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Foreword

Crop sequences in modern Australian farming systems

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It is widely recognised that cereal crops tend to perform better when grown after a legume or brassica break crop. Indeed, crop rotation, where different crops and/or phases of pastures are rotated to break disease and pest cycles, alter the water balance and nutrient dynamics, or help manage weed seed banks, is one of the oldest agronomic practices used in agriculture. In this *Crop & Pasture Science* Special Issue, Angus *et al*. (2015) discuss how crop rotation was utilised by ancient civilisations to sustain cereal grain production. Consequently, it may be argued that the benefits of break crops and crop rotation should be well understood. However, recent reviews of the biological mechanisms of break crops (e.g. Kirkegaard *et al*. 2008; Peoples *et al*. 2009; Kirkegaard and Ryan 2014) suggest that while biological concepts are known, the impact of including a break crop on the yield of the following crop is often variable. Angus *et al*. (2015) uses a meta-analysis approach to build upon earlier reviews to argue that the size of the break crop effect on cereals is primarily influenced by the type of break, where oats < oilseeds < legume crops. Individual studies measuring the size of the break crop effect have been more equivocal, reporting yield advantages of between 0.6–0.8 t/ha (Angus *et al*. 2011; Seymour *et al*. 2012; Lawes *et al*. 2013) under Australian conditions.

The benefits of growing a break crop on subsequent cereal crops are juxtaposed against the ability to grow the break crop or pasture profitably. The ley farming system, where repeated cycles of cropping rotated with periods of legume-based pastures as a means of supplying crops with nitrogen, declined during the 1990s after previously being the basis of much of Australia's dryland grain production (Angus and Peoples 2012). In this issue, Whitbread *et al*. (2015) evaluates the performance of the ley farming system against an intensive cropping system and demonstrate why, from an economic perspective, intensive cropping systems are superior to the ley farming system. Such a scenario gives rise to the intensive cropping systems observed in the new millennium. However, 'false breaks', late starts to the growing season and poor spring rainfall during the millennium drought (Kirkegaard and Hunt 2010), combined with outbreaks of disease in canola and legume crops (e.g. Khan *et al*. 1999), discouraged farmers from growing traditional legume break crops. Price volatility and farmer aversion to risk also contributed to a decline in areas sown to canola and legume pulse crops (Angus and Peoples 2012). In most instances, farmers grew fewer break crops than economic models would optimally suggest (Robertson *et al*. 2010). Such findings encouraged additional investment by the Grains Research & Development Corporation (GRDC) into break crop research, in the belief that grain growers had prematurely abandoned an important management tool for sustainable cropping.

This special issue of *Crop & Pasture Science* explores different aspects of break crops, as applied to modern Australian farming systems. The research is divided between conventional agronomic studies of break crops (French *et al*. 2015; McBeath *et al*. 2015; Malik *et al*. 2015; Whitbread *et al*. 2015), and studies that adopt a survey of either the literature, farmers fields, or use bio-economic models to evaluate break crops in a broader farming systems context (Angus *et al*. 2015; Harries *et al*. 2015; Renton *et al*. 2015; Lawes and Renton 2015).

From an agronomic perspective, weeds, and in particular annual rye grass (*Lolium rigidum*), tended to affect the size of the break crop effect in Western Australia. French *et al*. (2015) demonstrated that the agronomic management of the break phase needed to concentrate on reducing this weed burden, and if this was successful, the break crop effect may continue for a second and third year. In these series of experiments, factors such as soil water dynamics, nitrogen and disease appeared to be less important than weeds. This finding contrasts with another Western Australian study where the break crop effect that legume and oilseed crops impart on future wheat crops could be replicated using wheat sown with a fungicide seed dressing (Malik *et al*. 2015). Pronounced differences between treatments in soil borne diseases such as *Rhizoctonia solani* (AG8) were difficult to detect, and it is conceivable that subclinical levels of the disease still affected cereal performance. In South Australian studies undertaken at low rainfall sites, McBeath *et al*. (2015) identified substantial yield improvements to subsequent cereal yields following break crops. Those break crops improved nutrient cycling and reduced the levels of Rhizoctonia infection in cereals and these findings were remarkably consistent across soil types in that region.

While the particular mechanism contributing to the observed yield advantages in subsequent cereal crops seemed to be site and season specific, the impact was remarkably consistent, and was in line with yield benefits identified by earlier investigations. The agronomic studies reported here have been paired with an industry survey of farmer practice by Harries *et al*. (2015). In Western Australia, wheat was the main crop grown, and the dominant break crop was canola. However, pastures were also an important break from cereal production and Harries *et al*. (2015) suggest these pastures may require additional management to ensure they provide the desired benefits for following cereal crops. This survey demonstrated that the importance of pastures in an Australian context may have been underestimated and perhaps deserve greater attention. The bio-economic study conducted by Lawes and Renton (2015) adds further weight to this conclusion, where the LUSO model suggests farmers may consider a period of exploitation followed by a period of rehabilitation in their cropping systems

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using successive break crops or pastures to manage agronomic problems in cereals once they materialise. Over a 10-year period, two pastures that successfully managed weeds, may provide greater economic benefits than the sporadic use of a single break crop or pasture. Renton *et al*. (2015) also used the LUSO model to illustrate how a break crop such as lupin may be managed tactically for weed control (brown manuring) or grain, depending on season and price signals. The two modelling studies illustrate the importance of commodity price and season on the economic outcome in modern farming systems and these highly variable factors need to be considered when formulating a particular crop rotation or sequence.

As a collection, the papers published in this special issue of *Crop & Pasture Science* demonstrate how research into crop rotation and break crops has evolved in recent times. Agronomy studies can now be complemented with modelling studies to first ascertain which particular ecological drivers are relevant to a region, and then the models can be employed to evaluate strategic and tactical crop sequence management questions in the context of profit and risk.

Break crops will continue to play an important role in modern Australian farming systems. The challenge for researchers is to deliver economically viable break crop and pasture choices to farmers that address the key biotic stresses in the systems and to identify under what circumstances these break crops will have the most impact on agricultural sustainability.

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