Sustainability of continuous wheat sequences in relation to crown rot in the low rainfall Eastern wheatbelt

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Key messages

Continuous wheat was sustainable for three years on a site with high levels of crown rot inoculum.

Emu Rock had lower levels of crown rot infection and higher yield in the presence of crown rot than Mace and Magenta.

A high level of crop competition is an important factor in keeping ryegrass populations low.

Background and Aims

The benefits of break crops and fallows in cereal-based cropping systems are well known but rarely persist beyond 3 years (Angus *et al.* 2015).

Historically break crops have tended to be thought of as components of strategically fixed rotations. In contemporary farming systems they are utilised to influence the dynamics of weeds, pathogens and soil nitrogen (Renton *et al.* 2015) in what Tanaka *et al.* (2002) call dynamic cropping systems. Despite the known biological benefits of break crops they are often not as profitable nor as reliable as wheat and as such crop sequences on Western Australian farms often contain long phases of continuous cereal, particularly in low rainfall environments. In Western Australia's low rainfall Eastern Wheatbelt the productivity of continuous wheat is commonly inhibited by three factors that break crops can potentially mitigate. They are: 1) build-up of herbicide resistant grass weeds, 2) increasing levels of soil-borne cereal pathogens, or 3) plant nutrient exhaustion. If the rates at which these constraints develop can be reduced by appropriate management during the continuous wheat phase the need for a break crop or fallow can be postponed thereby raising overall cropping system profitability. We set up an experiment to test the hypothesis that good management can maintain high levels of productivity in continuous wheat and, in particular, that wheat cultivars differ in their sustainability when grown in continuous sequences on a site with a background of annual ryegrass and *Fusarium* crown rot.

Method

In 2015 we commenced a trial on DPIRD's Merredin Research Facility comparing Mace, Emu Rock, and Magenta wheat in 6 different 4-year sequences (WWWW, WFCW, FWWW, CWWW, FCWW, and CFWW where W signifies wheat, F fallow, and C canola) replicated 3 times. The site was known to have a high crown rot background as cv. Mace grown in 2014 showed obvious symptoms of crown rot infection. Crop management is summarised in Table1 and target plant density for wheat was 120 p/m^2 and for canola 30 p/m^2.

Table 1. Management details of continuous wheat trial at Merredin beginning 2015

	2015	2016	2017
Sowing date	16 June	16 June	16 June
Pre-sowing herbicides	2 L/ha Roundup 2 L/ha Sprayseed 2 L/ha Treflan	2 L/ha Roundup 1.5 L/ha Treflan 2 L/ha Sprayseed 118 g/ha Sakura 2 kg/ha Atrazine (canola)	0.045 L/ha Hammer 0.08 L/ha Garlon 0.5 L/ha 2,4-D Ester 2 L/ha Roundup 2 L/ha Sprayseed 2 L/ha Treflan
Post-sowing herbicides	0.3 L/ha Axial 1.1 kg/ha Atrazine (canola) 2 L/ha Roundup (fallow)	0.3 L/ha Axial 1.1 kg/ha Atrazine (canola) 2.2 kg/ha Atrazine (fallow) 2 L/ha Roundup (fallow)	0.3 L/ha Axial
Sowing fertiliser	100 kg/ha Agras	100 kg/ha Agras	100 kg/ha Agras
Post-sowing fertiliser	30 L/ha Flexi-N	20 L/ha Flexi-N	20 L/ha Flexi-N

It should be noted that in 2017 canola emerged poorly and was sprayed out before flowering, hence these plots are considered a fallow. This paper reports on results from the first 3 years of the trial. In 2018 the trial will be sown to wheat and plots split for a range of management treatments.

Results

The soil is a brown loam over a brown/white clay loam below about 30 cm. pH (1:5 in 0.01M $CaCl_2$) rises from about 4.8 at the surface to about 6.0 at 50 cm. Before sowing in 2015 P and K levels at 0-10 cm were 40 and 141 mg/kg respectively. PREDICTA B testing showed moderate to high levels of *Fusarium* crown rot DNA and very low, but still detectable, levels of *Bipolaris* and take-all DNA. No root lesion nematodes were detected.

Changes in annual ryegrass populations

Annual ryegrass head numbers were counted in each plot in early October each year. Land use sequence, cultivar, and year significantly affected ryegrass head number, and all interactions were significant as well. Average ryegrass head number in plots cropped to wheat or canola in 2015, when the trial began, was 18 heads/m² (Figure 1). This fell to 2 heads/m² when cropped to wheat in 2016 when Sakura was used as well as trifluralin, showing that moderate populations of ryegrass can be tolerated in wheat with good weed management.

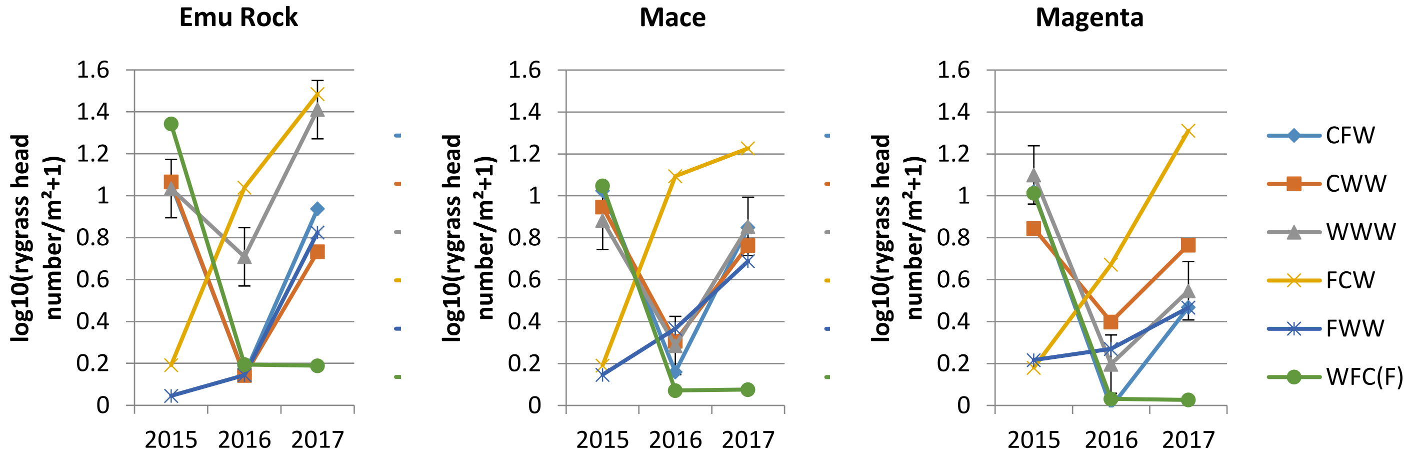

Figure 1. Changes in annual ryegrass head numbers counted in October from six land use sequences based on Emu Rock, Mace, and Magenta wheat from 2015 to 2017 at Merredin. Vertical bars indicate ± SED (standard error of difference). Data are log transformed raw counts to allow use of error bars; as a guide 1.4 on this scale is equivalent to 44 heads/m² and 0.2 to 1 head/m².

Ryegrass numbers were close to zero in fallowed plots in both 2015 and 2016 but recovered in the subsequent year: head number in wheat in 2016 after fallow in 2015 was 1.5 heads/m² which was not significantly different to wheat after wheat or canola. Canola after fallow grew poorly due to late sowing and had 14 ryegrass heads/m², despite additional herbicide in the form of atrazine being used. This highlights the importance of early sowing to set the crop up for crop competition to suppress weeds. This result also indicates that one year of seed set control was not sufficient to reduce the ryegrass seedbank to very low levels at this site. In 2017 ryegrass head number was higher at 9 heads/m² in cropped plots other than FCW which had 38 heads/m².

Emu Rock had higher ryegrass head numbers than Mace or Magenta, particularly in FCW and WWW in 2017. While this suggests Emu Rock could be less competitive than the other cultivars it is more likely to be related to plant density; in 2017 Emu Rock established 25% fewer plants/m² than Mace or Magenta. Further analysis including 2017 crop density in a regression model of 2017 ryegrass head number as a function of 2016 ryegrass head number significantly improved its fit (P=0.012) at the same time as making the cultivar effect non-significant.

Incidence of Fusarium crown rot

In 2015 background levels of *Fusarium* at the site were assessed by two methods: 1) PREDICTA B assay and 2) plating out crowns and stems of 2014 remnant stubble. Both methods indicated there were high levels of crown rot present. Crown rot infection and expression was monitored throughout the life of the experiment in two ways: firstly by counting white heads during grain filling, and secondly by recording the incidence and severity of crown rot symptoms on the stem base of 40 plants from each plot just prior to harvest. There was a difference (P <.001) in incidence and disease severity between wheat cultivars with Emu Rock having fewer infection symptoms. The incidence of Emu Rock plants with crown rot symptoms was 13% of that of Mace in 2016 and 21% in 2017. Magenta had 14% greater crown rot incidence than Mace in 2016 and 12% more in 2017 (Figure 2). The data for white head number and severity of infection show the same cultivar differences.

Crop sequence significantly affected crown rot incidence and severity, although WWWW did not necessarily have the highest values: in 2016 wheat after fallow (F**W**WW) exhibited most severe crown rot (Figure 2). This is likely due to the greater early vigour in this sequence (anthesis biomass was 13% greater than W**W**WW) resulting in greater water stress during grain filling as post anthesis-rainfall was only 21 mm in 2016. In 2017 crown rot incidence and severity was least in sequences where wheat was not grown in 2016 (FC**W**W and CF**W**W).

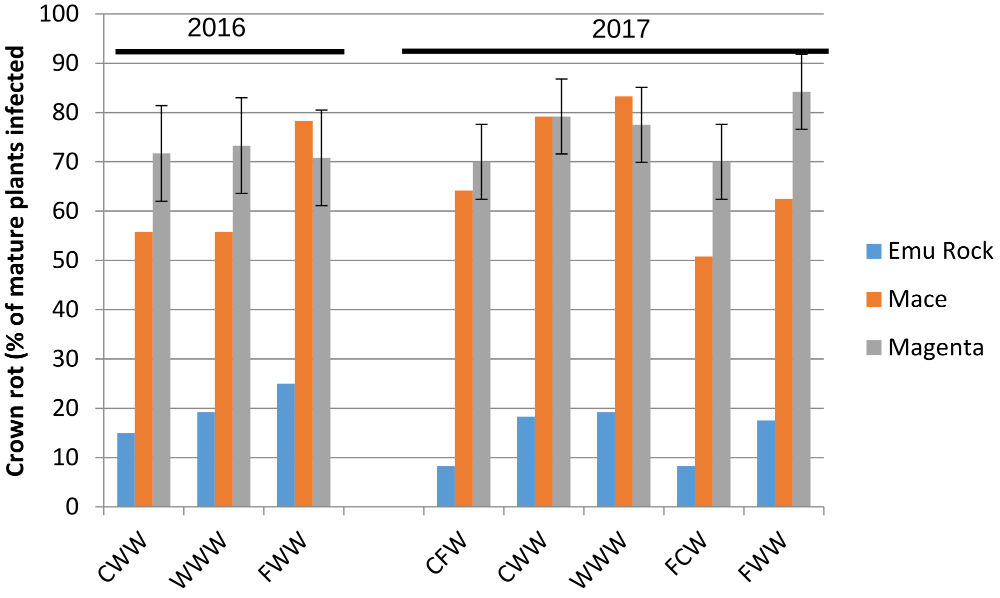

Figure 2. Percentage of mature plants showing crown rot symptoms at the stem base of of three wheat cultivars grown in different sequences at Merredin in 2016 and 2017. Vertical bars represent ± SED.

There were also differences in crown rot DNA present in the soil, as measured by PREDICTA B. DNA levels measured before seeding in 2016 indicated small differences in DNA levels (Figure 3) but levels were already lower in plots that had grown Emu Rock in 2015 than other cultivars (W**W**WW and W**F**CW sequences). In 2017 levels were clearly lower in all plots that had grown Emu Rock rather than Mace or Magenta. Crop sequence also had a significant effect in 2017: sequences that had not grown wheat in 2016 (CF**W**W, FC**W**W, WF**C**W) averaged 20 pg crown rot DNA/g soil (1.3 on the log scale) compared to 168 (2.2 on the log scale) after wheat in 2016.

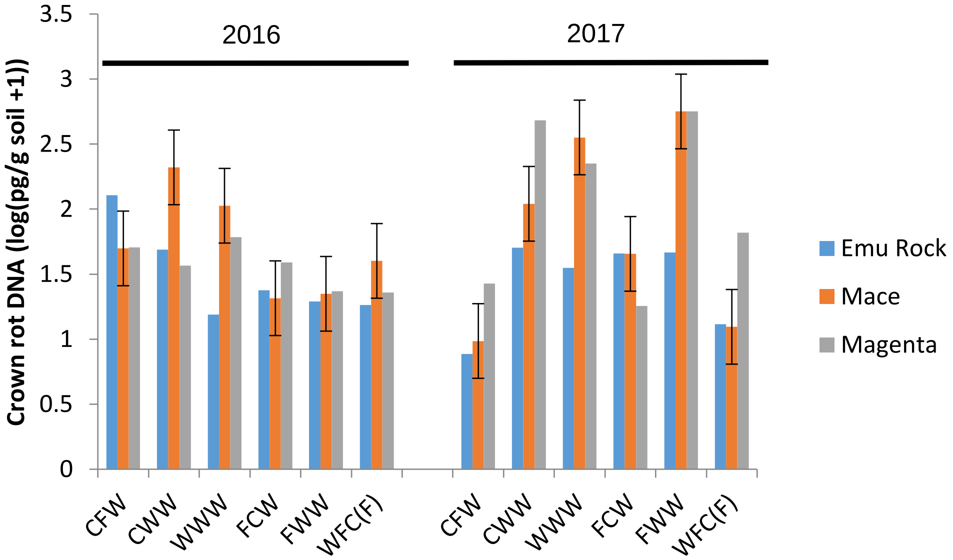

Figure 3. Soil crown rot DNA (PREDICTA B) pre-sowing under three wheat cultivars in six crop sequences at Merredin in 2016 and 2017. Data are log transformed; as a guide 2.5 is equivalent to 315 pg DNA/g soil, and 1 is equivalent to 9 pg DNA/g soil. Vertical bars represent ± SED

High levels of crown rot incidence in the stem bases led to greater levels of crown rot DNA in the soil at the start of the following season (Figure 4). This explains why pathogen DNA is lower after Emu Rock than after Mace or Magenta.

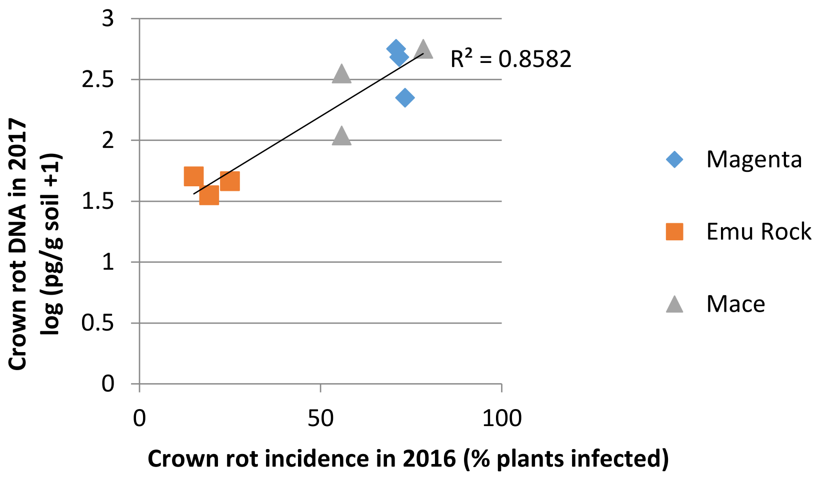

Figure 4. Dependence of soil crown rot DNA at pre-sowing in 2017 on disease incidence on stems in wheat crops in 2016.

Crop yield

Despite the observed differences in weed populations and disease incidence there were only small yield differences between sequences (Figure 5) and none of them were statistically significant. There were significant yield differences between cultivars: Emu Rock averaged 1.68 t/ha compared to 1.49 for Mace and 1.52 for Magenta in 2017, and in 2016 Magenta averaged 1.76 t/ha compared to 2.00 for Emu Rock and 2.02 for Mace. These results align with those of Daniel Huberli and the national crown rot program (DAN00175) where Emu Rock was consistently showed less yield loss to crown rot under high disease pressure (Hüberli *et al*. 2017). Yield was negatively related to both ryegrass head number in October and soil levels of crown rot DNA prior to sowing, however these relationships were not significant.

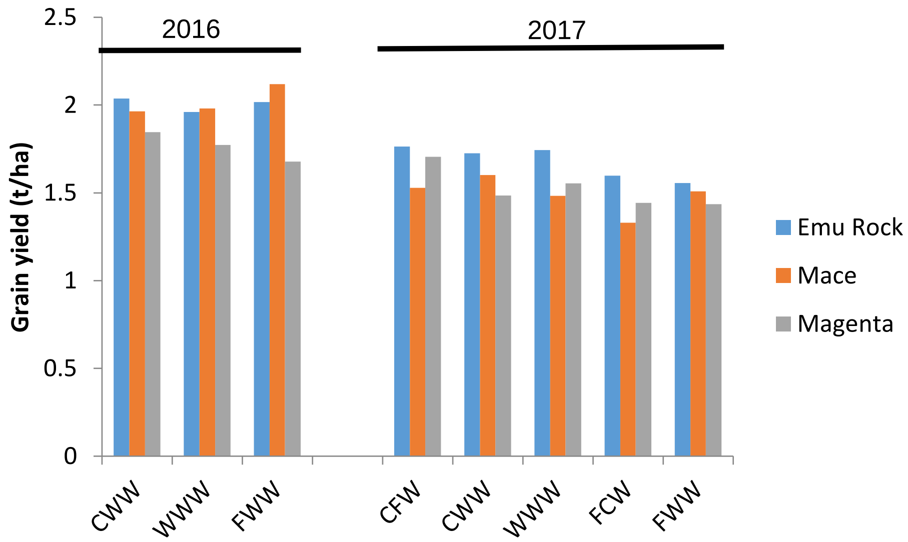

Figure 5. 2016 and 2017 grain yields of three wheat cultivars grown in five different sequences starting in 2015 at Merredin.

Other considerations

Water storage in the fallow plots was not as good as it might have been. The loamy soil crusted during fallowing causing more runoff of summer rain than in cropped plots with more cover. Also summer weeds were more vigorous on fallow plots than plots with stubble cover which may also have reduced stored soil moisture. For example in December 2016 fallow plots held 84 mm more water in the soil profile than continuous wheat plots, but by May 2017 this advantage was reduced to only 1 mm. Also bare soil surfaces of fallow plots dried quickly compared to those with stubble cover. Consequently dry conditions following sowing in 2017 resulted in emergence being delayed up to a week in wheat after fallow compared to compared to wheat sown into stubble and wheat after fallow established poorly with 69% plant density of wheat on stubble.

The only significant effects of sequence on grain quality were that grain protein was greater after canola or fallow than after wheat, and continuous wheat was lowest. Nevertheless grain protein levels were high: in 2017 wheat after fallow had 15.2% compared to 14.7% for wheat after canola, 14.1% for wheat after one wheat crop, and 13.1% for continuous wheat.

Conclusion

Grain yield was maintained in continuous wheat at the same level as wheat in sequences including fallow or canola over the three years of the trial. Crown rot infection increased over this time however, levels were lower in continuous Emu Rock than Mace or Magenta. Additionally, Emu Rock had higher grain yields than Mace or Magenta. This indicates that Emu Rock may be a better choice in continuous wheat sequences in high crown rot situations.

Capturing the benefits of breaks in wheat sequences requires good management. For instance ryegrass numbers built up more in a poor canola crop than a healthy wheat crop despite being able to use atrazine in the canola. Also not maintaining good ground cover in fallow plots reduced their effectiveness in water storage and led to poor soil conditions for crop establishment in the following year.

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Key words

Continuous wheat, canola, fallow, crown rot, ryegrass

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