Department of Primary Industries
Department of Regional NSW

NSW research results

RESEARCH & DEVELOPMENT – INDEPENDENT RESEARCH FOR INDUSTRY

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Northern farming systems – Spring Ridge site report, 2015–2020

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Key findings

- The lower crop intensity system resulted in a significantly lower overall system grain/lint productivity (t/ha) compared with the baseline (–4.8 t/ha) however, it performed very well in the economic evaluation (+$56/ha).
- Winter pulse crop choice (chickpea versus faba bean versus field pea) had little effect on the long-term soil nitrate dynamics.
- The higher legume system required less nitrogen (N) fertiliser inputs (114 kg N/ha vs 137 kg N/ha) and exported more N (428 kg N/ha vs 347 kg N/ha), while maintaining higher soil nitrate (+80 kg N/ha) than the baseline system at harvest 2020.
- Potassium (K) export in grain ranged from 34 kg/ha to 73 kg/ha between all systems. The highest removal was seen in the higher legume system. This K removal is concerning, particularly in the long-term, considering that currently there is no additional K applied to offset this removal.
- Short fallows (4–8 months) out of wheat gave the highest fallow efficiencies (20–53%) compared with the two short fallows (4–8 months) following pulse crops (0–17%) and the longer fallows after cereals (10–34 months) (12–22%).

Introduction

Growers face challenges from declining soil fertility, increasing herbicide resistance, and increasing soil-borne pathogens in their farming systems (FS). Change is needed to maintain FS productivity and profitability. Consequently, Queensland Department of Agriculture and Fisheries (QDAF), New South Wales Department of Primary Industries (NSW DPI) and CSIRO are collaborating to conduct an extensive field-based FS research program, focused on developing FS to better use the available rainfall to increase productivity and profitability.

The project started in 2014 and will continue through to 2025 with sites in NSW and Qld. The experiment examined multiple aspects of a northern FS, including the effects modified systems have on water use, nutrient use, weed ecology and soil/root pathogens.

What was done

In 2014 research began in consultation with local growers and agronomists to:

- identify the key FS limitations, consequences and economic drivers in the northern region
- evaluate crop sequences that can meet the emerging challenges
- identify and to develop the systems with the most potential for use across the northern region.

Experiments were established at seven locations: a large factorial experiment at Pampas, and at six locally relevant sites (Emerald, Billa Billa, Mungindi, Spring Ridge, Narrabri and Trangie (red and grey soils)).

Site details

Location

"Nowley Farm" - University of Sydney research farm, Spring Ridge, Narrabri (Latitude 31°34'31.52"S, Longitude 150°10'53.44"E).

Farming system protocols at Spring Ridge

- **Baseline**: represents a standard cropping system for the local grains region. The planting trigger will be 50% of a full moisture profile.
- **Higher nutrients**: This system duplicates the crop sequence for the baseline system, but fertiliser application rates will be targeting a higher yield (90% of seasonal yield potential for N and 100% replacement for phosphorus (P)).
- **Higher crop intensity**: the trigger for planting will be 30% of full soil moisture profile.
- **Higher crop diversity**: This system is investigating alternative crop options to help manage and reduce nematode populations, disease and herbicide resistance.
- **Higher legume**: focused on soil fertility and reducing the amount of N input required through fertiliser. One in every two crops must be a legume.
- **Lower crop intensity**: designed to plant at a lower frequency when the soil moisture profile is greater than 80% full. High value crops are targeted.

Site characteristics

Nowley is a chocolate vertosol with plant available water content (PAWC) of 240 mm to a depth of 120 cm (Table 1). It is quite likely additional water could be available below the 120 cm depth level in the soil profile.

Table 1 Site soil chemical characteristics for 0–120 cm depth at Spring Ridge.

Characteristic	Soil depth (cm)				
	0–10	10–30	30–60	60–90	90–120
pH_{Ca}	6.18	7.35	7.96	8.26	8.37
Organic carbon (%)	1.09	0.66	0.67	0.52	0.31
Colwell-P (mg/kg)	66.40	18.70	5.22	6.07	11.30
Conductivity (dS/m)	0.10	0.16	0.18	0.25	0.33

Weather report

Rainfall was highly variable over the past six years at Spring Ridge, with only the 2020 calendar year exceeding the long-term average (LTA) rainfall (Table 2).

On three occasions the site received rainfall greater than the LTA. The 2016 winter, 2017 summer and 2020 summer.

Table 2 Spring Ridge summer and winter seasonal rainfall (2015–2020) and LTA rainfall.

Period	Rainfall (mm)						
	2015	2016	2017	2018	2019	2020	LTA
Preceding summer (December–May)	265	214	416	177	207	620	329
Winter (June–November)	186	340	123	210	165	178	257

System cropping sequence at Spring Ridge

The Spring Ridge FS experiment started in the winter of 2015, with wheat grown across all systems to establish a baseline (Figure 1).

During the project life:

- the baseline system (grower's practice), the higher nutrient, higher legume, higher intensity and higher diversity systems all had five crops planted

- the lower intensity system, with a conservative planting trigger of >180 mm PAWC, had only three crops planted during the life of the project.

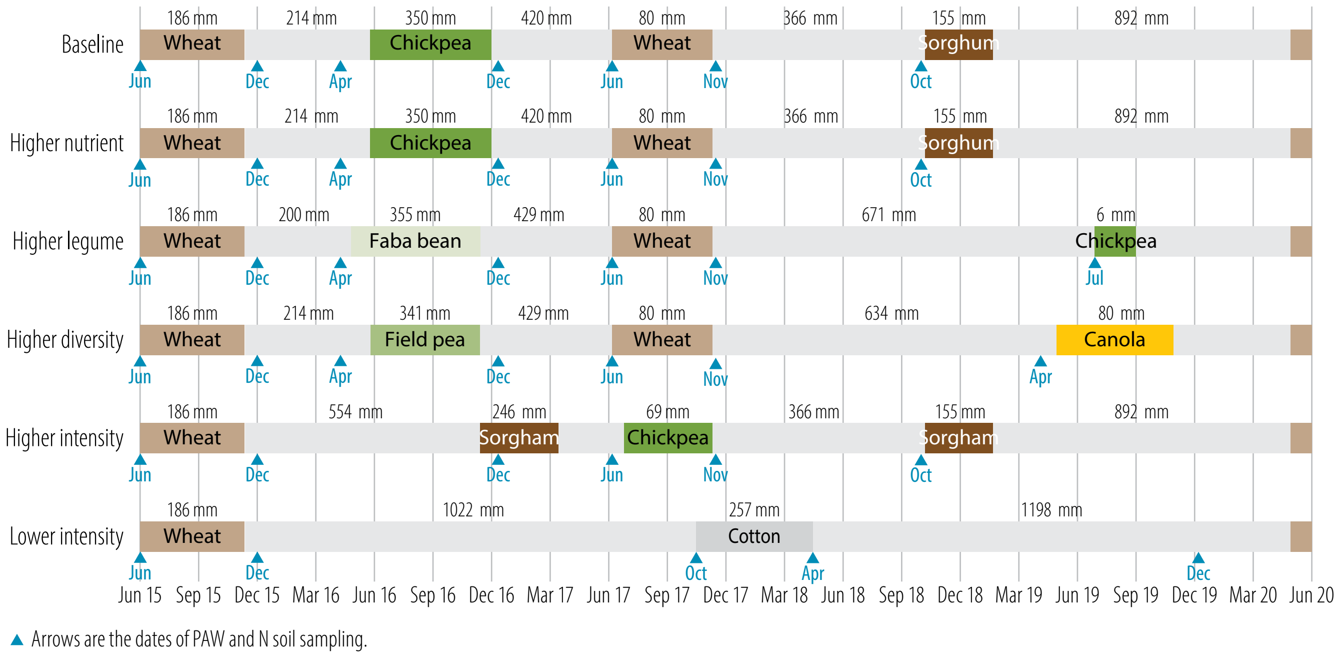

Figure 1 Crop sequences implemented in each of the FS, with the rainfall during each crop (in-crop rain) or during intervening fallow periods (grey).

Results

System grain yields

- The cumulated grain yields of the various systems at ranged between 16 t/ha and 10.7 t/ha (Figure 2). Increasing the legume frequency (higher legume), increasing cropping diversity (higher diversity) and applying greater amounts of nutrients (higher nutrients) resulted in similar grain yield to the baseline system (16, 15.5, 15.3 and 15.5 t/ha respectively).
- The higher intensity system had a lower grain yield than that of the baseline system. This can be attributed to the variable and lower than average rainfall over the project life.
- As expected, the lower intensity system with fewer crops planted had the lowest grain yield at the site with 10.7 t/ha.

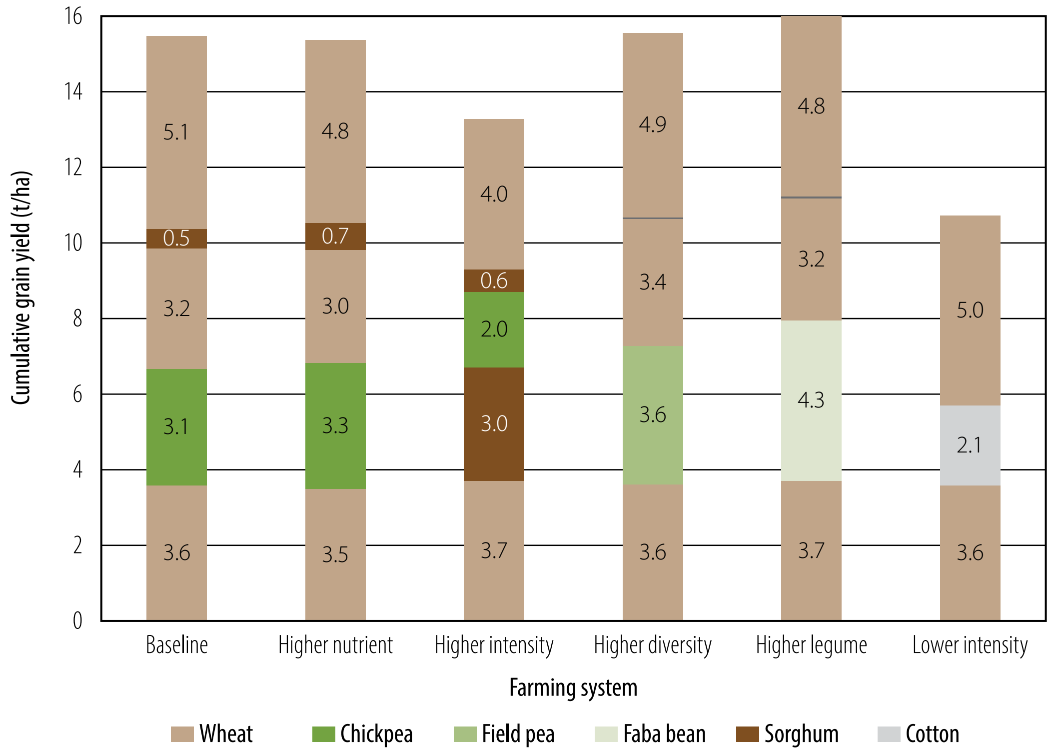

Figure 2 Cumulative system grain yield of the six farming systems treatments at Spring Ridge (2015–2020).

System gross margin

At Spring Ridge it was an advantage to extend the fallow periods and sow fewer, but higher, value crops (such as cotton), compared with sowing more frequently. This was due to the high value of the 2017 cotton crop ($1440/ha) in the lower intensity system and the failure of the 2018 sorghum crop in the higher intensity system. Growing diverse crop species (higher diversity) decreased system gross margins (GM) compared with the grower's practice (baseline). In the higher diversity system the 2016 low value field pea crop and the canola failure in 2019 lowered the cumulative system GM and resulted in the lowest return of all the systems (Figure 3).

System water and nutrient efficiency

Both the higher diversity and higher legume systems had the highest water use efficiency (WUE), 12.3 kg/mm and 13.2 kg/mm respectively, which was >3 kg/mm more than the baseline system (Table 3). When a dollar value was put against water use ($/mm), the lower intensity system with its high value grain crops was the best performer ($2.36/mm of rainfall).

A project outcome across all sites found that the shorter the fallow period, the greater the fallow efficiency. This was the case at Spring Ridge, with the higher intensity system having the best WUE compared with other systems.

Two methods were used to evaluate water use efficiency in this experiment: productivity (kg/mm) and economically ($/mm).

- Both higher diversity and higher legume systems had a better WUE than the baseline system (>3 kg/mm) for the first six years.
- The high value of cotton in the lower intensity systems resulted in the best $/mm return (>$0.5 /mm than the higher legume and >$1.5 /mm than the baseline system).

The higher legume systems had the greatest N use, as modern high-yielding legumes export high amounts of N in the harvested seed. While N exportation was high, growing a higher frequency of legumes decreased the system's reliance on synthetic N fertiliser, resulting in a lower drawdown of background soil mineral N compared with the baseline system.

Another aspect of modern legumes is the high exportation of K from the system. In this experiment, all systems that contained a legume had large K removal in the grain. Future management might require K application to ensure there is no K deficiency for future cropping sequences as there are no supplemental K inputs into these systems.

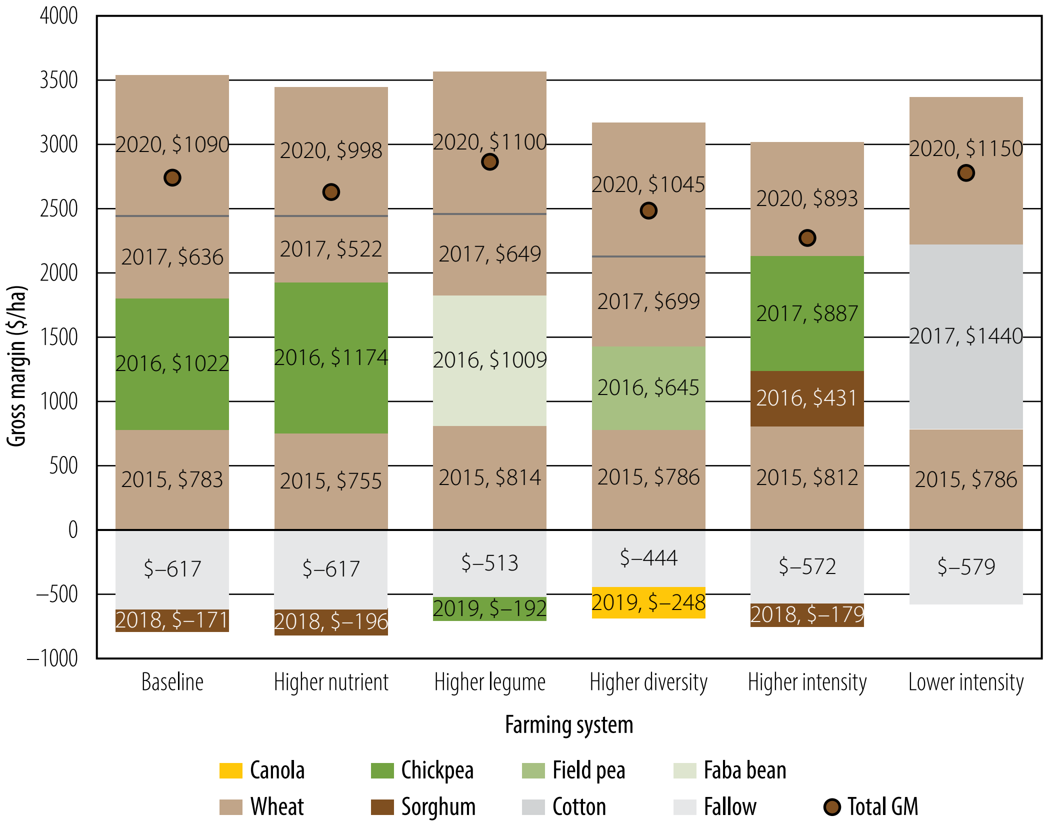

Figure 3 Farming system GM at Spring Ridge (2015–2020).

Table 3 System water and nutrient use at Spring Ridge (2015–2020).

System	System water use			System nutrient use			
	Grain WUE (kg/mm)	**Fallow efficiency (%)**	**System WUE ($/mm)**	**Exported N (kg N/ha)**	**System NUE (kg grain/ kg N)**	**Grain P removal (kg P/ha)**	**Grain K removal (kg K/ha)**
Baseline	8.9	16	0.72	347	1.32	38	62
Higher nutrient	9.0	17	0.72	358	1.27	37	63
Higher intensity	7.4	24	0.57	290	1.80	27	34
Higher diversity	12.3	14	1.68	378	1.31	35	63
Higher legume	13.2	14	1.80	428	2.68	40	73
Lower intensity	7.4	11	2.36	398	2.84	16	50

FE = ∑soil water ÷ ∑fallow rain
Grain WUE = ∑grain yield ÷ crop water use
System WUE = system GM ÷ crop water use
Exported N, P and K = grain yield × grain content (N, P or K)
System NUE = exported N ÷ ∑crop N use

System influence on crown rot

Eighteen soil and plant pathogens were monitored throughout the FS experiment, with sampling occurring pre-sowing and post harvest, and similar timings when in fallow, over the five years.

At Spring Ridge, the pathogen that had the largest affect on the various systems was crown rot, caused by the fungus *Fusarium pseudograminearum* (Fp). It is a stubble-borne disease of cereals and is endemic across northern NSW. Figure 4 shows the trends in Fp inoculum over the experiment for the six FS, sampled on the rows. Over this period, Fp disease risk levels have varied significantly between systems with four of the six systems reaching the high-risk category at various times. In 2017 applying higher fertiliser rates (higher nutrients system) resulted in greater Fp infestation – this result corresponds with recent data from NSW DPI pathologist Steve Simpfendorfer (2020).

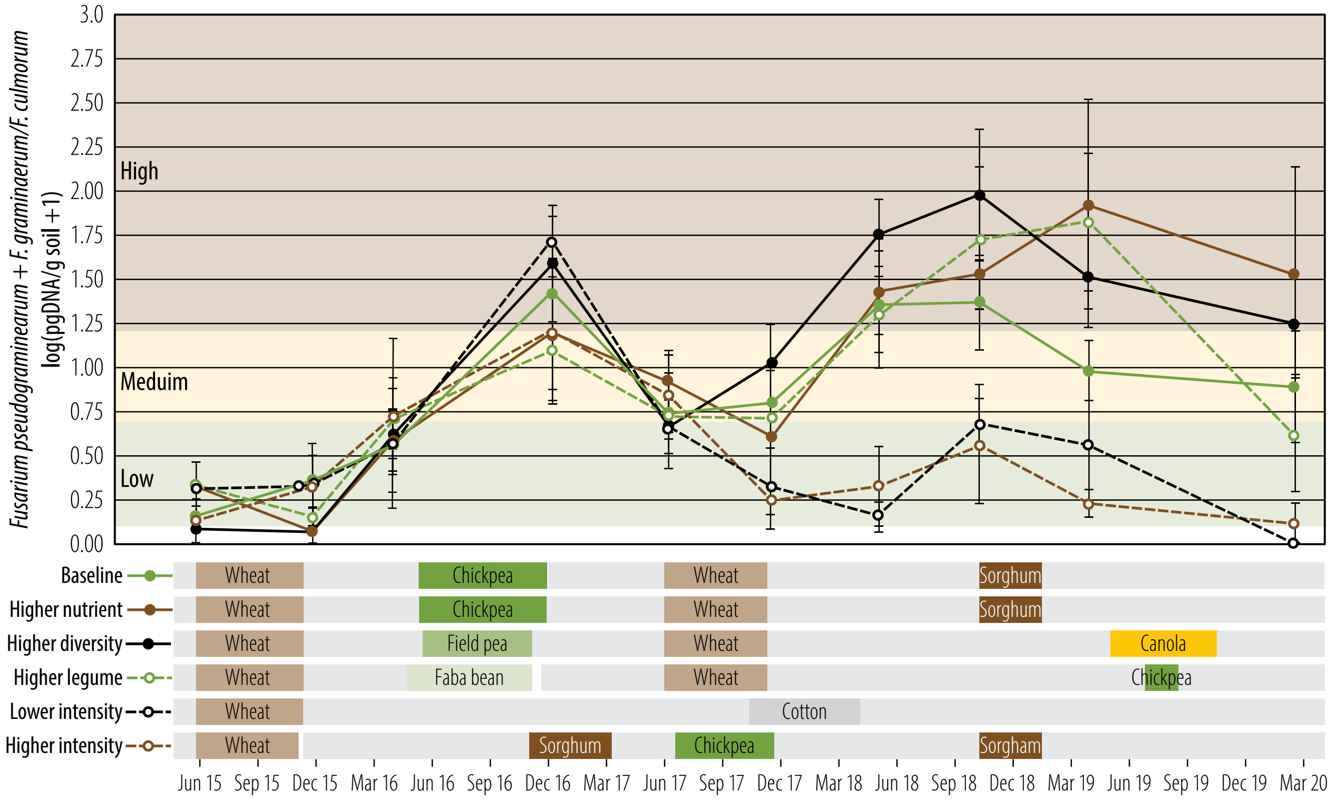

Figure 4 Trends in crown rot at Spring Ridge over time across the six systems.

Conclusions

- The lower intensity system had lower grain/lint productivity (t/ha), but it performed very well in the economic evaluation. The system productivity was more than 3 t/ha lower than the other five systems between 2015–2020, but the strong GM performance of the 2017 cotton crop ($1440/ha) resulted in a high system GM, which is equal to the highest performing systems. Also, the lower FS cost associated with low cropping frequency meant the lower intensity had the highest return on variable costs.
- Since 2017, the higher nutrient system (which had an additional 69 kg N/ha of fertiliser N applied) has maintained higher mineral N levels than the baseline system (101 kg N/ha compared with 60 kg N/ha) at harvest 2020.
- Growing a higher proportion of legume crops increased the N balance. The higher legume system has required less N fertiliser (114 kg N/ha versus 137 kg N/ha) and exported more N from the system as grain (428 kg N/ha versus 347 kg N/ha), while maintaining more soil nitrate (–46 kg N/ha versus –125 kg N/ha) than the baseline system.

- All systems are removing large amounts of K. Potassium export in grain ranged from 34 kg N/ha to 73 kg/ha between all systems. The highest removal was seen in the higher legume system. This K removal is concerning in the longer term considering currently there is no offsetting this removal with K inputs into any of these systems.
- Short fallows out of wheat crops achieved higher fallow efficiencies compared with both short fallows out of winter pulse crops and long fallows systems. Short fallows (4–8 months) out of wheat gave the highest fallow efficiencies (20–53%) compared with both short fallows (4–8 months) following pulses (0–17%) and longer fallows from cereals (10–34 months) (12–22%)

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