Initiation of a farming systems trial series in Western Australia.

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Abstract
In recent years substantial changes to Western Australian broadacre farming systems include large reductions in the area of pasture and grain legumes, increased canola production and more frequent cereal plantings (Harries 2023). In addition, the use of farm inputs such as pesticide and fertiliser have increased. To understand the implications of these changes on production constraints across the rotation, multi-year trials, that are managed as per farmer practice, are required.

To achieve this, a similar approach as Eastern Australian colleagues was utilised, combining rotation x nitrogen fertiliser rate x sowing time treatments to simulate a wide range of current and alternative farming systems. In 2023 three trial sites were established: Northampton (Northern medium rainfall), Merredin (Central low rainfall) and Lake Grace (Southern medium rainfall). These trials test a range of crop and pasture rotations over four years.

Introduction
The Western Australian Farming Systems (WAFS) project commenced in July 2022. A seven-month consultative period ensued, identifying research needs within the farming systems space that align with the themes of the project:

1) Optimise sowing opportunities.
2) Increase diversification in cropping systems.
3) Investigate profitable options for lower GHG emissions.

This engagement process identified research questions similar to those identified within farming systems trials currently being conducted in Eastern Australia to "identify strategies to increase conversion of rainfall to profit ($/ha/mm) across crop and pasture sequences while managing weeds, diseases and soil fertility and risk" (Kirkegaard and Dunn 2023).

Hence, aims of the WAFS project are similar, to investigate strategies to increase profit across the rotation while managing production constraints and risk. The focus being on opportunities and risks of changing the timing of seeding, identification of system break options that deliver improved profit and acceptable risk and an analysis of management options for maintaining profitability under lower greenhouse gas (GHG) emission scenarios.

Research questions focus on how cereal and rotational water use efficiency (WUE) and nitrogen use efficiency (NUE) change in response to altered rotations, reduced fertiliser nitrogen and their interactions.

By answering these questions, we will identify which rotation x nitrogen strategy combination maximises:

- WUE; cereal & rotation
- NUE: cereal & rotation
- Profit cereal & rotation

… what was the best treatment to convert rainfall to profit $/ha/mm

and minimises:

- Financial risk
- GHG emissions across rotation and fertiliser nitrogen rates

Methods

Three sites were selected across three different regions: Northampton, Merredin and Lake Grace. Northampton has more in-season rainfall and higher temperatures than Merredin and Lake Grace, Merredin has similar rainfall to Lake Grace but is drier and warmer during the latter part of the growing season (September to November) (Figure 1), and Lake Grace has a more uniform rainfall distribution than Northampton and Merredin. The soil types at each site represent major soil types within each region: Northampton a Red sandy earth (Haplic Mesotrophic Red Kandosol), Merredin a Calcarosol (Calcareous loamy earth), and Lake Grace a Sandy duplex (van Gool *et al.* 2018). The trial design aligns with the themes of the WAFS project (Table 1) utilising a latinized layout, blocked in two directions. Nitrogen treatments are applied in a strip plot design at Merredin and split plot design at Northampton and Lake Grace (Figure 2).

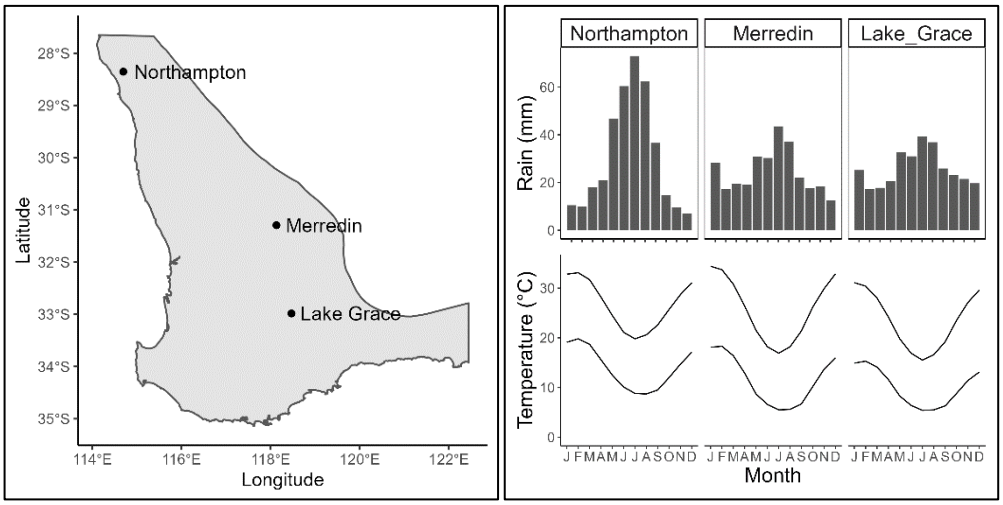

Figure 1. Location of WAFS project systems trials and long-term (2000-2023) rainfall and temperature data. Climate data obtained using the SILO (Scientific Information for Land Owners) database.

Table 1. Linkage of project themes to trial treatments.

Theme 1 **Maximise sowing opportunities**	**Theme 2** **Increase diversification in cropping systems**	**Theme 3** **Investigate options for lower GHG emission**
2 or 3 sowing windows	Several levels of rotation	2 or 3 levels of fertiliser N
Summer (March), Timely/Dry, Wet/Delayed	Several rotations, with emphasis on varying levels of legume inclusion	Current commercial N rates vs lower N rates

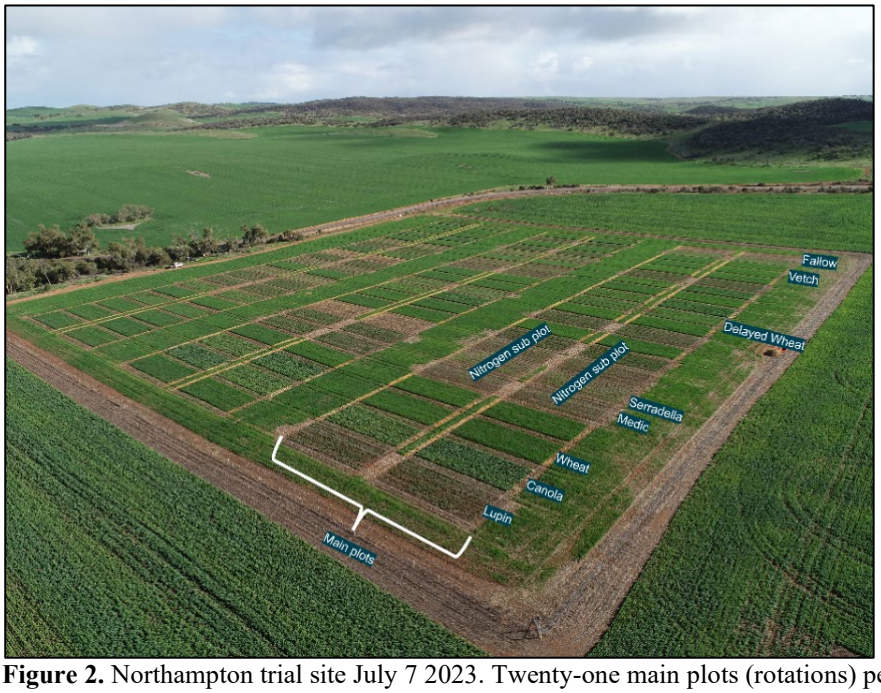

Figure 2. Northampton trial site July 7 2023. Twenty-one main plots (rotations) per replicate, split-plot for fertiliser nitrogen rate, with three row and column replicates (latinised). (Photo, Boyce, DPIRD 2023)

The project has a participatory research approach, with an advisory group, called a Regional Innovation Group (RIG), comprised of local farmers, agronomists and researchers within each of the three regions in which there are trials. Each RIG identified a wide range of rotations to test, including current standard rotations and novel rotations (Table 2).

Within each trial most of these rotations are phased, with several plots of each rotation in different phases each year. RIGs also review agronomic management to ensure trials are managed close to what is occurring within farmers' paddocks in each region. Nitrogen fertiliser treatments were determined based on the amount of nitrogen required to replace nitrogen exported in grain of cereals and canola in a decile 2 and decile 7 rainfall season at each site. Legumes had a small amount of starter fertiliser N (~10 kg/ha) applied versus no N applied. Hence, at all sites two levels of fertiliser nitrogen were tested. Additionally, at Merredin, a third treatment of nil nitrogen was included across all rotations. The rationale for a strip or spit plot design was to increase the power of statistical analysis of the rotation x nitrogen interaction. The effect of high and low fertiliser regimes on legume performance is of particular interest, with the expectation that legumes will be well adapted to low soil nitrogen conditions and have a competitive advantage over other plants in these conditions. Additional satellite trials and bio-economic modelling is also being undertaken within the WAFS project, see https://www.agric.wa.gov.au/wa-farming-systems-project for more details.

Table 2. Rotations at Merredin trial site.

Description	Sow time	Typical sequence
Continuous wheat, delayed	Wet/delayed	Cer/Cer/Cer/Cer
Continuous wheat	Dry/timely	Cer/Cer/Cer/Cer
Continuous pasture	Dry/timely	Pas/Pas/Pas/Pas
Continuous crop, simple	Dry/timely	Leg/Cer/Leg/Cer
Continuous crop, intense baseline	Timely	Cer/Can/Cer/Can
Continuous crop, diverse	Dry/timely	Cer/Leg/Cer/Can
Continuous crop, diverse, double break	Dry/timely	Cer/Leg/Can/Cer
Cover crop	Dry/timely	LegCover/Cer/LegCover/Cer
Annual pasture	Dry/timely	Pas/Cer/Pas/Cer
Phase pasture	Dry/timely	Pas/Pas/Cer/Cer
Diverse mixed farm	Dry/timely	MS/Cer/MS/Cer
Diverse mixed farm	Dry/timely	Lu/Lu/Cer/Cer
Diverse mixed farm	Dry/timely	Lu/Lu/Tac/Tac
Tactical	None/Timely	Fal/Tac/Tac/Tac
Fallow crop, simple	None/Timely	Fal/Cer/Fal/Cer
Fallow crop, diverse	None/Timely	Fal/Can/Cer/Cer

Cer = cereal (wheat), Leg = grain legume (chickpea), Can = canola, LegCover = vetch desiccated in spring, MS = Multi-Species mix (chicory, tillage radish, vetch, sub-clover, ryegrass), Pas = pasture (sub-clover), Fal = fallow, Tac = tactical (decided annually with input from RIG).

Results and Discussion

2023 was a dry year at all sites, in the lowest 10% of years. Growing season rainfall was 180mm at Northampton, 120mm at Merredin and 180mm at Lake Grace. Mean yield of 'timely' (early June) sown wheat was 1589 kg/ha at Northampton and 849 kg/ha at Merredin, and 3347 kg/ha for barley at Lake Grace sown late April (Table 3). As noted above, Lake Grace is a milder site with cooler spring temperatures and the site received more rain than the other two sites in spring, around flowering. Yields of non-legume crops were affected by nitrogen treatment, with greater differences at Lake Grace ($P < 0.001$) and no significant effect at Northampton ($P = 0.98$) or Merredin ($P = 0.07$). There was a nitrogen x species interaction at lake Grace ($P < 0.01$). Differences in yield between species and with nitrogen treatment translated to WUE (Figure 3). A summary of all WFS project trial results is available at https://www.agric.wa.gov.au/wa-farming-systems-project.

Table 3. Crop yield (kg/ha) at each of the western farming systems trials sites.

	Lake Grace			Merredin				Northampton		
Sp. Sow	**High N**	**Low N**	**Mean**	**High N**	**Low N**	**Zero N**	**Mean**	**High N**	**Low N**	**Mean**
Barley	3818	3043	3431							
Barley delayed	3214	2767	2991							
Canola	1354	1174	1264	437	382	337	385	1116	941	1028
Chickpea				403	407	381	397			
Lupin	2459	2466	2463					1235	1207	1221
Wheat	3591	3103	3347	908	866	772	849	1545	1634	1589
Wheat delayed				633	446	551	547	1583	1526	1554
Mean	2323	1959	2141	471	443	402	438	1058	1059	1059
lsd mean(range)	220 (83-293)			150 (87-197)				329 (90-439)		

N = fertiliser nitrogen. Low N applied to cereals & canola is 23 kg.N/ha at Merredin & 27 kg.N/ha at Lake Grace. High N applied to cereals & canola is 64 kg.N/ha at Merredin & 69 kg.N/ha at Lake Grace. Low N applied to canola and wheat at Northampton is 49 kg.N/ha & 37 kg.N/ha respectively. High N applied to canola and wheat at Northampton is 98 kg.N/ha & 75 kg.N/ha respectively.

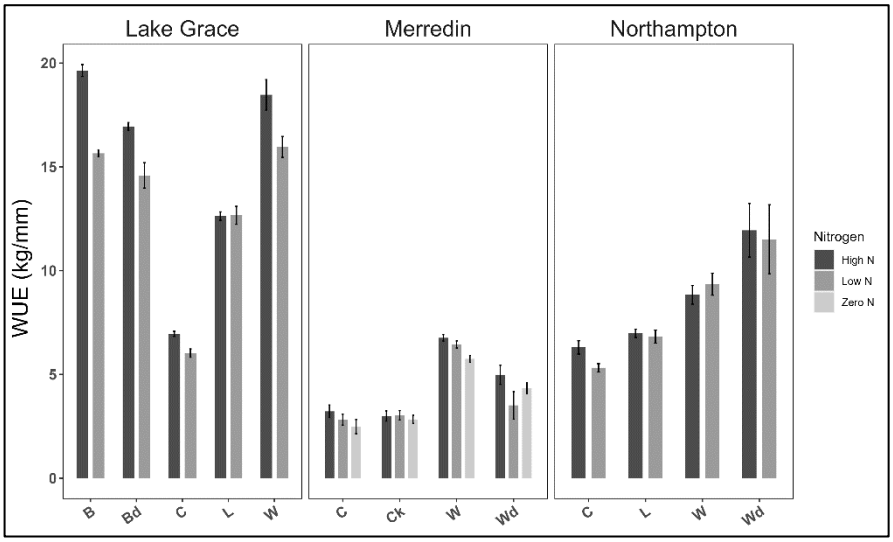

Figure 3. WUE of crops by nitrogen treatment at three locations. B = Barley, Bd = Delay sown barley, C = canola, CK = chickpea, W = wheat, Wd = delay sown wheat. Error bars represent standard error of mean.

Conclusions

We have successfully implemented three complex farming systems trials. Results to date are quite basic but all trials grew well enough to ensure that rotational responses can be studied. Results will become more informative as rotations/treatments diverge.

Acknowledgements

Thanks to the Western Australian Farming Systems project team; Balwinder Singh, Bella Tyak-White, Brenda Shackley, Bob French, Dion Nicol, Grace Williams, Imma Farre, Karyn Reeves, Kristy Hunter, Lea Obadia, Mark Seymour, Marty Harries, Megan Abrahams, Naomi Simpson, Rachel Mason, Rod Bowey, Steph Boyce, Sud Kharel, Tinula Kariyawasam, Vanessa Stewart-McGinniss, Waseem Ashfaq and former team members Adam Sparks and Dayna Hutchison We thank the DPIRD Geraldton and Merredin Field Research Operations teams and Living Farm for their support establishing and harvesting trials. Also to farmers, consultants on regional advisory groups and trial hosts Jess Horstman and Kevin Naisbitt and Merredin Research Station. This is a DPIRD GRDC co-investment, project DAW2204-003RTX.

Keywords

Dryland farming system, wheat, break crop, canola, fallow, cover crop, rotation. a

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