# Extending the understanding of break crop sequences in the low rainfall region of south eastern Australia

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## Abstract

To quantify the benefits of break crops in the low rainfall region of south eastern Australia, five trials were established at Mildura (VIC), Minnipa (SA), Appila (SA), Chinkapook (VIC) and Condobolin (NSW). To further develop confidence in the trial outcomes at a regional level, the results were extended using the farming systems model APSIM across a range of seasons and a variety of soil types, including additional locations Loxton (SA) and Carwarp (VIC). At the majority of sites a legume increased the following wheat yield by 67-854 kg/ha, over a run of the previous 100 seasons. Wheat was the lowest risk crop, being the crop type least likely to yield less than 500 kg/ha. At Loxton and Carwarp break crops had yield potentials greater than 500 kg/ha in 50 - 80% of years. This was also the case for oats and fieldpea at a further 2 of the 6 sites. Soil type was an important determinate of break crop success, with pulses, lupin and chickpea performing poorly on constrained soils. The modelling results give greater confidence for increasing the percentage of break crops grown in the low rainfall farming systems of south eastern Australia through careful species and paddock selection. However, there is still a need to focus on addressing the constraints to break crops achieving water limited yield potential in these environments.

## Keywords

Wheat, Canola, Fieldpea, Oats, APSIM, crop sequencing, low rainfall.

## Introduction

A challenge for sustained productivity in low rainfall farming systems of south eastern Australia is the high proportions of cereals grown. A survey conducted in 2009 as part of the GRDC Water Use Efficiency project showed 90 % of the cropped area in the low rainfall zone was planted to cereal in that year, meaning many paddocks had been in continuous cereal for many years (Moodie and Wilhelm, 2016). This high intensity continuous cropping is due to a number of drivers including risk and higher productivity of cereal crops (McBeath et al. 2015). However, this high intensity can lead to productivity and profitability eventually declining, due to agronomic constraints such as grass weeds, soil borne disease and soil nitrogen fertility. With little data to provide estimates of the break crop effect in the low rainfall zone, a crop sequencing project was developed and ran from 2011-2015 to quantify potential break crop benefits for the region and thereby increase confidence of farmers to modify crop sequences to include break crops (Moodie and Wilhelm 2016). A limitation of field experimentation is the results are seasonally and site specific. Increasingly, farming systems models such as the Agricultural Production System Simulator (APSIM) are being used as a cost effective means of extrapolating and extending results beyond the original seasonal conditions and field site soils (Monjardino et al. 2013). APSIM has been shown to satisfactorily simulate wheat and canola cropping field data in low rainfall farming systems (Rodriguez et al. 2006; Hunt et al. 2013). To further understand the potential for break crops in the low rainfall farming system, this study used modelling to extending the results of the crop sequencing field experiments.

## Methods

APSIM was parameterised using data from the five experimental sites (Table 1) of the project "Profitable crop sequences in the low rainfall regions of south eastern Australia (DAS00119)" (Moodie & Wilhelm, 2016), APSIM versions 7.5 and 7.7 were used. The soils for each site were characterised based on field conditions, with initial nitrogen and soil water set according to the field measurements for each site in the first year. Weather files for each site simulated were obtained as Patched Point Datasets from the SILO database (http://www.longpaddock.qld.gov.au/silo). Simulation output was evaluated by comparing the simulated and observed data for both production, soil water and nitrogen data. Where there was agreement of the simulated and observed data, as at Mildura, Minnipa and Chinkapook, the validated model was extended over 100-year time sequences. Additional modelling to investigate long-term probability sequences were undertaken at two further locations, Loxton and Carwarp, where there were 3 different soils types for each location. These soils were from the APSoil database. Long-term simulations were run from 1 January 1915 to 31 December 2014. A reset to initial starting levels was included each year for surface organic matter, with nitrogen applied at trial rates to non-legume crops (Table 2). An additional annual reset was included for soil nitrogen in the long-term probability sequences.

**Table 1. Field sites and additional sites modelled in APSIM, location, annual rainfall (mm) and soil type.**

| | Site | Location | Rainfall |
|---|---|---|---|
| Field sites | Mildura | Mallee, VIC | 273 |
| | Minnipa | Upper Eyre Peninsula, SA | 325 |
| | Chinkapook | Mallee, VIC | 328 |
| Model sites | Loxton #1 | Mallee, SA | 262 |
| | Loxton #2 | Mallee, SA | 262 |
| | Loxton #3 | Mallee, SA | 262 |
| | Carwarp #1 | Mallee, VIC | 283 |
| | Carwarp #2 | Mallee, VIC | 283 |
| | Carwarp #3 | Mallee, VIC | 283 |

**Table 2. Soil type, wheat plant available water capacity (PAWC), and nitrogen applied at seeding for non-legumes at field and modelled sites.**

| | Site | Soil type | PAWC | Nitrogen |
|---|---|---|---|---|
| Field sites | Mildura | Deep sand | 122.5 | 19.6 |
| | Minnipa | Sandy clay loam | 154.4 | 34.7 |
| | Chinkapook | Sandy clay | 128.6 | 18.1 |
| Model sites | Loxton #1 | Deep sand | 72.0 | 50.0 |
| | Loxton #2 | Moderate deep sand over loam over sandy clay | 118.0 | 50.0 |
| | Loxton #3 | Sandy loam over sandy clay | 70.4 | 50.0 |
| | Carwarp #1 | Sandy loam over sandy clay loam | 134.0 | 34.7 |
| | Carwarp #2 | Sandy loam over sandy clay loam | 142.0 | 34.7 |
| | Carwarp #3 | Sandy clay over clay | 43.2 | 34.7 |

## Results

*Break effects*

Generally over the 100 year period, wheat production increased following a break crop, with the level of benefit depending on break crop species and site (Table 3). Legume break crops provided the greatest average break crop benefit at all sites, ranging between 67 to 854 kg/ha. The lower or negative change in yield for non-legume break crops is likely a result of lower stored soil moisture following these crops compared to the legume break crops. This pattern of results is expected as the APSIM model is capturing the increased yield potential due to additional soil moisture available to the wheat crop in the following season. The magnitude of the break crop effect modelled is consistent with that achieved at the crop sequencing trial sites, which ranged between 20 and 1200 kg/ha at Minnipa, and 500 and 1500 kg/ha at Mildura, with little break crop yield benefits observed at Chinkapook. This benefit is also within the 300-1000 kg/ha range of previous break crop studies in the low rainfall zones (McBeath et al. 2015; Kirkegaard and Ryan 2014; Seymour et al. 2012). It is likely the increases in wheat production following break crops were not as high in the model output as that observed due to the long-term averaging of the modelling output, and/or the additional benefit of pest, weed and disease control that is not captured in the model.

**Table 3. Average change in wheat production kg/ha, and range, following a break crop over 100 years, for Mildura, Minnipa and Chinkapook.**

| Location | Lupin | Fieldpea | Chickpea | Canola | Oats |
|---|---|---|---|---|---|
| Mildura | 887 | 854 | 809 | 56 | |
| Minnipa | | 461 | | 314 | -10 |
| Chinkapook | | 67 | | -111 | |

*Break crop productivity*

At all the modelled locations (Table 1), wheat had the lowest probability of yielding less than 500 kg/ha and the greatest probability of yielding >1000 kg/ha (Figure 1). This finding reflects farmer experience with intensive cereal crop systems in the low rainfall zone, as wheat is perceived to be a more reliable crop than break crops. At two locations, soil type had a large impact on the yield probability distribution of all crops. All crops yielded less than 500 kg/ha more than 50% of the time on the constrained soils at both Loxton and Carwarp (soil #3), with pulse crop most greatly affected (Figure 1). The break crops most likely to achieve yield potentials greater than 1000 kg/ha were oats (greater than 50 to 80 % of the time on the better soil types), followed by fieldpea (greater than 60% on better soil types), and then canola (more than 40% of the time on the better soils).

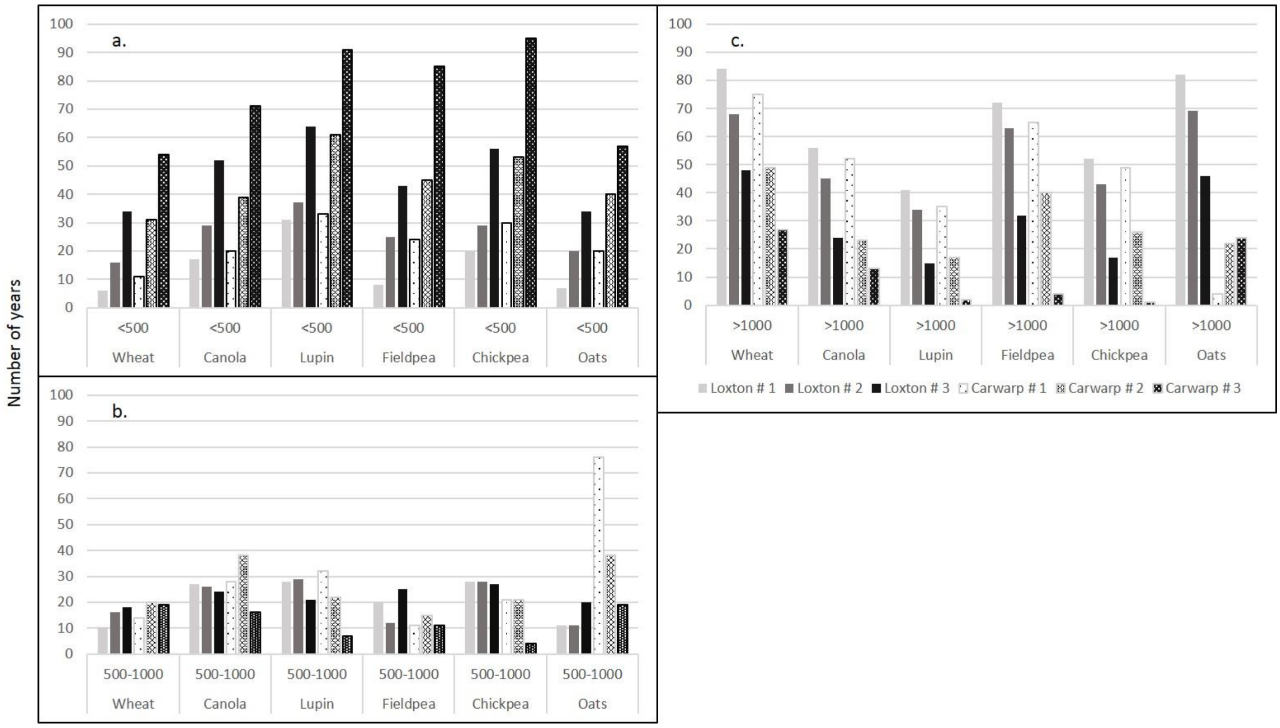


**Figure 1. Number of years in a 100 year sequence that wheat and break crops yielded a. <500 kg/ha, b. between 500-1000 kg/ha, and c. >1000kg/ha, for three different soil types at Loxton and Carwarp.**

## Conclusion

Field trial and modelling outcomes provide greater confidence for growing break crops in the low rainfall farming systems, demonstrating both break crop benefits and a reasonable probability of achieving a successful break crop grain yield. There are however some challenges that still face break crops in these environments that modelling currently does not capture, such as frost and heat risk. These risks need to be taken into account when selecting break crop species for individual farms and paddocks, as does the soil type. Soil types with lower water holding capacity appear less suited to pulse break crops. Further research to address the constraints to achieving break crop water limited yield potential in the low rainfall farming systems will further improve confidence to grow these species.

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