Can systems performance be improved by modifying farming systems in Queensland?

Jayne Gentry[1], David Lawrence[1], Darren Aisthorpe[2], Andrew Erbacher[3], Joanna Weier[4], James Hagan[1] and Lindsay Bell[5]

[1] Department of Agriculture and Fisheries, 203 Tor St, Toowoomba, QLD 4350, www.daf.qld.gov.au, jayne.gentry@daf.qld.gov.au
[2] Department of Agriculture and Fisheries, 99 Hospital Rd, Emerald, QLD 4720
[3] Department of Agriculture and Fisheries, 22-26 Lagoon St, Goondiwindi, QLD 4390
[4] "Clermont", Mungindi, NSW 2406
[5] CSIRO Agriculture and Food, PO Box 102, Toowoomba QLD 4350

Abstract
Farming systems are currently underperforming in terms of yield, due to challenges that include declines in soil fertility, herbicide resistant weeds and increasing soil pathogens. Farming system changes will have to be made to maintain and improve productivity into the future. In 2015 research began, supported by the Grains Research Development Corporation, with experiments established at seven locations throughout Queensland and northern New South Wales. These experiments will assess the impact of nine farming systems across numerous parameters, including system production and economics, resource use efficiency, pathogen loads/populations, weed populations and soil health. Interim results indicate that differences in cumulative yields and gross margins are mainly driven by crop choice. These results will be tracked over a five to 10 year timeframe, when systems performance will be evaluated against all parameters at the conclusion of the project in 2019. Ideally, the project will continue until 2024 to fully assess the expected long-term differences between the systems in the study.

Keywords
Farming systems, Queensland, yield, gross margin.

Introduction
Advances in agronomy and the performance of individual crops have helped growers to maintain their profitability. However, there is evidence that current farming systems are underperforming, with only 29% of the crop sequences in the northern grains region achieving 80% of their water limited yield potential (Hochman et al. 2014). Northern farming systems are also being challenged with declines in soil fertility, increased herbicide resistance, and increased soil-borne pathogens. Changes will be needed to meet these new challenges and to maintain the productivity and profitability of regional farming systems. The Northern Farming Systems initiative, being supported by the Grains Research Development Corporation (GRDC), was consequently established around the question "Can systems performance be improved by modifying farming systems in the northern grains region"?

This research question is being addressed at two levels: to look at the systems performance across the whole grains region, and to provide rigorous data on the performance of local farming systems at key locations across Queensland and New South Wales.

Methods
Research began with a series of consultative meetings of local growers and agronomists in 2015 to identify key limitations, consequences and economic drivers of farming systems in the northern region; to assess farming systems and crop sequences that can meet the emerging challenges; and to develop the systems with the most potential for use across the northern region.

Experiments were established at seven locations, with one large factorial experiment managed by CSIRO at Pampas near Toowoomba, and with the evaluation of locally relevant systems at a further six regional centres (Table 1) by the Department of Agriculture and Fisheries in Queensland (DAF) and the Department of Primary Industries in New South Wales (NSW DPI). These experiments will be conducted for five years, with the possibility of a further five years, depending on funding. Several of these systems are represented at every site to allow major insights across the northern region, while the site-specific systems will provide insights for local conditions. Results from the sites managed by DAF (Emerald, Billa Billa and Mungindi sites) will be discussed.

The systems include:

1. *Baseline* – represents a zero tillage farming system typical of local practice. This system varies by region but aims to grow one crop/year, with moderate nutrition and planting water triggers and crops of wheat, chickpea and sorghum)
2. *Higher Nutrient Supply* – as for the *Baseline* system but with fertilisers for 100% phosphorus replacement and nitrogen targeted at 90% of the yield potential each season
3. *Higher Legume* - 50% of the crops are sown to legumes
4. *Higher Crop Diversity* – a wider range of crops are introduced to manage nematodes, diseases and herbicide resistance
5. *Higher Crop Intensity* – a lower soil moisture threshold is used to increase the number of crops per decade
6. *Lower Crop Intensity* – crops are only planted when there is an 80% profile of soil moisture to ensure individual crops are higher yielding and more profitable
7. *Grass Pasture Rotations* – pasture rotations are used to improve soil fertility for the cropping phase. One treatment has no additional nitrogen fertiliser, while the other has 100 kg N/ha/year to boost grass production
8. *Higher Fertility* (higher nutrient supply plus organic matter) – as in the high nutrient system but with compost/manure added at the beginning to mimic a soil of higher fertility status
9. *Integrated Weed Management* – where crops, sowing rates, row spacings and 'strategic tillage' are included to manage weeds and herbicide resistance

Table 1. Summary of the regional farming systems being studies at each location.

Farming system	Emerald	Billa Billa	Mungindi	Spring Ridge	Narrabri	Trangie x2
Baseline	*	*	*	*	*	*
Higher Nutrient Supply	*	*	*	*	*	*
Higher Legume	*	*	*	*	*	*
Higher Crop Diversity		*	*	*	*	*
Higher Crop Intensity	*	*		*	*	*
Lower Crop Intensity		*	*	*	*	*
Grass Pasture Rotations		*				
Higher Fertility	*	*				
Integrated Weed Management	*					

Systems will be assessed against the following key experimental measurements:

1. System production/economics - crop yields, grain quality, inputs
2. Resource use efficiency - Soil water, mineral nitrate, grain N, P & K, full soil nutrient analysis
3. Pathogen loads/populations - Predicta B (0-30) pre-plant (each crop), severity & incidence
4. Weed populations - numbers and species
5. Soil health - organic carbon

Results

All three Queensland regional trials began in winter 2015, with each system being planted according to the negotiated regional planting rules for each system. Preliminary results up to the end of winter 2016 are presented in this paper. Cumulative yields and gross margins from the first two years of this research are presented below (Figures 1-3). Gross margins were calculated using 10-year average prices for all crops, to ensure that a crop in 2015 was directly comparable with a crop in 2020.

Emerald

All treatments were planted 13 May 2015 to wheat except for the High Legume treatment which was planted to chickpea. This was a dry year for Emerald. Chickpea was harvested 22 September 2015 and wheat 8 October 2015. There was a yield increase from *Baseline* to *Integrated Weed Management (IWM)* treatment due to a higher plant establishment in the *IWM* treatment. Summer 2015-16 was dry until late January. The *Higher Crop Intensity* treatment was planted to mungbean 12 February, and harvested 29 April 2016. *Baseline,, Higher Nutrient Supply, Higher Fertility* and *IWM* treatments were deep planted to chickpea 6 May 2016. The *Higher Legume* treatment was planted to wheat 16 June and the *Higher Crop Intensity* was planted 1 July 2016. These treatments were harvested 12 October 2016. Yields were greater in 2016 compared to 2015. All chickpea yields exceeded 3t/ha. Wheat yield for the *Higher Legume* treatment was up to 3.8t/ha despite the late planting, and even the *Higher Crop Intensity* treatment (which had been double cropped from mungbeans two months earlier) averaged over 2.5 t/ha.

Cumulative yields and gross margins (Figure 1) currently indicate that the *Baseline*, *Higher Nutrient Supply*, *Higher Fertility* and *IWM* treatments are all quite similar, mainly due to the fact that they have all had wheat followed by chickpea. The *Higher Legume* and *Higher Crop Intensity* treatments are both behind in terms of gross margin which is due to a lack of 2016 chickpeas; an excellent chickpea season.

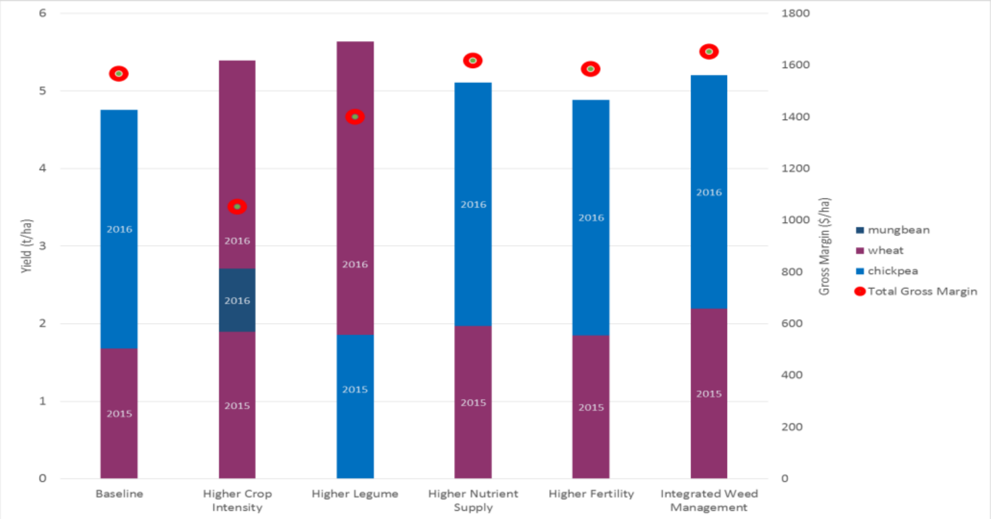

Figure 1. Emerald cumulative grain yields and total gross margins of these crops (including fallow costs) up to the end of the 2016 winter season.

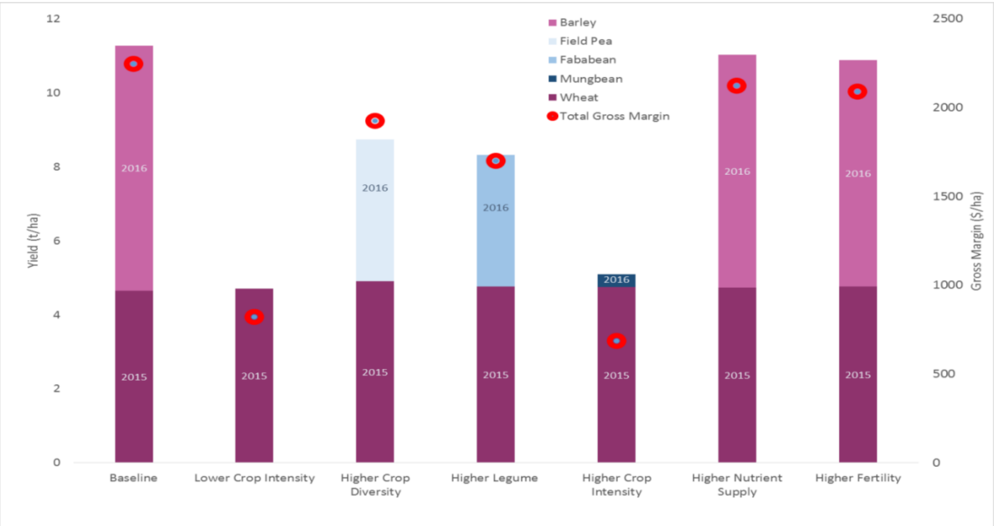

Figure 2. Billa Billa cumulative grain yields and total gross margins of these crops (including fallow costs) up to the end of the 2016 winter season.

]

Billa Billa

All systems were planted to wheat 2015, as the paddock had been fallowed from chickpea. Summer 2015-16 was dry with mainly storm rain. The *Higher Crop Intensity* plots accumulated sufficient water to be planted to mungbeans 15 January 2016. A lack of further rain meant yield was low (0.35 t/ha). With little rain in April, faba beans were deep planted (15 cm deep) in the *Higher Legume* system on 28 April, and established a good population after 12 mm of rain five days later. Dry conditions continued into May, so fieldpeas were deep planted (10 cm deep) in the *Higher Crop Diversity* system on 26 May. However, 10 mm of rain fell the next day, which allowed barley to be shallow planted into the remaining systems on 31 May 2016.

A comparison of cumulative grain yields and total gross margins ($/ha) at this early stage indicate that income is largely related to the total tonnage of grain produced (Figure 2). Currently the *Baseline, Higher*

Nutrient Supply and *Higher Fertility* have produced the greatest yields and gross margins, all consisting of wheat in 2015 followed by barley in 2016.

Mungindi
The systems were planted to wheat in 2015, except for the *Higher Crop Diversity* which was prepared for a summer crop to avoid three winter cereals in a row. The *Lower Crop Intensity* system had not yet reached the necessary moisture level for planting. The *Higher Crop Diversity* system was planted to sunflowers on 1 September 2015. Sunflowers were chosen as the site has high numbers of *P. thornei*. Due to the following dry conditions crop establishment was difficult. In-crop rainfall totalled 140 mm and the crop yielded 0.65 t/ha with an average oil content of 43.7 %. Single skip sorghum was planted in the *Lower Crop Intensity* system 15 January 2016. The crop received 98 mm of rainfall and yielded 1.8 t/ha. The *Higher Nutrient, Baseline and Higher Legume* systems were all planted to chickpeas 4 July 2016 when the moisture trigger of 80 mm was reached. This planting date was 2 weeks later than most planting in the district. Chickpeas were harvested 12 December 2016. Above average rainfall for the winter months led to considerable waterlogging of the site and this combined with the later planting date resulted in reduced chickpea yields. There was no significant difference between the performances of chickpeas in the three systems.

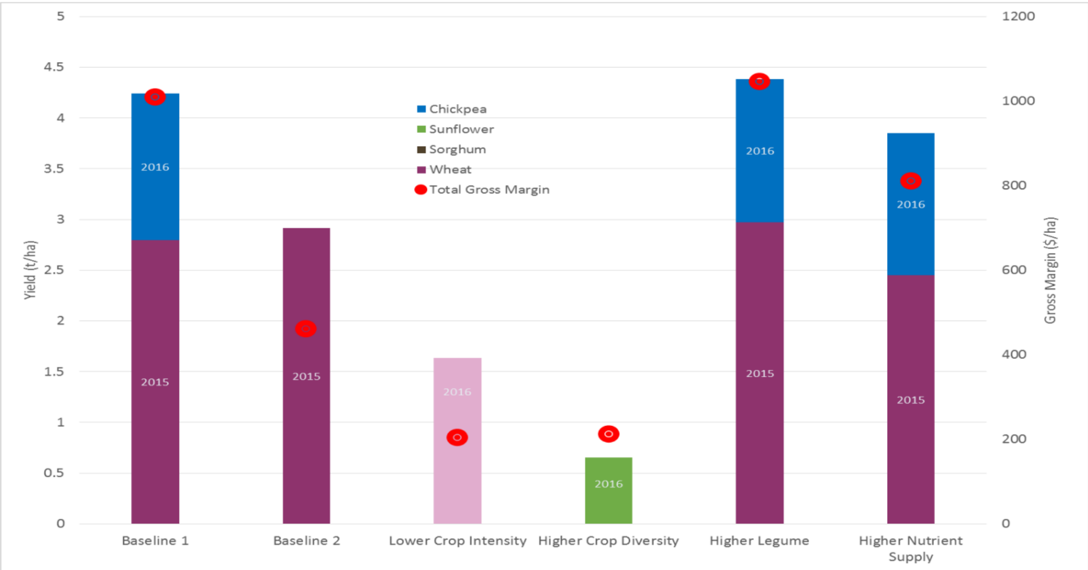

Figure 3. Mungindi cumulative grain yields and total gross margins of these crops (including fallow costs) up to the end of the 2016 winter season.

The current cumulative yield and gross margins (Figure 3) are widely spread; driven by crop choice. Mungindi is not a traditional summer cropping region, as reflected in the results in the *Low Crop Intensity* and *Higher Crop Diversity* treatments, both with summer crops showing lower yields and gross margins.

Conclusion
Interim yield and gross margin results reflect crop choice rather than the impacts of the underlying farming system treatment. As these results are only from the first two years of this five year project, it will be interesting to evaluate these results over the coming years. Yield and gross margin are only two indicators from a suite of measurements being analysed. To date, systems that are aimed at introducing more diversity or altering crop intensity are yet to realise any system benefits. At the end of the project, any detectable treatment differences in the other parameters (pathogen loads/populations, weed populations and soil organic carbon levels) will be evaluated. The farming systems' performance of the seven sites will be assessed against all criteria in 2019. However, the continuation of the project until 2024 will allow a better assessment of the overall system performance and its constituent components.

Reference

Hochman Z, Prestwidge D and Carberry PS (2014). Crop sequences in Australia's northern grains zone are less agronomically efficient than the sum of their parts. Agricultural Systems 129, 124-132.