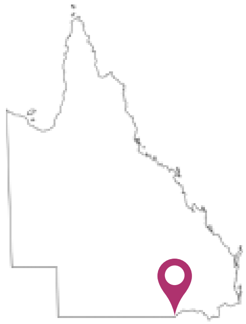
Northern Farming Systems site—Mungindi



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Research Questions: *Can systems performance be improved by modifying farming systems in the northern grains region? | What are the trends that are expected and how will these changes impact on the performance and status of our farming systems?*

Key findings

1. Summer break crops reduced levels of cereal soil-borne disease and allowed more even and higher yielding wheat crops in 2018, however they were the least profitable.
2. Root lesion nematodes continued to decline, even under susceptible crops due to the dry growing conditions of 2017 and 2018.
3. Higher nitrogen supply did not increase plant uptake or yield due to low in-crop rainfall, but this extra nitrogen is still available in the soil profile for following crops.

Background

The Mungindi dryland farming area is based mainly on winter cropping systems; primarily cereals (wheat and barley) with pulses (chickpea) and limited opportunity summer cropping (dryland cotton and sorghum). Local rainfall is variable and winter cropping relies heavily upon stored moisture, typically from the highest rainfall months in late summer.

Most farms operate on a zero or minimum tillage system with a fairly set rotation of cereal/cereal/chickpea. Local knowledge of root lesion nematodes (RLN) is limited, however soil samples taken in some long-term cropping areas north of the border have shown significant numbers while RLN levels are typically lower to the south.

The trial site is located 22 km north-west of Mungindi towards Thallon on a Grey Vertosol soil with a plant available water capacity (PAWC) of 180 mm. The site has been cropped for 30 years and is representative of a large proportion of cropping in the region. The site had high RLN populations (*Pratylenchus thornei*; 6-26/g of soil). The trial area has been fenced to protect the trial site from local wildlife.

What was done

Six systems were identified as research priorities through consultation with farmers and advisers in the Mungindi Cropping Group.

1. **Baseline** represents a standard cropping system for the Mungindi region. The area is winter dominant with three main crops of wheat, barley and chickpea on a fairly set rotation of wheat/wheat/chickpea (with an average of one crop per year) and fertilised for 50% of seasonal yield potential for nitrogen, and a standard starter phosphorus rate.

Trial site location and layout.

2. **Lower crop intensity (winter)** is designed to be planted at a lower frequency i.e. when the profile is at least ¾ full. The rotation includes wheat/barley/chickpea and the option of a cover crop when ground cover is below 30%.
3. **Lower crop intensity (mixed)** is similar to the *Lower crop intensity (winter)* system, but may also include summer crop options including dryland cotton as a high value crop followed by wheat that is able to be planted on a lower soil moisture trigger for stubble cover.
4. **Higher crop diversity** investigates alternative crop options to help manage and reduce nematode populations, soil-borne diseases and herbicide resistance. The profitability of these alternative systems will be critical. A wider range of 'profitable' crops may enable growers to maintain soil health and sustainability as the age of their cropping lands increase. Crop options include: wheat/barley, chickpea, sorghum, maize, sunflowers, canola/mustard, field pea, faba bean and mungbeans.
5. **Higher legume** focuses on improving soil fertility and reducing the amount of nitrogen input required through fertiliser by growing more pulse (legume) crops. One in every two crops is a legume and the suite of crops available are: wheat/barley, chickpea, faba beans and field peas all based on a *Baseline* moisture trigger. Non-pulse crops are fertilised at the same regime as *Baseline*.
6. **Higher nutrient supply** identifies the impacts of fertilising for a higher yield potential (90% of yield potential for nitrogen, and 100% replacement of phosphorus), in this environment. Nutrient supply is an area that is currently very conservative in the Mungindi region. The same crop as the baseline is grown, to compare the two treatments.

Systems were implemented in 2015 with a range of crops grown in 2015 and 2016 across the different systems (Figure 1). Unfortunately, low rainfall in 2017 did not accumulate sufficient PAW to plant any systems, so a wheat cover crop was planted in *Baseline*, *Higher nutrient supply*, *Higher legume* and *Lower crop intensity (winter)* systems to maintain ground cover above 30%. There was sufficient fallow rain to plant all systems to winter crops in 2018.

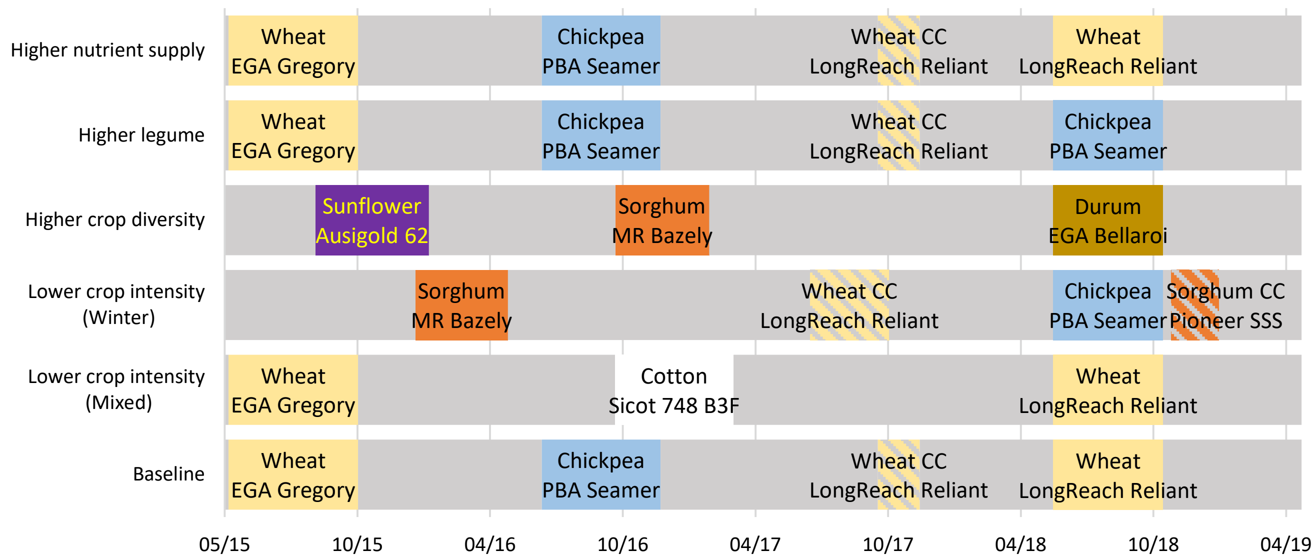

Figure 1. Crop sequences grown at Mungindi following the defined system rules, plotted on a time scale.

Crops grown at the Mungindi site will be represented by specific colours for all figures and graphs throughout this report (key provided right).

Wheat	Durum	Sunflower	Fallow
Chickpea	Sorghum	Cotton	Cover crop

Results

Rain in February and March 2018 provided a good profile of moisture. Due to an extended dry period after this rainfall, the moist soil was 200 mm deep at planting on 29 May. As a result chickpeas were deep-sown into moisture, but limitations of research planting equipment meant wheat could only be planted to 150 mm with 100 mm soil above the seed. Since this was not deep enough to plant into moisture, it was decided to proceed at that depth then apply water to the seed row using trickle tape to establish these plots. As a result all systems were planted to winter crops in 2018 (Figure 1).

Baseline and *Higher nutrient supply* were planted to wheat with the *Higher legume* and *Lower crop intensity (winter)* systems planted to chickpea in 2018 after their cover crop in 2017. The *Lower crop intensity (mixed)* system was planted to wheat to provide stubble cover following the 2016/17 cotton crop. The *Higher crop diversity* system grew two crops resistant to *Pratylenchus thornei* prior to 2018 which reduced populations to 2.1/g soil, so durum wheat (EGA Bellaroi$^{\phi}$—ranked as moderately resistant) was selected to bring the populations back below damaging levels (2/g soil) and also to provide stubble cover.

The three systems planted to wheat in 2018 had similar starting water. However the *Baseline* and *Higher nutrient supply* plots had sparse patches which were not present in the *Lower crop intensity (mixed)* system. These patches had an impact on yield and water use efficiencies (WUE), with *Lower crop intensity (mixed)* yielding 1.25 t/ha and a WUE of 11.1 kg/mm compared to a yield of 0.84 t/ha and WUE of 8.4 kg/mm for both the *Baseline* and *Higher nutrient supply* systems. The durum in *Higher crop diversity* was an even crop, but suffered from terminal drought, maturing earlier with tipped-out heads, producing a grain yield of 0.85 t/ha. Grain proteins were high for all wheat and durum plots (average 14.3% for wheat and 15.7% for durum), so nitrogen had no impact on yield differences this season. The deep-planted chickpea had a patchy establishment with ~50% of the plot area not germinating across both systems. The *Lower crop intensity (winter)* system had 50 mm more PAW (110 mm versus 60 mm) than the *Higher legume* system, but with low in-crop rainfall, both systems yielded similarly. *Higher legume* produced 0.20 t/ha of grain yield and *Lower crop intensity (winter)* yielded 0.23 t/ha.

With 65 mm of rain falling just prior to harvest all six systems had similar PAW post-harvest as at planting. That is ~120 mm in *Lower crop intensity (winter)* and ~70 mm in the other five systems. The *Lower crop intensity (winter)* system had very little stubble post-harvest, this rain provided an opportunity to plant a sorghum cover crop to improve ground cover at the start of a long fallow.

Overall system performance 2015-2018

The Mungindi environment has been challenging, with excessive rainfall in 2016 moving into an extended low rainfall period until 2019. This has severely impacted yields and number of crops planted.

Over the four years of the trial the most productive system has been the *Baseline* system, with two wheat crops and a chickpea crop (Figure 2). The *Higher nutrient supply* system

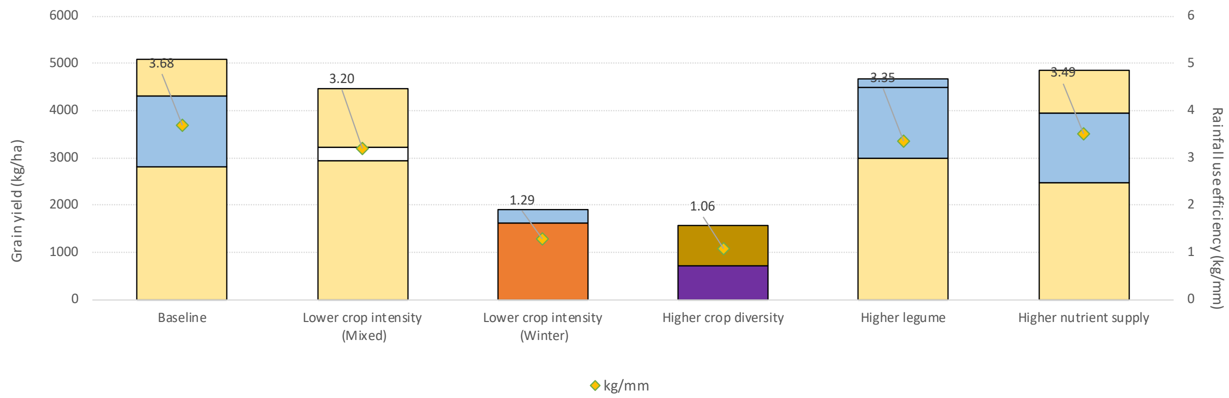

Figure 2. Cumulative grain yield and rainfall-use-efficiency. Colours represent crop types as indicated in Figure 1.

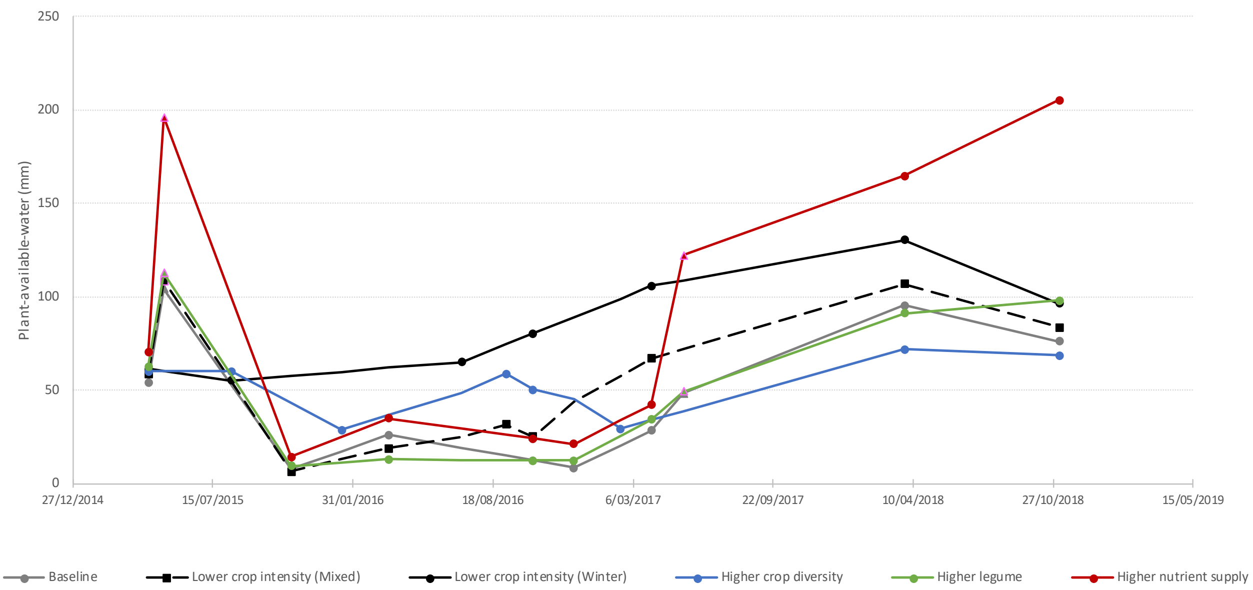

Figure 3. Dynamics of measured soil plant available nitrogen. ∆ is soil N plus added urea N.

has had the same crop rotation, but the higher nitrogen supply in 2015 caused the wheat crop to grow higher biomass early, which resulted in reduced grain yield and increased screenings under a dry finish. There is currently an extra 130 kg N/ha available in *Higher nutrient supply* over the *Baseline* (Figure 3). The 2018 wheat crops were also planted into similar nitrogen situations to 2015, with 95 kg N/ha in *Baseline* versus 165 kg N/ha in *Higher nutrient supply*, but with the lack of in-crop rain, neither crop grew excessive biomass, and both had similar N unlimited yields.

Baseline, *Lower crop intensity (mixed)*, *Higher legume* and *Higher nutrient supply* were dominated by winter crops, so all produced similar accumulated grain yields (4.5–5 t/ha) over the past four years (Figure 2). However, the use of summer crops in *Lower crop intensity* and *Higher crop diversity* systems has produced far less grain yield (at only 1.9 and 1.6 t/ha).

It is interesting to note that the biomass results do not follow the same pattern (Figure 4). The *Baseline*, *Lower crop intensity (mixed)*, *Higher legume* and *Higher nutrient supply* all have similar biomass, however the greatest amount of biomass was produced on the lowest-yielding system, *Higher crop diversity*, indicating that although the summer crops grew well in this system, they were not able to transfer this biomass to grain with high temperatures and low rainfall during anthesis and grain-fill.

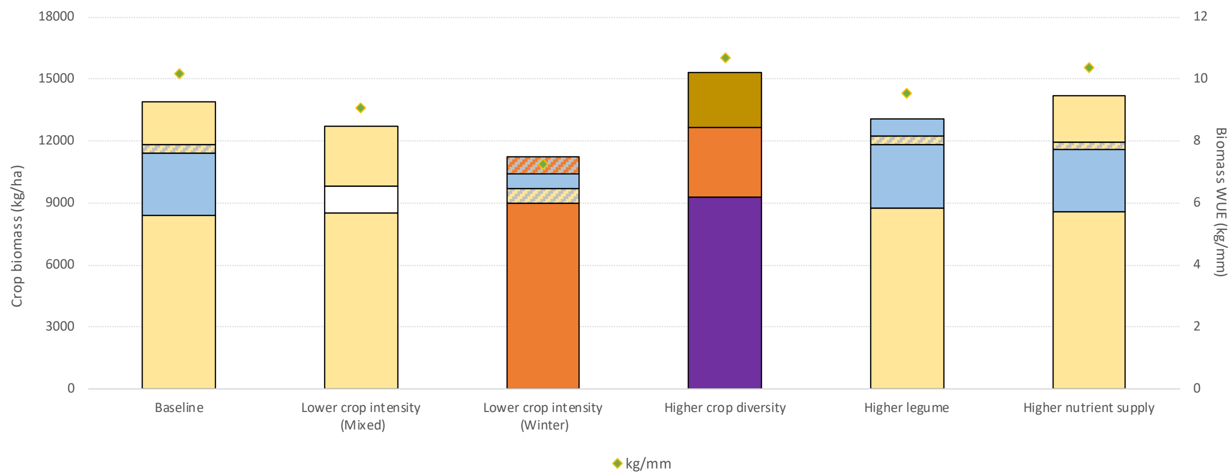

Figure 4. Cumulative total dry matter production for each of the systems. Colours represent crop types as indicated in Figure 1.

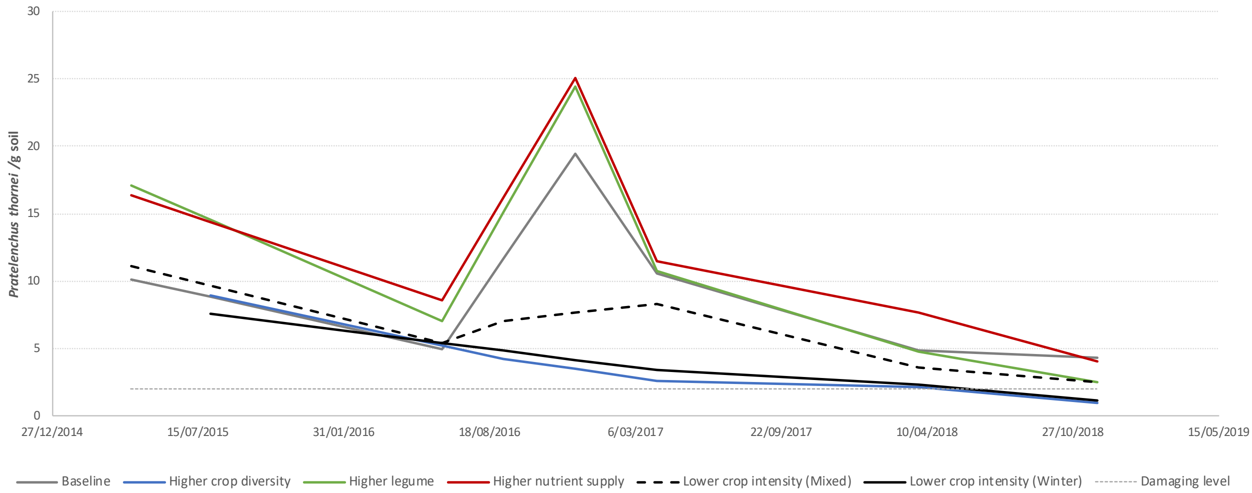

Figure 5. Dynamics of root-lesion-nematode populations over the life of the experiment.

Despite the yield outcomes of the summer crops, their inclusion in the *Higher crop diversity* system has had the greatest effect on reducing the high RLN (*Pratylenchus thornei*) populations present at this site (Figure 5). The *Lower crop intensity (winter)* system that had a RLN resistant crop in 2015-16, then remained fallow until 2018 has had a similar reduction in RLN over the same period, as the *Higher crop diversity*'s two resistant crops. Similarly as previously mentioned, the 2018 wheat yields in the *Lower crop intensity (mixed)* system benefited from the summer break-crop, although with only one resistant crop, RLN populations are not as low as the *Higher crop diversity* system.

This site has been quite dry since 2017, as such RLN have decreased in all systems despite susceptible crops being grown (Figure 5). This means the four systems with RLN populations above damaging levels are a result of the RLN increases in 2015 and 2016 winter crops. As such the two systems growing either resistant crops or fallowed in these wet years, RLN populations have reduced and are now below levels likely to cause damage to a susceptible crop. This will put these systems at an advantage on a return to better seasons.

To date, the most profitable rotation has been a wheat and chickpea rotation. *Baseline* and *Higher legume* had the same cropping history and gross margin until 2018. The *Baseline* system was planted to wheat and *Higher legume* to chickpea in 2018, with the higher wheat yields and lower input costs making the wheat crop more profitable in this season. The *Higher nutrient supply* system had the same crop history as *Baseline*, but had the extra expense of higher rates of urea applied prior to the two wheat crops. With no yield advantage and reduced yield in 2015 from the applied fertiliser, profitability of the *Higher nutrient supply* wheat crops was lower than those in the *Baseline* (Figure 6).

The poor reliability of summer crops in this environment has meant the *Lower crop intensity (mixed)*, *Lower crop intensity (winter)* and *Higher crop diversity* systems have had the lowest returns to date. The most profitable summer crop to date has been sunflowers.

It is interesting to note that apart from the extra nitrogen fertiliser applied to three systems in 2015 and two systems 2017, the expenses of all the systems have been very similar to date, however with very large differences in income achieved (Figure 6).

Implications for growers

In 2015, the moderate nutrient supply strategy adopted in the *Baseline* system provided greater grain yields and profitability than the *Higher nutrient supply* system, because the *Higher nutrient supply* wheat crop used more water early in the season, grew more biomass, and flowered later, so then suffered from heat stress and terminal drought under a dry finish. Under the drier growing conditions of 2018, the extra nitrogen applied was not taken up by the crop, hence is still available for use by following crops.

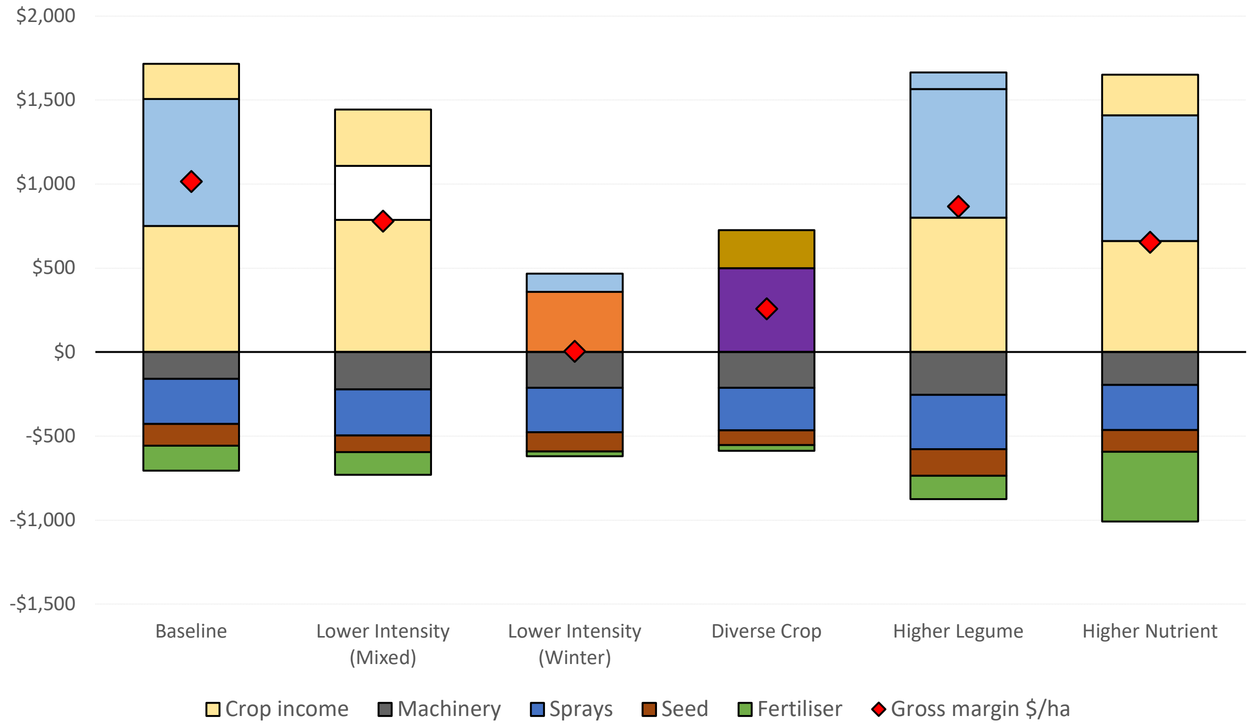

Figure 6. System gross margins, showing break-down of income and expenses.
Crop income colours displayed above the X axis represent crop types as indicated in Figure 1.

The use of summer crops and long fallows have proven useful in reducing soil-borne pathogens (specifically RLN, but not exclusively). Unfortunately, the summer crops grown have not been as successful at producing grain yield as the winter crop options. This is due to the crops experiencing hotter and drier summers than average, however these conditions are not unexpected in this environment.

These summer crops have been able to produce the highest biomass yields, which offers the opportunity to further investigate agronomic strategies to better convert this biomass to grain yield or the use of summer forage crops as an alternative to fill this break-crop role.

Acknowledgements

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Trial details

Location:	Mungindi
Soil Type:	Grey Vertosol
Rainfall:	261mm (2018)

Even wheat following a summer break crop (L) beside weak patches of wheat in a continuous wheat, chickpea rotation (R).