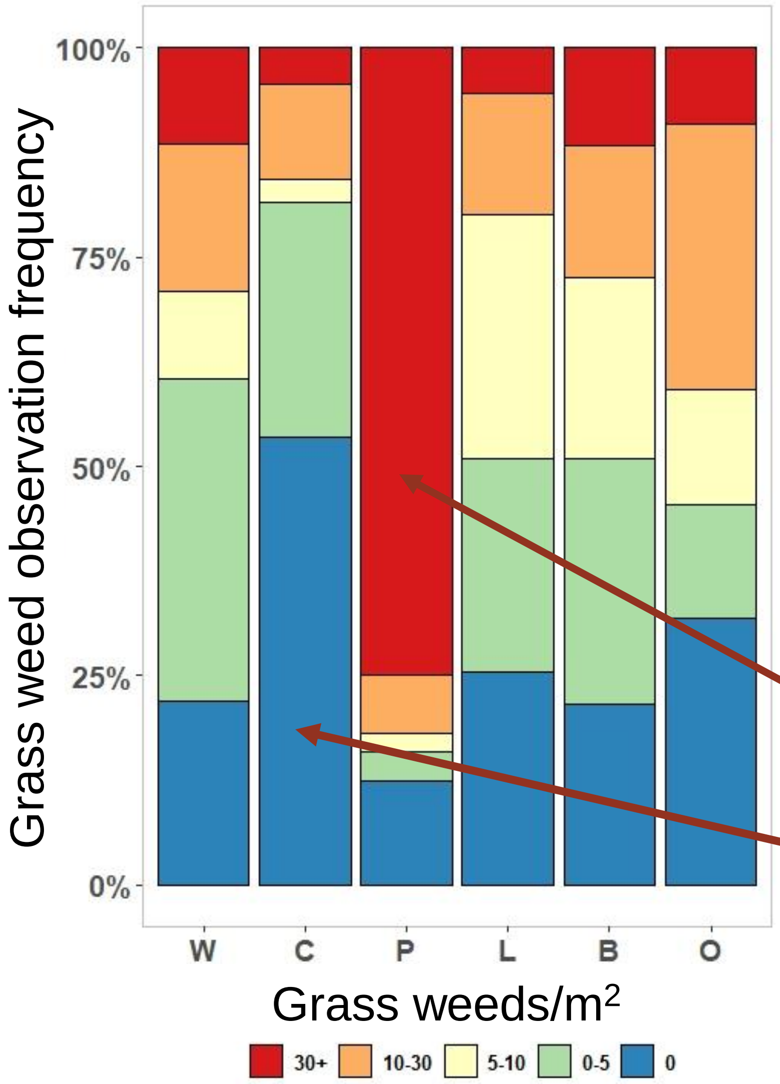
GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

DPIRD: Liebe Group, Facey group, MIG, WANTFA, GRDC

Weeds



W = wheat, C = canola, P = pasture
L = Lupin, B = barley, O = other

Weeds were well managed in most paddocks

- >70% crop paddocks with <10 grass weeds/m2 at anthesis.

Herbicide resistance common

- 92% paddocks ryegrass resistance to at least 1 herbicide

Herbicides were still key to weed control

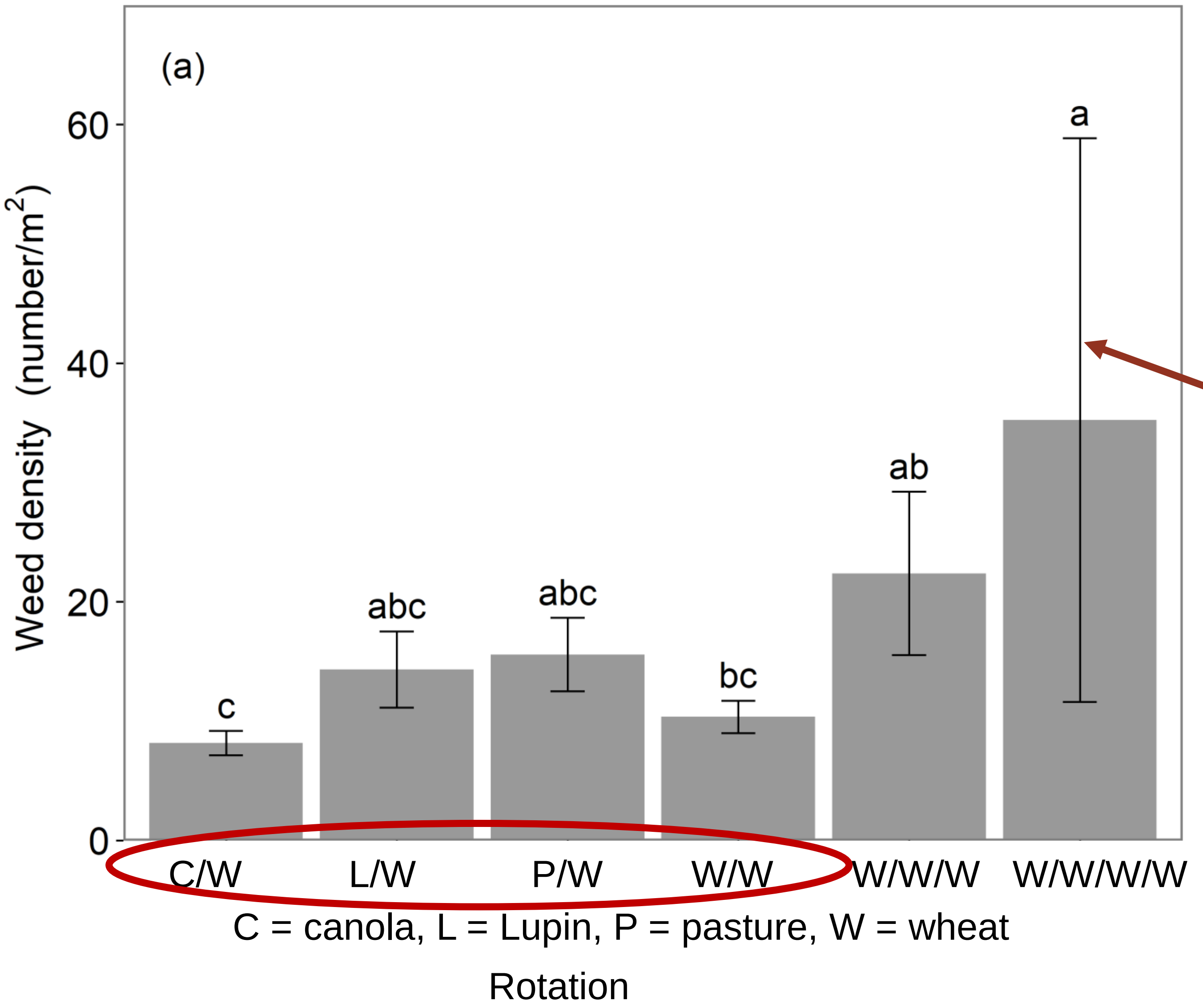
- 45 actives used (~6.5 p.a. for crops, ~2 for pasture)

Switch to land uses with fewer weeds

- Pasture most weeds (~70% > 30 grass/m2)
- Canola fewest weeds (~80% < 5 grass/m2)

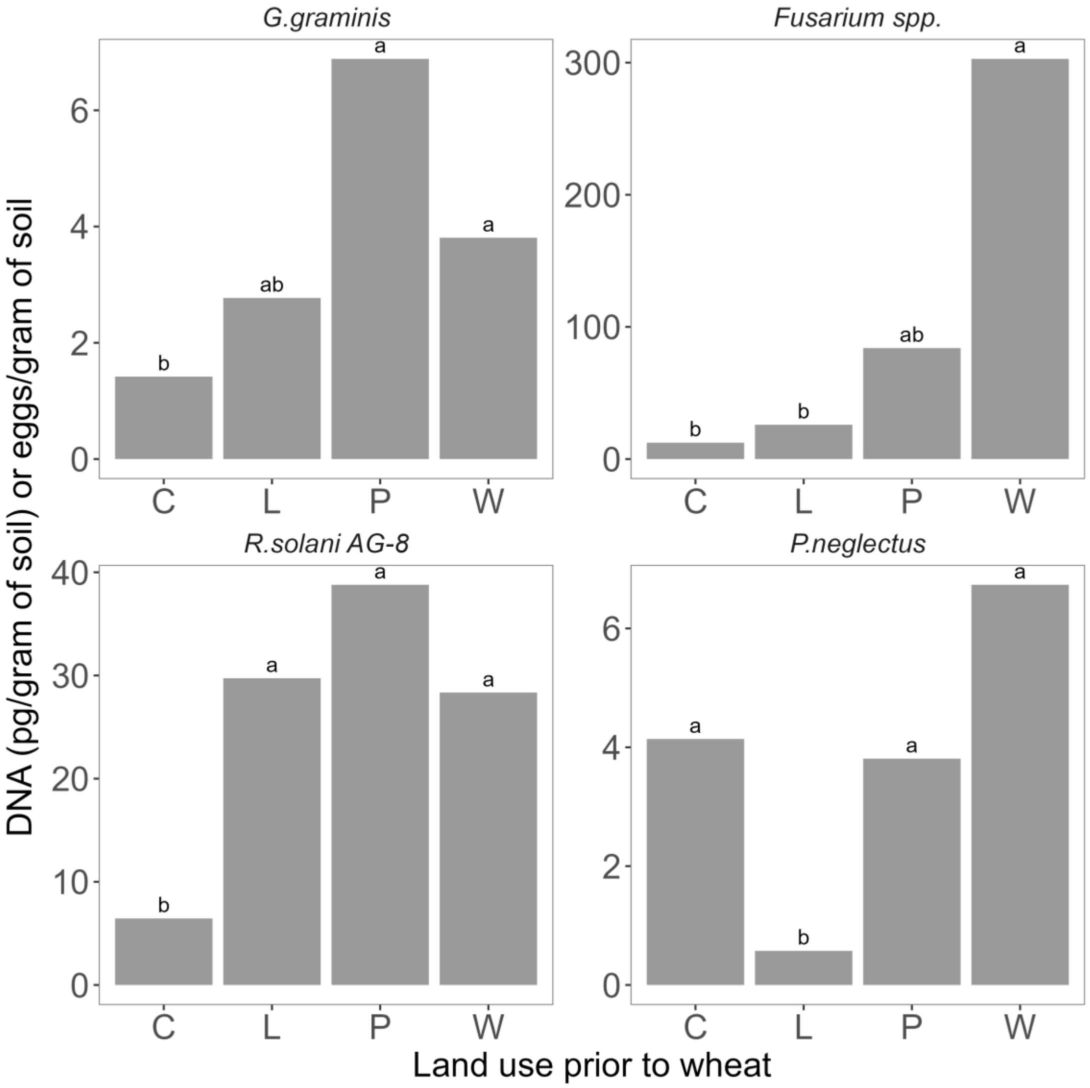
Suite of IWM used

Weeds increased in wheat sequences



- 2nd wheat in a row (W/W) had similar weed density as wheat after canola, lupin or pasture
- 3rd and 4th wheat weeds increasing
- 4th wheat results variable, some blow outs

Soil pathogens

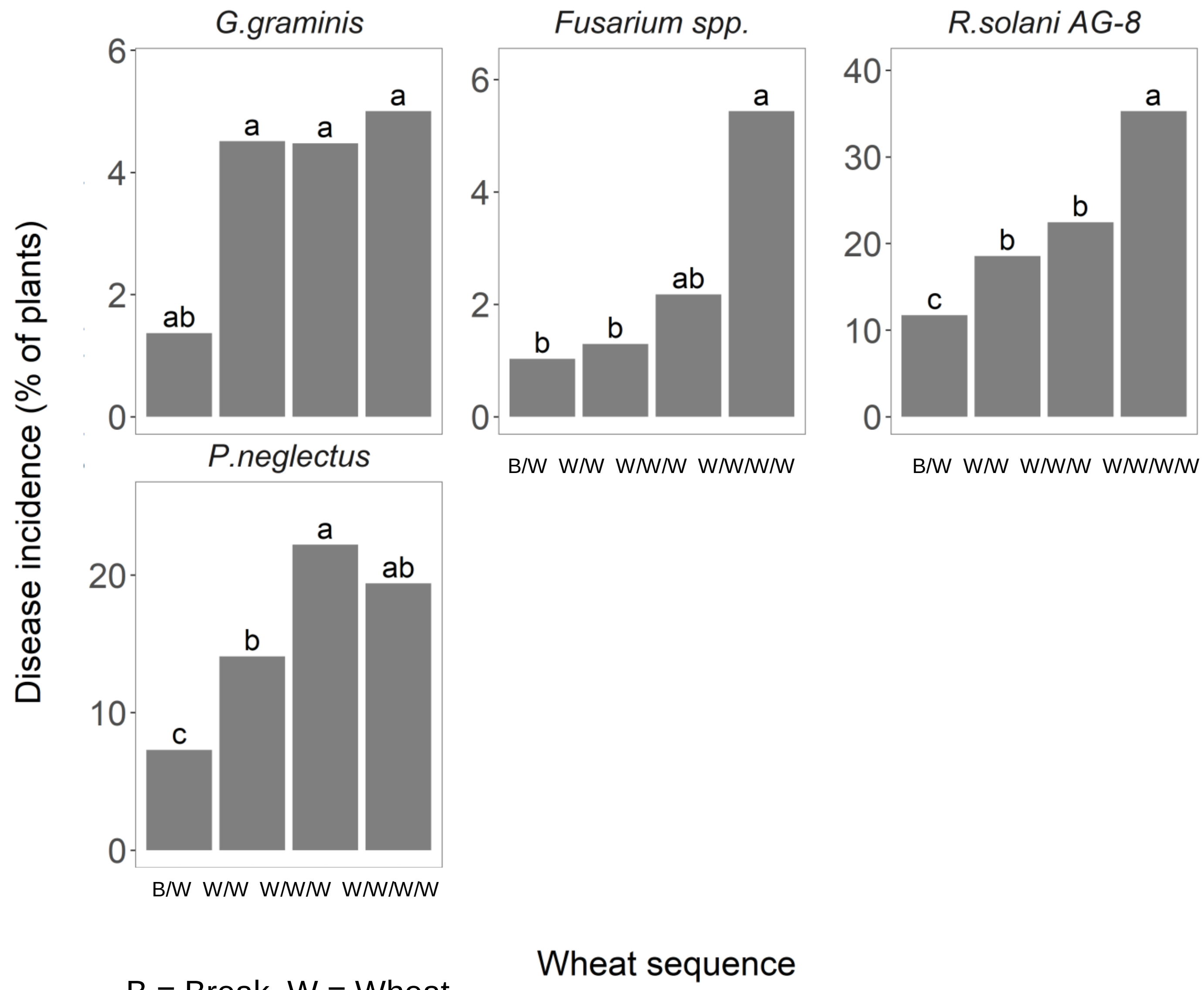


C = canola, L = Lupin, P = pasture, W = wheat

PreDictaB DNA results

- Take all higher after pasture (grassy pasture)
- Crown rot large increase in successive wheat
- *R.solani AG-8* lower after canola
- *P. neglectus (nematode)* lower after lupin
- All are responses we would expect…..

Soil pathogens increased in wheat sequences

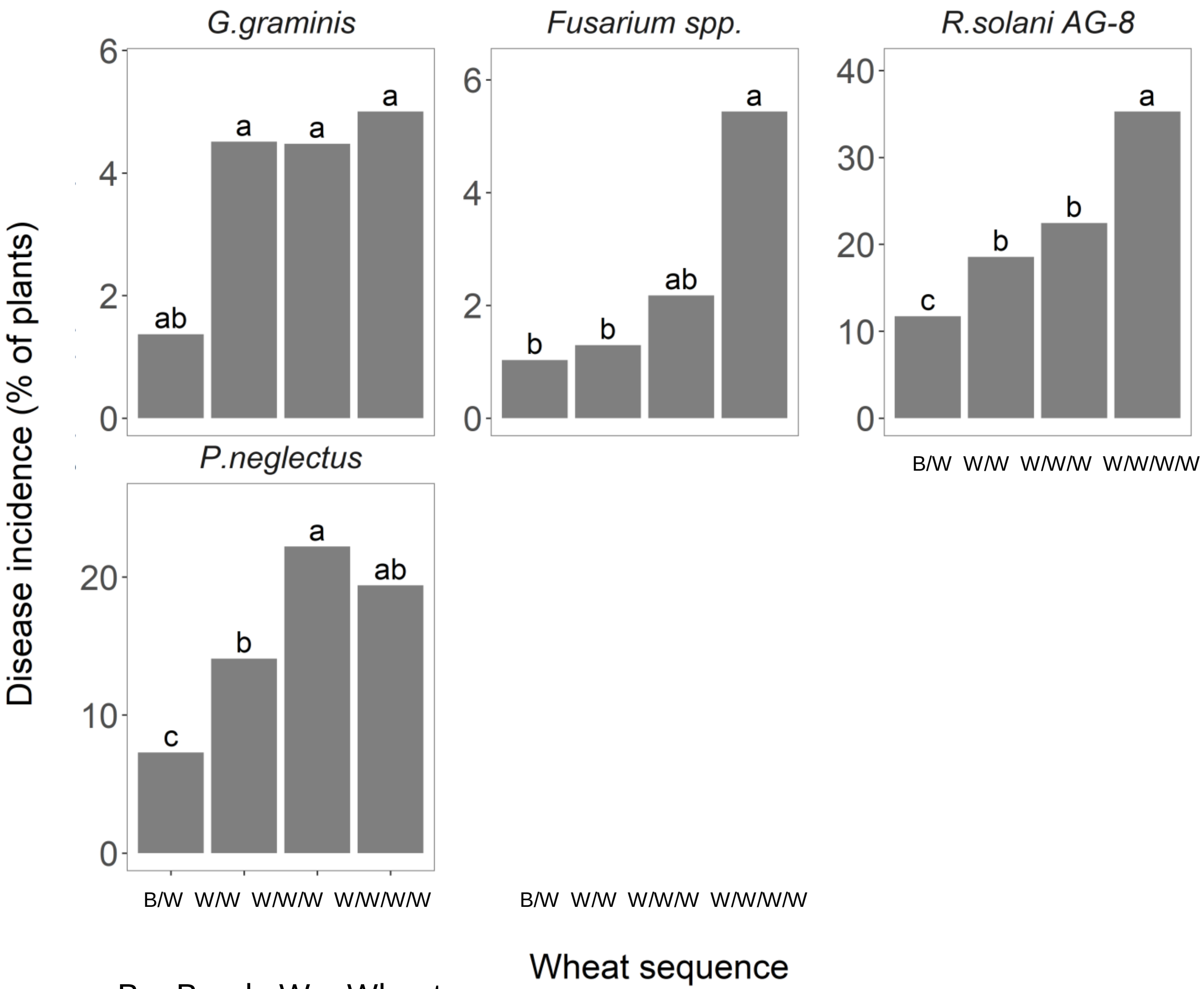


B = Break, W = Wheat

Soil root damage results…

- Incidence of each pathogen increased in wheat sequences

Soil pathogens increased in wheat sequences

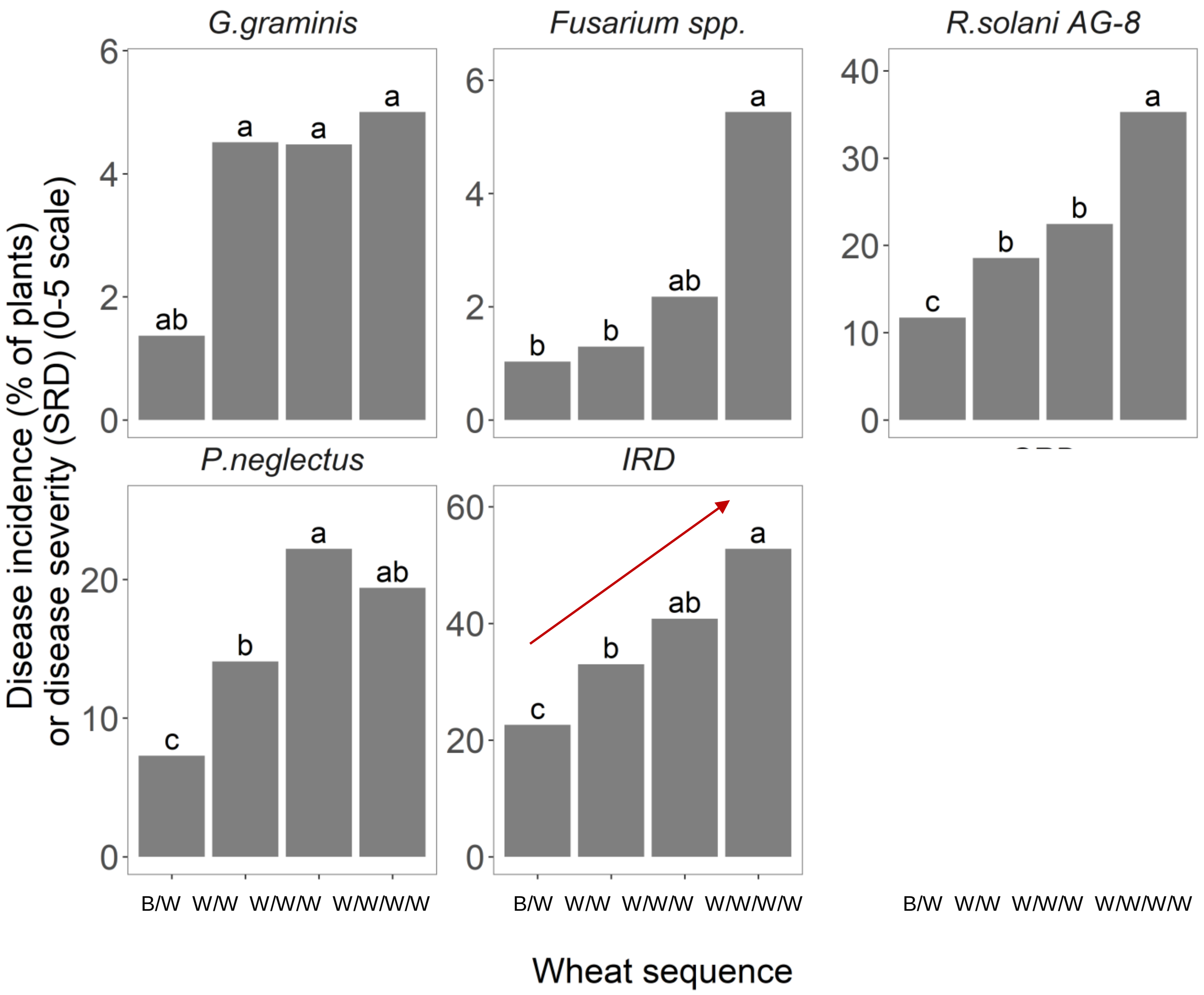


B = Break, W = Wheat

Soil root damage results…

- Incidence of each pathogen increased in wheat sequences
- Combined incidence of root disease (IRD) of wheat pathogens increased in longer sequences of wheat (from ~ 20% to ~50%)

Soil pathogens increased in wheat sequences



NW = not wheat/W, W = W/W, W2 = W/W/W, W3 = W/W/W/W

Soil root damage results…

- Incidence of each pathogen increased in wheat sequences
- Combined incidence of root disease (IRD) of wheat pathogens increased in longer sequences of wheat (from ~ 20% to ~50%)
- Severe root damage (SRD = 4-5) was rare. But damage less after a break.

Soil pathogens were well managed in most paddocks

Nutrition

N, P, K, S balances for each land use

Land use	N	P	K	S
Barley	-24	2	-8	3
Canola	-15	2	-10	-3
Lupin	47	2	-9	0
Pasture	48	1	0	1
Wheat	-20	3	-6	3
W2	-24	2	-8	2
W3	-8	4	-7	4
W4	1	8	-5	3

N budget

- Barley, canola, wheat –ve

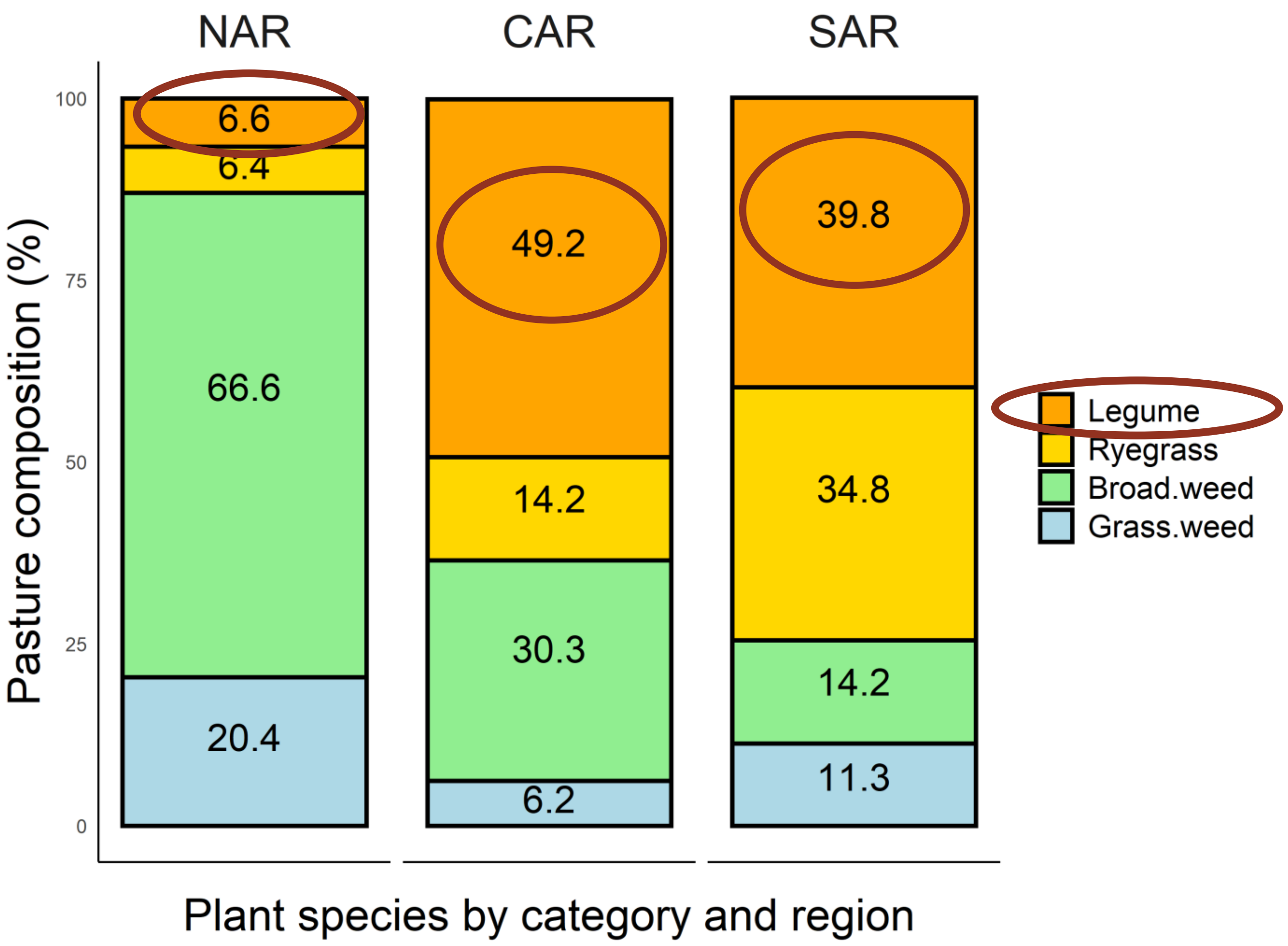
- 74 paddocks +ve rotational N balance (over study years)
- 110 paddocks -ve rotational N balance (over study years)
  - NAR mean +2.8 kg N/ha/year (1860 kg/ha grain)
  - CAR mean -7.0 kg N/ha/year (2404 kg/ha grain)
  - SAR mean -15 kg N/ha/year (3320 kg/ha grain)

Fertiliser N on wheat

- Mean of 45 kg N/ha
- 35 kg first year after legume
- 45 kg second year after legume (W2)
- ~ 55 kg third & fourth year after legume (W3)

W4 +ve N balance due to higher fert and lower yield

Nutrition



Pasture composition data B. Nutt & R. Yates (Focus Paddock Survey)

Legume N fixation

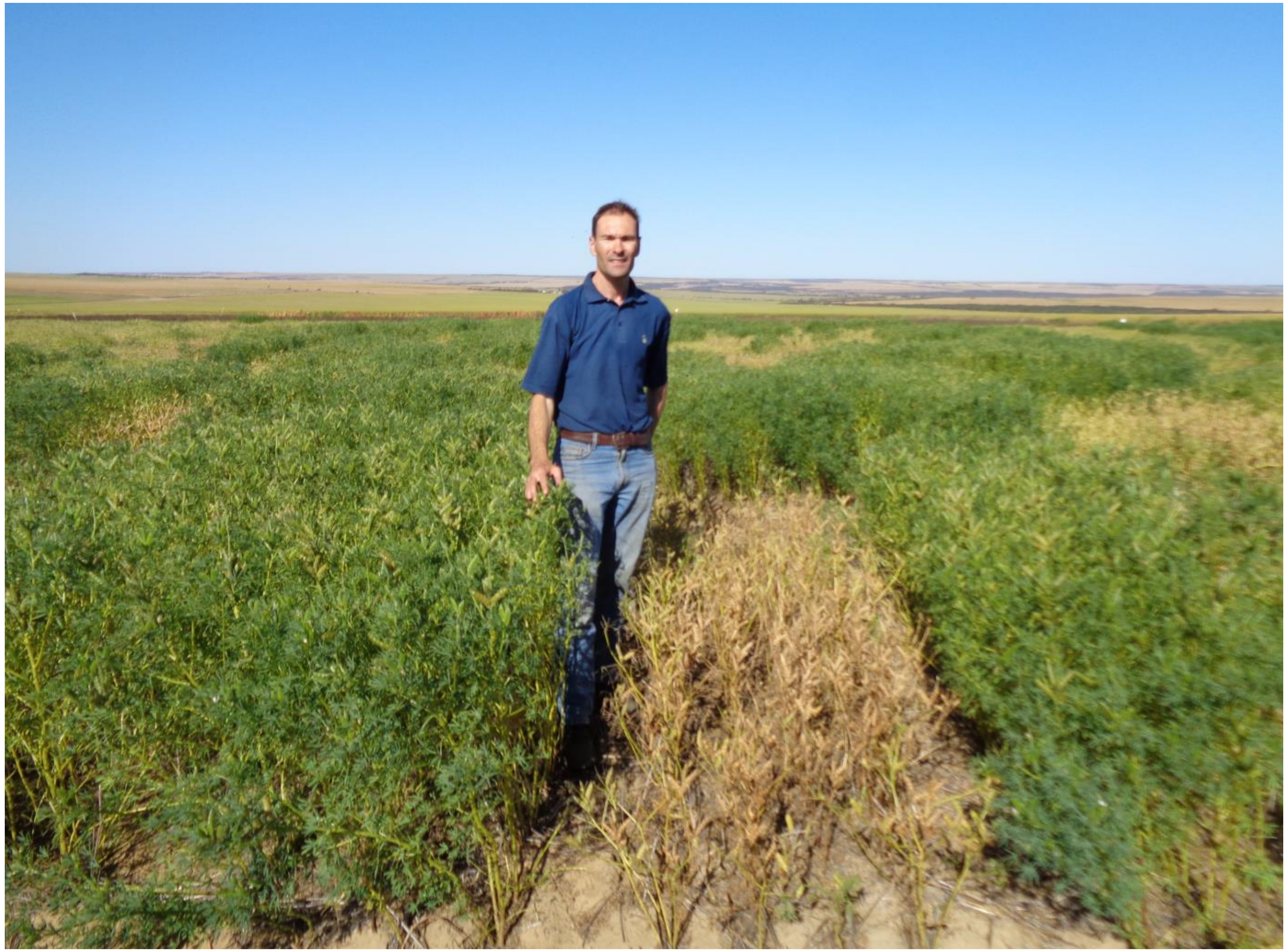
- **Pasture (mean = 46 kg/ha/year)**
  - NAR = 6 kg/ha, CAR = 65, SAR = 50
  - Low legume content and biomass in NAR

Unkovich, M, Pate, J, Hamblin, J (1994) The nitrogen economy of broadacre lupin in southwest Australia. *Australian Journal of Agricultural Research* ***45, 149-164.***
Evans, J, McNeill, A, Unkovich, M, Fettell, N, Heenan, D (2001) Net nitrogen balances for cool-season grain legume crops and contributions to wheat nitrogen uptake: a review. *Australian Journal of Experimental Agriculture* ***41, 347-359.***
Harries, M, Flower, KC, Scanlan, CA (2021) Sustainability of nutrient management in grain production systems of south-west Australia. *Crop and Pasture Science* ***72, 197-212.***

Pasture productivity

North **South**

Nutrition



Unicrop Jurien Chittick

Legume N fixation

- Pasture (mean = 46 kg/ha/year)
  - NAR = 6 kg/ha, CAR = 65, SAR = 50
  - Low legume content and biomass in NAR

- **Lupin (mean 41 kg/ha/year)**
  - NAR = 35 kg/ha, CAR = 55, SAR = 40
  - High harvest index of lupin in NAR

Study	Year	HI	Mean n-fix (kg.N/ha)
Unkovich	1986	0.11	96
Evans	2001	0.23	80
Harries	2010-16	0.31	41

Unkovich, M, Pate, J, Hamblin, J (1994) The nitrogen economy of broadacre lupin in southwest Australia. *Australian Journal of Agricultural Research* ***45, 149-164.***
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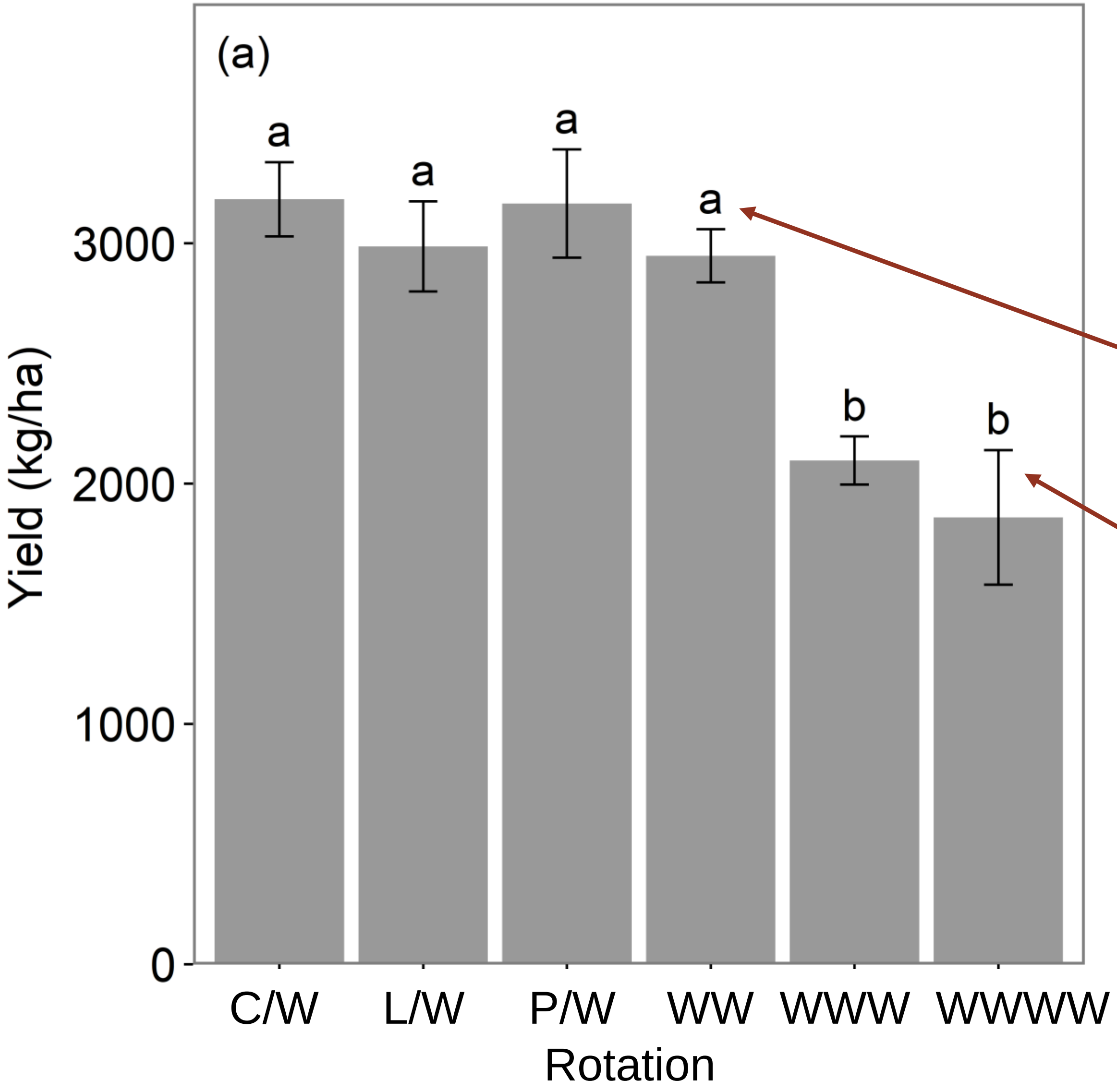
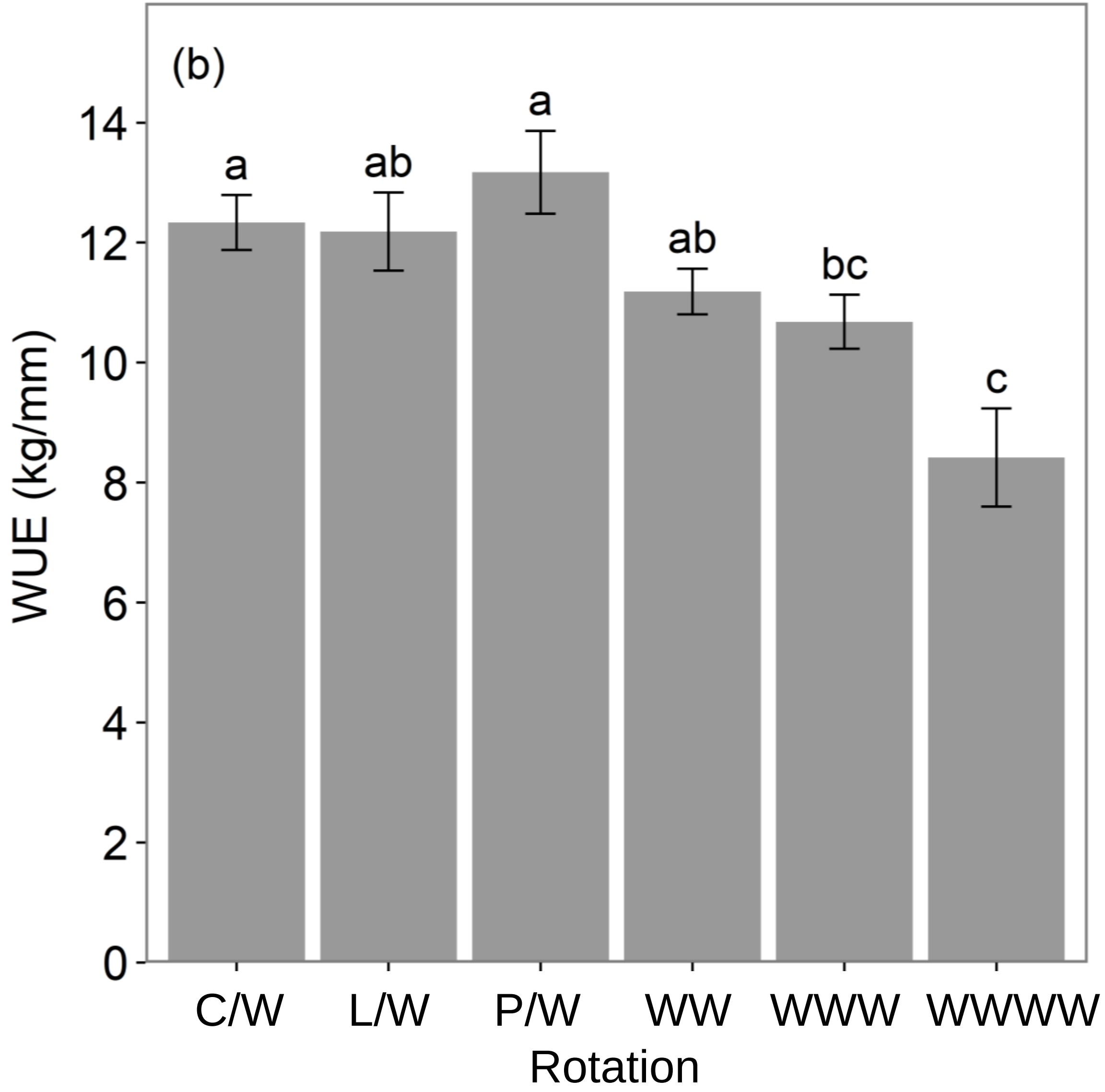
Wheat yield



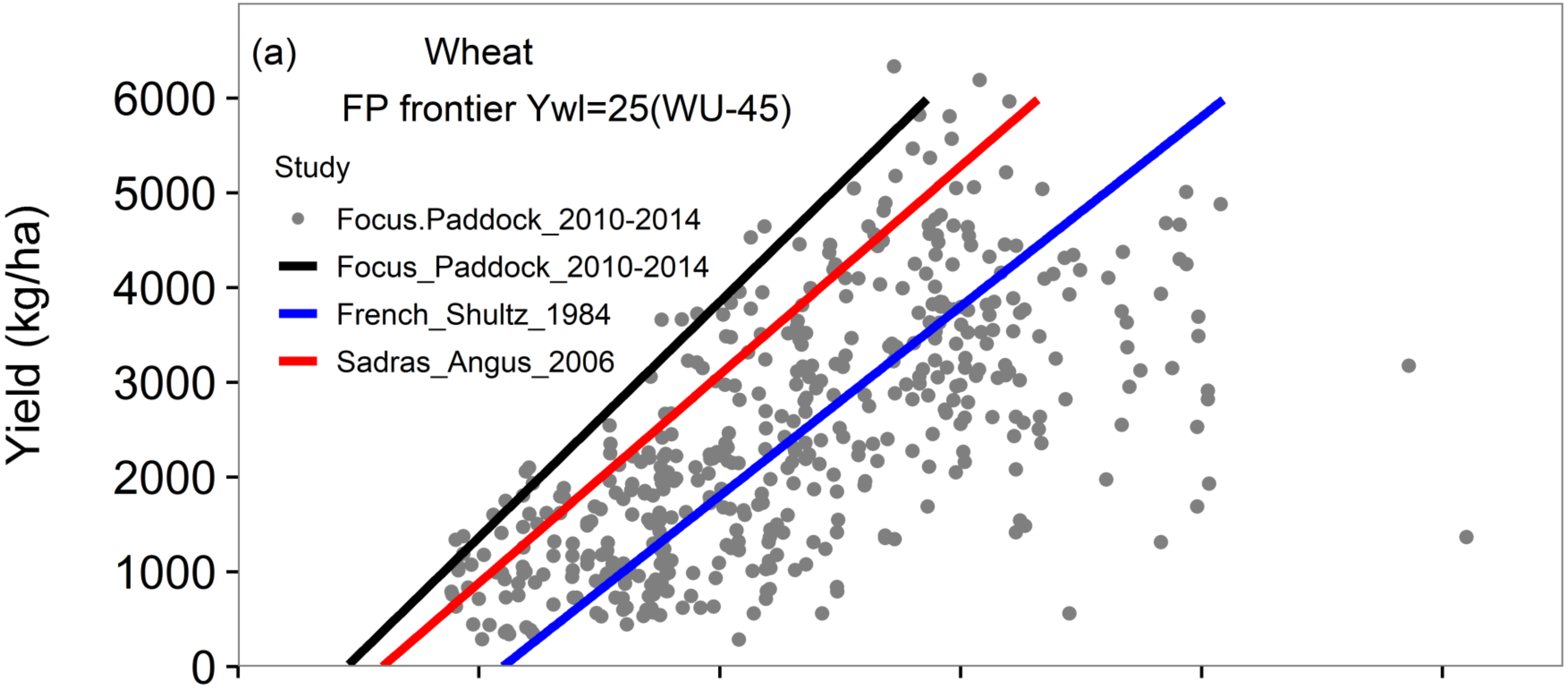
- Yield declined…
- But only after a few years of wheat in succession.
- Traditional break effect response; wheat yield boost after break was not significant.
- But wheat yield declined from 2.7 t/ha to 1.9 t/ha from first crop after break to fourth wheat crop in a row.

Wheat WUE



- WUE is a better measure of the break effect, it also declined…
- But only after a few years of wheat in succession
- Traditional break boost to following wheat not significant
- Wheat after break 12.5 kg/mm
- Wheat/wheat 11.2 kg/mm
- Fourth wheat 8.4 kg/mm

Wheat WUE has increased further



- Boundary function evaporation 45 mm
- Mean transpiration 25 kg/mm
- Higher WUE than previous studies

Few long wheat sequences
- 20% pdks WWW
- 5% pdks WWWW
- 1% pdks WWWWW

= high mean wheat WUE

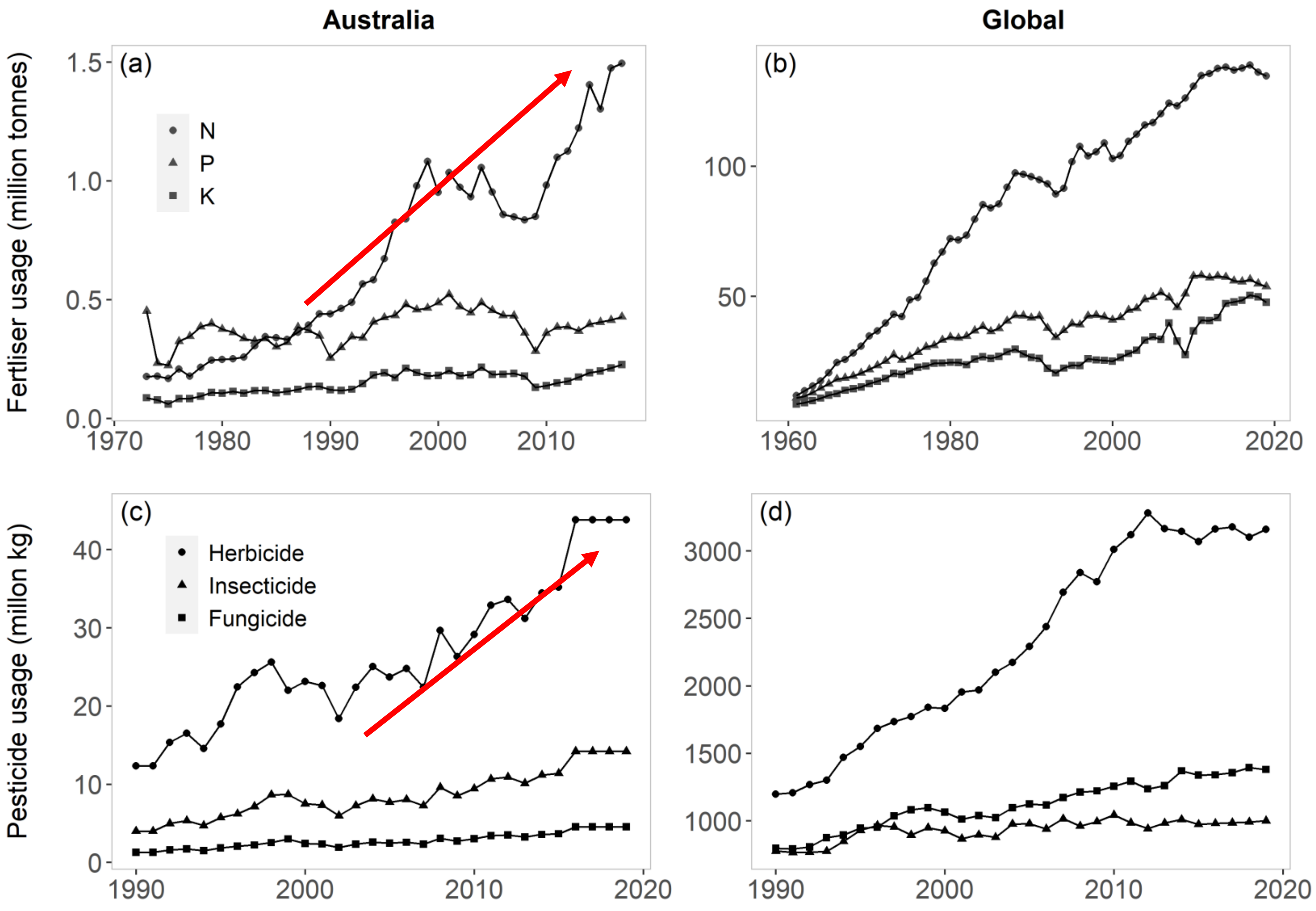
Higher now with soils work?

French, R, Schultz, J (1984) Water use efficiency of wheat in a Mediterranean-type environment. I. The relation between yield, water use and climate. *Australian Journal of Agricultural Research* ***35, 743-764.10.1071/AR9840743***
Sadras, VO, Angus, JF (2006) Benchmarking water-use efficiency of rainfed wheat in dry environments. *Australian Journal of Agricultural Research* ***57, 847-856.10.1071/AR05359***
Harries, M, Flower, KC, Renton, M, Anderson, GC (2022) Water use efficiency in Western Australian cropping systems. *Crop and Pasture Science -.https://doi.org/10.1071/CP21745*

Conclusions from field survey

- Farmers and agronomists have acted pragmatically to managed weeds, disease, nutrition well and increase WUE
- At an inclusion of 20% break crop within the landscape high WUE of wheat was being achieved.
- Clearly biological N has reduced, due to changed land use and agronomy
- Break crops must be assessed from a rotational perspective
    - Rotational WUE and rotational NUE
- More inputs and new technologies are in part replacing the traditional functions of the break crop in the rotation.

Inputs are increasing



- Large increases in inputs, fert N & herbicide.
- Fert N & herbicide use tripled in Aus since early 1990s
- This increases financial risk and will come under increased scrutiny regarding sustainability and GHG emissions.

Sources ABARES, FAOSTAT Fertiliser by Nutrient database http://www.fao.org/faostat/en/#data/RFN FAOSTAT Pesticide Use database, http://www.fao.org/faostat/en/#data/RP

Research need identified

Re-examine break crops and pastures in farming systems context, using modern rotations and farming practices/inputs.

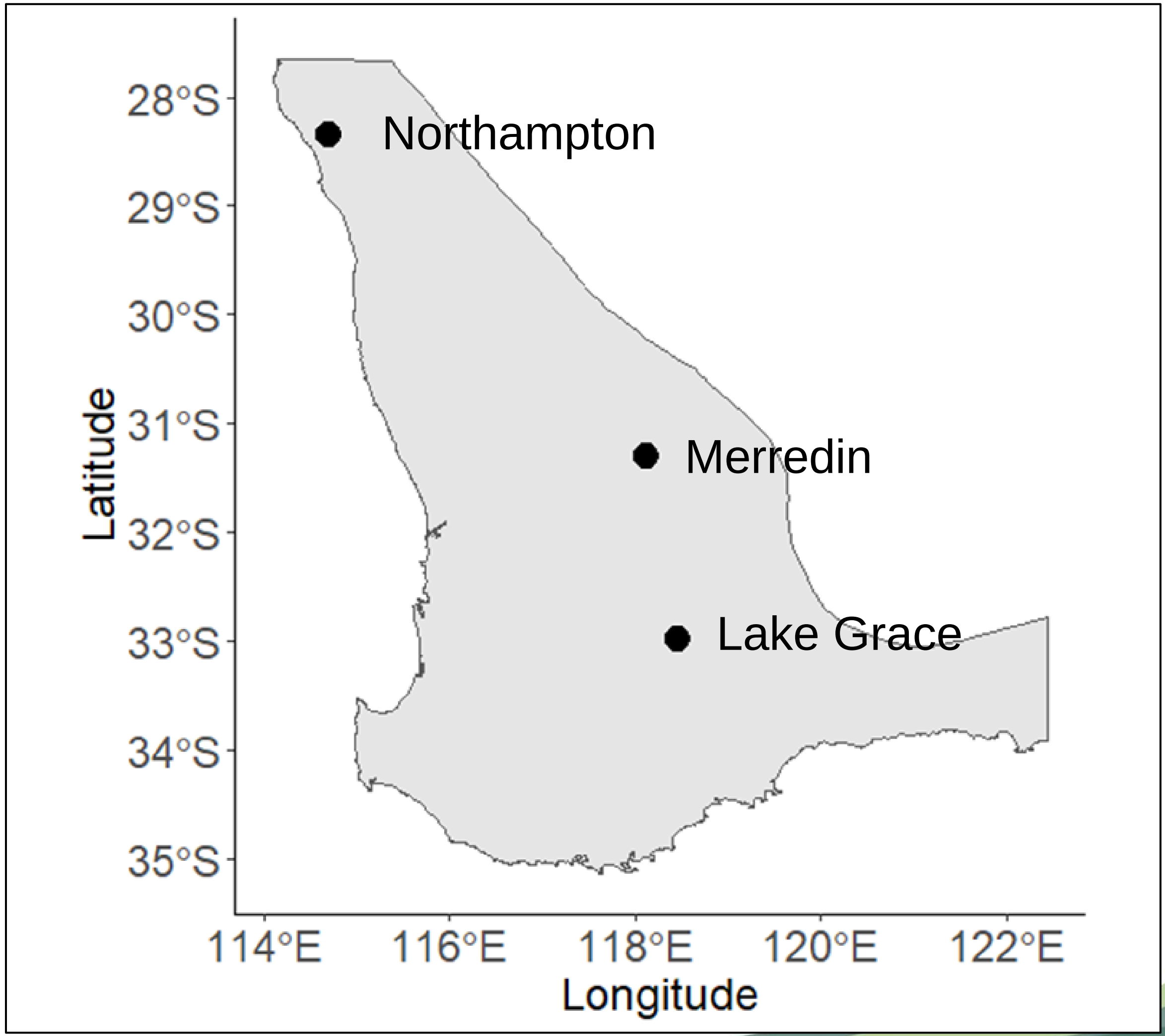
- Multi-year trials
- Measuring multiple biophysical constraints to understand interactions
- Managed as per farmer practice
- Testing various input strategies
    - Lower input for reduced financial risk and reduced GHG emissions.





Western Farming Systems Project

- Started 2023, 5 years
- $20 million DPIRD, GRDC co-investment
- 3 Systems field trials
  - Northampton
  - Merredin
  - Lake Grace
- Participative R&D
  - Regional innovation groups -
    determine rotations, advise on agronomy
    guide other field activities
- Modelling
  - APSIM: (N and H_2O) dynamics, yields, rotations
  - GHG emissions:
  - Whole farm bioeconomic:
    - i.e. seeding decisions/pastures



Objectives

Investigate strategies to increase profit across the rotation while managing weeds, diseases, soil fertility and risk.

Output 1; Sowing opportunities

A thorough analysis of the opportunities and risk of changing the timing of seeding.

Output 2; Diversity/rotation

System break options that deliver improved profit and acceptable risk.

Output 3; Nitrogen inputs & GHG emissions

Analysis of management options for maintaining profitability under low greenhouse gas (GHG) emission scenarios.

Treatment: summary

Sequence	Merredin	Lake Grace	Northampton	Theme
Cer/Cer/Cer/Cer	1	1	1	Wheat (early)
Leg/Cer/Leg/Cer	2		2	Simple
Leg/Cer/Cer/Leg	3	3	3	Simple extened
Can/Cer/Can/Cer	4	4	4	Canola/Wheat
Leg/Cer/Can/Cer	5	5	5	Diverse
Leg/Can/Cer/Cer	6	6	6	Double break
LegCover/Cer/LegCover/Cer	7	7	7	Cover crop
Pas/Cer/Pas/Cer	8	8	8	Annual pasture
Pas/Pas/Cer/Cer	9	9	9	Double pasture
Pas/Pas/Pas/Pas	10	10	10	Continuous pasture
MS/Cer/MS/Cer	12			Multispecies
Fal/Tac/Tac/Tac	11	11	11	Tactical
Fal/Cer/Cer/Fal	13			Fallow/wheat
Fal/Can/Cer/Cer	14			Fallow/canola/wheat
Lu/Lu/Cer/Cer	15			Deep rooting
Lu/Lu/Tac/Tac	16			Deep rooting

- Summer sowing, timely and delayed cereal
- 10 common rotations across all sites (phased)
- Wide range of rotations
  - Continuous wheat
  - Continuous pasture
  - Various amounts of legume crop and pasture
  - Brown manure
  - Fallow
  - Multi-species mixes
  - Tactical
- Nitrogen rates split plot
  - Farmer rates vs lower

Design:

- Rotations phased
- Nitrogen
  - Strip or split plot
- Latinised

Key observations

- Crop sequence induced responses of biophysical variables

- Weed & disease effects

- Legacy effect of nitrogen and water key observations
  - rotational WUE and $/mm
  - rotational NUE and $/unit of N

- Interactions between nitrogen rate and rotation are important
  - Do legumes perform better within the rotation with lower fert N in the rotation?

Thank you

dpird.wa.gov.au

Project team:

Adam Sparks, Bella Tyak-White, Brenda Shackley, Dion Nicol, Grace Williams, Imma Farre, Karyn Reeves, Kristy Hunter, Lea Obadia, Mark Seymour, Megan Abrahams, Naomi Simpson, Rod Bowey, Steph Boyce, Sud Kharel, Tinula Kariyawasam, Vanessa Stewart-McGinniss